City of Walla Walla … the best of the best of the Northwest.

WALLA WALLA CITY COUNCIL
Regular Meeting Agenda
October 14, 2026 - 6:30 p.m.

Live stream of the meeting may be viewed on the City's website at https://www.wallawallawa.gov/government/city-council. Members of the public also may attend and participate in this regular meeting by using this Zoom meeting link: https://us02web.zoom.us/j/84531798905 or by calling 253-215-8782 and entering meeting ID 845 3179 8905#.

Individuals who need auxiliary aids for effective communication are encouraged to make their needs and preferences known by contacting the Human Resources Department at 509-527-4475.

Mission: Dedicated to enhancing the quality of life in Walla Walla.

1. **CALL TO ORDER**

2. **PLEDGE OF ALLEGIANCE**

3. **PRESENTATIONS AND PROCLAMATIONS**

A. Pgs. 3-4 Proclamation - Domestic Violence Awareness Month - October 2026

4. **PUBLIC COMMENTS:** (3 Min. Time Limit) Persons making irrelevant, personal, impertinent, overly redundant, vulgar, or slanderous remarks that disrupt, disturb or otherwise render orderly conduct of the meeting unfeasible may be barred by the presiding officer from making further comments before the Council during the meeting.

The public may comment at this time on matters of City business. To provide comments virtually, please use the Zoom meeting link, raise your virtual hand, wait to be recognized, and then unmute. If you are calling in, dial *9 to raise your virtual hand, wait to be recognized, and dial *6 to unmute the connection. Public comments may also be provided by emailing the City Clerk at CityClerk@wallawallawa.gov

If you would like to request staff follow-up regarding your public comments, please email your contact information (email and phone number) to CouncilFollowup@wallawallawa.gov and please summarize the topic of your comment so it can be directed to the correct department.

5. **CONSENT AGENDA**

A. Pgs. 5-12 Ordinance 2026-14: Amending the 2025-2026 Biennial Budget.

B. Pgs. 13-15 Resolution 2026-086: Authorize the City Manager to Sell or Dispose of Certain Surplus Items

C. Pgs. 16-22 Approves the minutes of the September 21, 2026 Work Session and the September 23, 2026 Regular Meeting.

6. **ACTIVE AGENDA**

A.	Pgs. 23-57	Public Hearing: CDBG 2025 Consolidated Annual Performance Evaluation Report
B.	Pgs. 58-88	Public Hearing on the Formation of the Woodlawn/Chestnut LID
C.	Pgs. 89-736	Public hearing for the Periodic Comprehensive Plan Update - Walla Walla 2046
D.	Pgs. 737-900	Public Hearing on the Municipal Code Amendments implementing the 2046 Comprehensive Plan
E.	Pgs. 901-2635	Public Hearing on the Critical Areas Ordinance (CAO) code amendments
F.	Pgs. 2633-2652	Public Hearing on Revenue Sources Supporting the Biennial Budget and Adopt Resolution 2026-087 Setting the 2027 Regular Property Tax Levy
G.	Pgs. 2653-2669	Approve the September 2026 Accounts Payable Register.
H.	Pgs. 2670-2672	Approve the September 2026 Payroll and Benefits Transactions.

7. **COUNCIL MEMBER MEETING REPORTS**

8. **UNFINISHED AND NEW BUSINESS**

9. **MEETING ENDS**

Values: Service, Integrity, Collaboration, Equity, Leadership, and Community

The City of Walla Walla complies with Title VI, ADA, and other applicable Federal civil rights laws and does not discriminate on the basis of race, color, national origin, age, disability, religion, veteran status, sexual orientation, gender identity, or sex.

ar-6054 **Pgs. 3-4**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Submitted For: City Council, City Council

Add'l Contributors:

Information

ITEM TITLE:

Proclamation - Domestic Violence Awareness Month - October 2026

Attachments

Proclamation

City of Walla Walla

PROCLAMATION

WHEREAS, YWCA Walla Walla has worked to enrich the lives of women and families since 1917; and

WHEREAS, in acknowledgment of the thousands of women who have been helped after escaping domestic violence in the 35 years since the YWCA opened its Domestic and Sexual Assault Shelter in 1991; and

WHEREAS, in acknowledgement that awareness is the first step to stopping domestic violence;

NOW, THEREFORE, recognizing the importance of raising awareness about domestic violence and its impact on women, men, and our community, the Walla Walla City Council do hereby proclaim the month of October as

DOMESTIC VIOLENCE AWARENESS MONTH

in the city of Walla Walla, and I urge every resident to join in this special observance.

Given under my hand and Seal of the City of Walla Walla on this 14th day of October 2026.

_____

Mayor, Gustavo Reyna

ar-6050 **Pgs. 5-12**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: Quarterly Budget Amendment to the 2025-2026 Biennial Budget

Submitted For: Lizbette Feria, Finance Department

Financial Comments:

This is a routine quarterly budget amendment. The Finance team routinely reviews expenditure and revenue accounts throughout the biennium to ensure that the budgets are accurate. Finance also works with departments to identify new revenue sources (typically grants or donations) and budget the associated expenses.

For operations, the City is adding $1,204,070 in revenue and is increasing expenses by $98,900.
For the Capital Improvement Plan (CIP), the City is adding $300,000 in project funding and increasing project expenses by $300,000.

For the General Fund, we are adding $628,000, for permit revenue, park donations, and state fire mobilization reimbursements. The General Fund will transfer $98,900 out of the state fire mobilization reimbursement to set-a-side for fire suppression equipment in the Vehicle Replacement Fund.

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

Quarterly budget amendment to the 2025-2026 biennial budget.

Information

HISTORY:

State statute allows cities to amend their budgets throughout the biennium, and the City has opted to amend its budget quarterly to reflect updates to revenue and expenditures. This is the 11th time the City has amended the 2025-2026 biennial budget. The City Council is required to adopt all budget ordinances.

POLICY ISSUES:

The City Council is required, by state statute, to adopt all budget ordinances.

PLAN COMPLIANCE:

STRATEGIC PLAN: This budget amendment supports all areas of the City's Strategic Plan.

ALTERNATIVES:

The City Council can direct staff to update the budget amendment or not adopt the ordinance.

STAFF RECOMMENDATION:

City staff recommends that the City Council adopt the ordinance amending the 2025-2026 biennial budget.

CITY MANAGER COMMENTS:

Concur with the staff recommendation and approved for City Council action.

Attachments

Ord 2026-14
2025-2026 Budget Amendment Fund Balance Summary
2025-2026 Budget Amendment 11 Details

ORDINANCE NO. 2026-14

AN ORDINANCE AMENDING THE 2025-2026 CITY OF WALLA WALLA BIENNIAL BUDGET

WHEREAS, the City of Walla Walla passed Municipal Ordinance A-2405 on May 13, 1970, which classified the City of Walla Walla as a nonchartered code city under Title 35A of the Revised Code Washington (RCW); and

WHEREAS, section 35A.33.120 of the Revised Code of Washington authorizes budget adjustments; and

WHEREAS, certain anticipated revenues included in the 2025-2026 Maintenance and Operations and CIP Budgets will not be received, and new sources have been identified; and

WHEREAS, certain necessary expenditures were not anticipated and therefore not included in the 2025-2026 Biennial Budget; and

WHEREAS, the Walla Walla City Council considered this ordinance during a regularly and duly called public meeting of said Council, and has given said ordinance careful review and consideration, and finds passage of this ordinance to be in the best interest of the City;

NOW THEREFORE, the City Council of the City of Walla Walla does ordain as follows:

Section 1: The City of Walla Walla's maintenance and operations budget for the 2025-26 fiscal biennium is hereby modified to include the following adjustments to revenues:

	M&O	CIP
General Fund	628,000	-
Golf Fund	101,000	-
Ambulance Fund	350,000	-
Stormwater Fund	-	300,000
Service Center Fund	26,170	-
Vehicle Replacement Fund	98,900	-

Section 2: The City of Walla Walla's maintenance and operations budget for the 2025-26 fiscal biennium is hereby modified to include the following adjustments to expenditures:

	M&O	CIP
General Fund	98,900	-
TBD Fund	-	300,000

Section 3: This ordinance is in the best interest of the City of Walla Walla

.

Section 4: If any item, section, or part of this ordinance be adjudged invalid, such adjudication shall not affect the validity of this ordinance, or any item, section, or part thereof not adjudged to be invalid.

Section 5: This ordinance, being one required by law, shall take effect and be in full force and effect upon its passage in its entirety as provided by law.

PASSED by the City Council of the City of Walla Walla, Washington, this 14th day of October 2026.

_____
Mayor

Attest:

_____
City Clerk

Approved as to Form:

_____
City Attorney

SUMMARY OF ORDINANCE NO. 2026-14

AN ORDINANCE AMENDING THE 2025-2026 CITY OF WALLA WALLA BIENNIAL BUDGET

Revenue – Appropriations

	M&O	CIP
General Fund	628,000	-
Golf Fund	101,000	-
Ambulance Fund	350,000	-
Stormwater Fund	-	300,000
Service Center Fund	26,170	-
Vehicle Replacement Fund	98,900	-

Expenses:

	M&O	CIP
General Fund	98,900	
TBD Fund	-	300,000

The Walla Walla City Council passed Municipal Ordinance 2026-14 on October 14th, 2026, at the regular meeting, which, in summary, amends the 2025-2026 budget.

The full text of Municipal Ordinance 2026-14 will be provided upon request to the Walla Walla City Clerk at Walla Walla City Hall, 15 N. Third Ave., Walla Walla, WA 99362.

Summary approved as to form:

_____

Tim Donaldson
City Attorney

City of Walla Walla 2025-26 Fund Summary

Fund	Beginning Fund Balance	2025 Revenues	2025 Expenditures	Estimated Ending Fund Balance	Ending FB %/ Expenditures	2026 Revenues	2026 Expenditures	Calculated Ending Fund Balance	Ending FB %/ Expenditures
Governmental									
General	8,838,532	48,800,146	47,529,074	**9,840,870**	**20.70%**	54,177,900	55,880,610	**8,406,894**	**15.04%**
LEOFF 1 Retirement	30,665	114,270	122,890	**22,045**	**17.94%**	100,490	100,480	**22,055**	**21.95%**
Street Maintenance	1,832,455	5,059,931	4,882,162	**2,010,224**	**41.17%**	6,823,580	7,689,395	**1,144,409**	**14.88%**
REET	663,920	947,056	669,000	**941,976**	**140.80%**	651,750	750,000	**843,726**	**112.50%**
Housing	17,541	1,134	315	**18,359**		100	-	**18,459**	
Lodging Tax	601,943	1,288,191	1,715,473	**174,661**	**10.18%**	1,418,000	1,400,520	**192,141**	**13.72%**
Tourism Promotion	-	533,076	533,076	**-**	**0.00%**	556,200	556,200	**-**	**0.00%**
Opioid Settlement	438,326	106,620	48,964	**495,982**	**1012.96%**	195,700	106,000	**585,682**	**552.53%**
E911 Emergency Communications	-	-	-	**-**	**0.00%**	3,475,000	-	**3,475,000**	**0.00%**
Forfeiture & Seizure	384,715	36,458	49,005	**372,168**	**759.45%**	10,000	10,410	**371,758**	**3571.16%**
Code Enforcement	213,660	14,192	27,279	**200,572**	**735.26%**	3,500	22,500	**181,572**	**806.99%**
General Debt	2,234	258,247	229,782	**30,699**	**13.36%**	314,830	277,330	**68,199**	**24.59%**
Police Voted	450,069	875,785	850,200	**475,654**	**55.95%**	892,450	863,300	**504,804**	**58.47%**
Pool Voted	122,132	432,289	416,090	**138,331**	**33.25%**	425,540	413,890	**149,981**	**36.24%**
General Construction	1,211,618	666,370	1,684,963	**193,024**	**11.46%**	15,056,830	14,027,350	**1,222,504**	**8.72%**
Street Construction	1,536,537	11,313,183	9,224,366	**3,625,353**	**39.30%**	9,875,060	13,486,810	**13,603**	**0.10%**
TBD Construction	3,947,058	2,237,161	676,384	**5,507,835**	**814.31%**	2,176,930	3,637,450	**4,047,315**	**111.27%**
Enterprise				**-**					
Golf Course	27,111	239,059	252,538	**13,632**	**5.40%**	1,393,880	1,202,800	**204,712**	**17.02%**
Sanitation	2,792,302	8,378,690	8,848,260	**2,322,732**	**26.25%**	8,531,410	9,078,730	**1,775,412**	**19.56%**
Water	17,393,298	20,319,847	20,376,342	**17,336,803**	**85.08%**	19,968,960	24,817,900	**12,487,863**	**50.32%**
Stormwater	3,098,064	4,030,494	4,327,444	**2,801,113**	**64.73%**	5,726,430	6,418,400	**2,109,143**	**32.86%**
Wastewater	11,768,629	15,383,230	15,159,316	**11,992,543**	**79.11%**	31,748,150	38,284,570	**5,456,123**	**14.25%**
Landfill	6,781,815	9,330,520	8,120,993	**7,991,342**	**98.40%**	7,784,610	14,561,520	**1,214,432**	**8.34%**
Ambulance	769,256	6,388,241	6,127,338	**1,030,159**	**16.81%**	6,899,300	6,960,110	**969,349**	**13.93%**
Internal Service				**-**				**-**	
WESCOM - E911	1,361,351	2,691,737	2,992,380	**1,060,708**	**35.45%**	2,887,620	3,115,800	**832,528**	**26.72%**
Service Center	311,702	299,950	508,000	**103,652**	**20.40%**	452,770	435,790	**120,632**	**27.68%**
Fleet	117,863	2,174,598	1,999,720	**292,742**	**14.64%**	2,151,200	2,098,210	**345,732**	**16.48%**
Vehicle Replacement	11,259,990	2,898,000	1,684,089	**12,473,900**	**740.69%**	4,742,770	13,528,050	**3,688,620**	**27.27%**
Medical Insurance	752,191	8,252,436	8,023,362	**981,265**	**12.23%**	8,402,820	8,142,820	**1,241,265**	**15.24%**
Workers Comp Self Insurance	199,141	919,410	848,882	**269,669**	**31.77%**	926,280	818,400	**377,549**	**46.13%**
Totals	**$ 76,924,115**	**$ 153,990,321**	**$ 147,927,687**			**$ 197,770,060**	**$ 228,685,345**		

General Fund - Fund Balance Classifications		
Unassigned - Used for Expenditures	8,406,894	15.04%
Committed Parking Lot	78,368	
Committed - Future Projects	1,250,000	
Restricted - Parks	310,867	
Total General Fund Balance	**10,046,130**	

City of Walla Walla
2025-2026 Budget Amendment #11

Account Description	Adopted Budget	2026 Proposed Adjustment	Amended Budget	% Change	Explanation
General Fund Revenues					
Buildings Structures & Equipment	620,700	350,000	970,700	36%	Actual revenue earned is higher than original estimate
State Fire Mobilization	60,000	250,000	310,000	81%	Actual revenue earned is higher than original estimate
Parks Donations	-	28,000	28,000	100%	Received donations for parks programs
Net Increase (Decrease) in Revenues		**$ 628,000**			
General Fund Expenditures					
Equipment Replacement	1,960	98,900	100,860.00	98%	Set aside from 2026 Fire Mobilization earned revenue
Net Increase (Decrease) in Expenditures		**$ 98,900**			
Golf Course Fund Revenues					
Sale of Merchandise	237,000	30,000	267,000	11.2%	Actual revenue earned is higher than original estimate
Golf Rounds Fee	31,000	4,000	35,000	11.4%	Actual revenue earned is higher than original estimate
Golf Rounds - Greens Fees	763,000	50,000	813,000	6.2%	Actual revenue earned is higher than original estimate
Convenience Fee	-	17,000	17,000	100.0%	Adding budget for fees collected
Net Increase (Decrease) in Revenue		**$ 101,000**			
Ambulance Fund Revenues					
GEMT Payment Program	685,000.00	350,000	1,035,000	33.8%	Received higher reimbursement than estimated
Net Increase (Decrease) in Revenues		**$ 350,000**			
Service Center Fund Revenues					
Miscellaneous Other	-	26,170	26,170	100.0%	Electric Vehicle Tax Credit
Net Increase (Decrease) in Revenues		**$ 26,170**			
Vehicle Replacement Fund Revenues					
Equipment Replacement	1,952,830.00	98,900	2,051,730.00	4.8%	Set aside from 2026 Fire Mobilization earned revenue
Net Increase (Decrease) in Revenues		**$ 98,900**			

City of Walla Walla
2025-2026 Budget Amendment #11

Account Description	2026 Adopted Budget	2026 Proposed Adjustment	2026 Amended Budget	% Increase	Explanation
TDB Fund					
Transfers-Out Stormwater	-	300,000	300,000	100%	TBD Match for Dept of Ecology Grants
Net Increase (Decrease) in Expenditures		**$ 300,000**			
Stormwater Fund					
Transfer-In TBD	-	300,000	300,000	100%	TBD Match for Dept of Ecology Grants
Net Increase (Decrease) in Revenues		**$ 300,000**			

ar-6067 **Pgs. 13-15**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: Surplus of Items No Longer Needed

Submitted For: Lizbette Feria, Finance Department

Financial Comments:

The declaration of surplus property is a routine administrative process conducted periodically to identify equipment and materials that are no longer required for City operations. Once declared surplus, these items may be sold, traded, recycled, or otherwise disposed of in accordance with applicable laws and City policy. Minimal funds may be recovered if items are sold after surplus approval by the City Council.

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

The declaration of surplus property is a routine administrative process conducted periodically to identify equipment and materials that are no longer required for City operations. Once declared surplus, these items may be sold, traded, recycled, or otherwise disposed of in accordance with applicable laws and City policy. Minimal funds may be recovered if items are sold after surplus approval by the City Council.

Information

HISTORY:

The city typically surpluses items quarterly or as needed to dispose of those that are broken, obsolete, or no longer needed.

POLICY ISSUES:

The City Council is required to approve the surplus of items valued at more than $10,000.

ALTERNATIVES:

Not approve the surplus resolution.

STAFF RECOMMENDATION:

Staff recommends that the Council approve the surplus resolution.

CITY MANAGER COMMENTS:

Concur withe staff recommendation and approved for City Council action.

Attachments

Res 2026-086

RESOLUTION NO. 2026-86

A RESOLUTION AUTHORIZING THE CITY MANAGER OF THE CITY OF WALLA WALLA TO SELL OR OTHERWISE DISPOSE OF CERTAIN SURPLUS PROPERTY OF THE CITY OF WALLA WALLA

WHEREAS, the City Administration has determined that certain property of the City of Walla Walla is surplus, and has recommended that the City Council declare said property to be surplus and to authorize its sale at public auction or other disposition as recommended by the City Manager, and

WHEREAS, the Walla Walla City Council has received recommendation and has determined that such property is no longer needed by the City of Walla Walla and should be declared surplus and sold or otherwise disposed of for the common benefit of the citizens of Walla Walla, and

WHEREAS, the Walla Walla City Council has considered this matter during a regular and duly called public meeting of said Council, has given said matter careful review and consideration, and finds that sale or disposal of the property is an appropriate function for the city and that the best interests of the City of Walla Walla, and good government of the city will be served by passage of this Resolution;

NOW THEREFORE, the City Council of the City of Walla Walla do resolve as follows:

Section 1: That the following described personal property of the City of Walla Walla is hereby declared to be surplus to the needs of the City of Walla Walla and no longer needed:

Fleet Services

Quantity	Description	S/N	Asset #
1	2008 Ford Escape Hybrid EQ 01003	1FMCUS9H08KE58625	479
1	2008 Chevrolet Trailblazer EQ 01004	1GNDT13S882204810	551
1	2000 Chevrolet Silverado EQ 01303	2GCEC19W411198954	186
1	Stanley Compactor Attachment EQ 02570A	HS6000	108
1	Trail King Utility Trailer EQ 04659	1TKU020294M016008	247
1	1988 Case Backhoe Loader EQ 02570	7413	92
1	1992 Spreader Hiway EQ 03301	91451	112

Police Department

Quantity	Description	S/N	Asset #
1	2017 Subaru Outback	4S4BSAAC8H3209199	1185
1	2022 Forensic Workstation	BZ1610-X9i-001	1236
1	HP Desktop/Monitor/Fingerprint Device	MXL6373S3Z	859

Technology Services

Quantity	Description	S/N	Asset #
1	HP MSA 2040 San DC SFF Storage #2	2S6513B185	780
1	Dell Powervault Md3400 12G	2SBRHQ2	959
1	Supermicro Windows Storage Server	C8470FD48M50139	N/A
1	Talino Lab PC	20140617735010001	N/A

Section 2: The City Manager of the City of Walla Walla is hereby authorized, to sell or dispose of the above-described surplus equipment in such manner as deemed to be in the best interests of the City of Walla.Walla.

PASSED by the City Council of the City of Walla Walla, Washington, on October 14, 2026.

_____
Mayor

Attest:

_____
City Clerk

Approved as to form

_____
City Attorney

ar-6059 **Pgs. 16-22**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Submitted For: Lisa Neissl, Support Services, City Clerk

Add'l Contributors:

Information

ITEM TITLE:

Approves the minutes of the September 21, 2026 Work Session and the September 23, 2026 Regular Meeting.

Attachments

09-21-2026 Minutes

09-23-2026 Minutes

D R A F T

WALLA WALLA CITY COUNCIL
Work Session Minutes
September 21, 2026

1. CALL TO ORDER - Mayor Reyna called the meeting to order at 5:00 p.m.

Present:	Councilmember Rick Eskil; Councilmember Rodney Outlaw; Mayor Gustavo Reyna; Councilmember Monte A. Willis; Councilmember Jeffrey Robinson; Councilmember Emily Brown; Councilmember/Mayor Pro Tempore Steve Moss
City Staff in attendance:	Elizabeth Chamberlain, City Manager; Preston Frederickson, Deputy City Manager; Tim Donaldson, City Attorney; Emily Arteche, Deputy Director Development Services; Jon Maland, Senior Planner; Lisa Wasson-Seilo, Planner; Lisa Neissl, City Clerk
Attendees:	Nell Lund, Principal, Senior Ecologist, Facet

2. ACTIVE AGENDA

A. 2026 Draft Implementing 2046 Comprehensive Plan and Critical Areas Ordinance Code Amendments

Staff and consultant gave presentations on implementing the 2046 Comprehensive Plan and the Critical Areas Ordinance code amendments.
There was discussion including:

- An overview of the September 14th Planning Commission meeting including their motion and vote.
- The State required Critical Areas Ordinance applies to both GMA (Growth Management Act) and non-GMA planning communities.
- Options, if any, for deviation from the Best Available Science (BAS) provided by the State.
    - Scientific analysis to back up protection of critical areas.
    - Critical area report which may be an additional expense for the property owner or developer.
- How BAS is determined - Years of study and peer review.
- The current proposal includes deviation options such as disconnected buffers and reasonable use exceptions.
- The need for a clear definition of what a reasonable use is.
- Potential exception for infill.
- State requirement to protect critical areas - WAC 365-195-485
- Debate over the 100' buffer which is set to have a natural filter to keep pollutants out of critical areas.
- Number of properties that may be impacted by the new buffer requirement.
- The GIS study showed 70% of current critical areas can be improved by the increased buffer.
- The new code will not impact established use of existing properties, buildings, and landscape.
- The new code will impact new development and redevelopment of properties.
- Fencing is listed in the new code as specifically allowed.
- The CAO Ordinance is required to meet GMA compliance.
- Impacts of not meeting GMA compliance, such as many grants the city receives, require GMA compliance.
- Timing and ways of communication about the CAO have been provided for the community.
- Next steps are currently scheduled for public hearing on October 14th and action on October 28th.
- The feasibility of asking for an extension as implementation is supposed to be done by December 31, 2026.
- The need to balance critical areas with needed infill housing.
- Staff confirmed the buffer is not going to impact the buildable land analysis for the Comprehensive Plan.
- Unfunded mandates from the State.

3. MEETING ENDS - There being no further business, the meeting ended at 6:56 p.m.

Approved: Attest:

_____ _____

Mayor City Clerk

D R A F T

WALLA WALLA CITY COUNCIL
Regular Meeting Minutes
September 23, 2026

1. **CALL TO ORDER** - Mayor Reyna called the meeting to order at 6:30 p.m.

Present: Councilmember Rick Eskil; Councilmember Rodney Outlaw; Mayor Gustavo Reyna; Councilmember Monte A. Willis; Councilmember Jeffrey Robinson; Councilmember Emily Brown; Councilmember/Mayor Pro Tempore Steve Moss

City Staff in attendance: Elizabeth Chamberlain, City Manager; Preston Frederickson, Deputy City Manager; Tim Donaldson, City Attorney; Chris Buttice, Police Chief; Esther Click, Public Safety Communications Manager; Ki Bealey, Public Works Director; Lisa Neissl, City Clerk

2. **PLEDGE OF ALLEGIANCE**

3. **PUBLIC COMMENTS:**

The following people expressed their concerns with the proposed Critical Areas Ordinance, specifically the effect the increased riparian buffer may have on their property values, resale values, and ability to develop additional housing or replacement housing in the event of a disaster. Barbara Knudson, Vicki McClellan, Ron McKay, Douglas DeMers, Stephen Zilliox, and Mary Gipson.
Sharon Schiller spoke about how comments are received and the obligations of representatives. Paul Lynn spoke about his own public comments and consideration for his research and input. R.L. McFarland spoke about communication and transparency and letters to and from Tim Donaldson.

4. **CONSENT AGENDA -** Staff introduced consent agenda items A through D as follows:

A. Resolution 2026-079: Authorizes an Interlocal agreement regarding the 2026 Edward Byrne Memorial Justice Assistance Grant between the City of Walla Walla and Walla Walla County.

B. Resolution 2026-080: Authorizes a professional services contract with Consor Engineers to amend the Water System Plan and develop a Watershed Control Program for the watershed in the amount of $74,144. - *Moved to Active A-1*

C. Resolution 2026-081: Authorizes a construction contract with Precision Concrete Cutting for the 2026 Sidewalk Grinding Project to reduce sidewalk tripping hazards in the amount of $65,618.44.

D. Approves the minutes of the September 9, 2026, Regular Meeting.

At the request of council, item B was moved to the active agenda.
Staff provided information on item A.

Moved by Councilmember Jeffrey Robinson, **seconded by** Councilmember/Mayor Pro Tempore Steve Moss **to approve the consent agenda as amended.**

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

7 - 0 Carried - Unanimously

5. **ACTIVE AGENDA**

A 1. Resolution 2026-080: Authorizes a professional services contract with Consor Engineers to amend the Water System Plan and develop a Watershed Control Program for the watershed in the amount of $74,144. - *Formerly Consent Item B*

Staff provided information on the proposed contract to amend the Water System Plan and develop a Watershed Control Program.
Public Comment: The following people expressed concerns of both items being combined into one contract and requested they be separated as their concerns lay with the amendment to the water system plan to include the MC Gateway property into the water service area. Dan Clark, Dorothy Obrien, R.L.McFarland, Charles Harney, Douglas DeMers, Jerry Norquist, Paul Lynn, Anna, Linda Herbert. Jake Coburn noted that the city is obligated to plan for services to properties in the city limits per the Growth Management Act. Jean Dahling spoke about waterways, floods and riparian areas.
There was discussion including:

- Opposition to the MC Gateway project and the history of that project originally getting water from the Port of Walla Walla.
- Costs and logistics of extending sewer services.
- Options to split the two items and legal concerns, if any, of not extending the water system plan at this time.

- Differences in water usage for this development or other developments.
- Importance of providing water for fire protection.
- The property owner transfer of water rights for irrigation purposes, which is outside the city's oversight.
- If the city can require specific types of drought-tolerant landscaping.
- City Manager authority for agreements.
- Savings by combining the two projects including costs, staff time, and efficiency.
- Process for the water system plan if removed from this contract.
- Development costs and who is responsible for the costs.
- The Watershed Control Program is a Washington Administrative Code requirement.

Moved by Councilmember Monte A. Willis, **seconded by** Councilmember Jeffrey Robinson **to approve the Watershed Control Program contract with Consor.**

Clerk Note: Resolution 2026-080 is to be revised to remove the water system plan portion of this contract.

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

7 - 0 Carried - Unanimously

A 2. Resolution 2026-082: Authorizes a Professional Services Contract with MJ Neal Associates, Architects, PLLC in an amount not to exceed $214,700.

Staff provided information on the proposed contract with MJ Neal Associates.
There was discussion including:

- The move would enable the dispatch center to continue operations in the event of an emergency / natural disaster.
- The RFP (Request for Proposals) process that was completed for this contract.
- The potential to relocate to a building at WW Community College Technology Building.
- The contract would determine if the plan is financially feasible.
- The consultant would provide a schematic design and perform lots of studies on an expedited timeline, finishing by the end of the year.
- The funding comes from the WESCOM budget, which is a user shared fund, and not from the city general fund.

Mayor Reyna inquired with the City Attorney if he should abstain due to his position on the WW Community College Board. It was clarified that there is not any conflict of interest as there is no financial benefit involved.

Moved by Councilmember/Mayor Pro Tempore Steve Moss, **seconded by** Councilmember Jeffrey Robinson **to approve Resolution 2026-082 authorizing a Professional Services Contract with MJ Neal Associates, Architects, PLLC in an amount not to exceed $214,700.**

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

7 - 0 Carried - Unanimously

B. Resolution 2026-083: Authorizes applying for and accepting a Water Quality Combined Funding Program loan for up to $8 million fo wastewater system improvements.

Staff provided information on the proposed loan application for wastewater system improvements, including interest rate and potential for some hardship loan forgiveness.
Public Comment: Paul Lynn commented about issues that people living adjacent to the wastewater treatment plant endure.
There was discussion including:

- The age of the wastewater treatment plant, its current condition, and the need for improvements.
- Various aspects that this loan of 8 million dollars would fund.
- This application would be for the maximum allowed amount.
- This funding will not provide a full overhaul of the plant as it is a very large and complex facility.
- The terms typically are dictated by the life of the asset being funded.
- The loan will impact the rate calculations in the financial planning.

Moved by Councilmember Jeffrey Robinson, **seconded by** Councilmember/Mayor Pro Tempore Steve Moss **to approve Resolution 2026-083 authorizing applying for and accepting a Water Quality Combined Funding Program loan for up to $8 million for wastewater system improvements.**

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

7 - 0 Carried - Unanimously

C. Resolution 2026-084: Authorizes a professional service contract amendment (No. 1) with David Evans & Associates, Inc., for construction phase services on the Poplar Street (5th-14th) Project in the amount of $1,695,312.

Staff provided information on the proposed contract amendment to continue the engineering services through the construction phase of the project.
There was discussion including:

- The difference between the RFQ (Request for Qualifications) and the bid process.
- The construction phase is expected to be two years.
- There is lots of grant funding for this project which increases the administrative work for the engineering consultant.
- It is standard to continue with the same firm for design engineering and in construction services.
- Federal grants create a considerable amount of additional administrative work.
- This contract is time and materials with a not-to-exceed amount.

Moved by Councilmember/Mayor Pro Tempore Steve Moss, **seconded by** Councilmember Rodney Outlaw **to approve Resolution 2026-084 authorizing a professional service contract amendment (No. 1) with David Evans & Associates, Inc., for construction phase services on the Poplar Street (5th-14th) Project in the amount of $1,695,312.**

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

7 - 0 Carried - Unanimously

D. Resolution 2026-085: Authorizes a contract with RH2 Engineering, Inc. for on-call water engineering support services in the amount of $50,000 per year (2026-2029).

Staff provided information and there was some discussion on the contract which replaces a current contract to separate out a generator project from general on-call work. The City Manager's authority is for amendments, just in case. Typically these services are used for less than $50,000 per year.

Moved by Councilmember Rick Eskil, **seconded by** Councilmember/Mayor Pro Tempore Steve Moss **to approve Resolution 2026-085 authorizing a contract with RH2 Engineering, Inc. for on-call water engineering support services in the amount up to $50,000 per year (2026-2029).**

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

No: Councilmember Monte A. Willis

6 - 1 Carried

E. Review and take action on submitting a City Comment Letter on the Draft Environmental Impact Statement Blue Mountain Forest Plan Revision

Staff provided information on the draft letter commenting on the Draft Environmental Impact Statement Blue Mountain Forest Plan Revision.
A revised map and comments emailed earlier from Councilmember Brown were provided to everyone on the dias.
Public Comment: Paul Lynn expressed concerns with the drafted letter and offered one he wrote as a potential replacement. The following people expressed concerns with the letter and supported the use of the letter provided by Mr. Lynn. Dan Clark, Linda Herbert, Jean Dahling, Jerry Norquist, Anna, and R.L. McFarland urged council to listen to the comments from the public.
There was discussion including:

- What may happen if we do not send a letter?
- A letter may be necessary to preserve rights later as this is a draft stage of the Environmental Impact Statement.
- The city should send a letter to preserve the right to object later.
- The importance of communication and how people may all care, but in different ways.

Moved by Councilmember/Mayor Pro Tempore Steve Moss, **seconded by** Councilmember Rodney Outlaw **to have Councilmembers Willis, Reyna, and Brown work with the City Attorney and staff to draft a letter from information provided at this meeting and submit it by the deadline on behalf of the City Council.**
There was some additional discussion.

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

7 - 0 Carried - Unanimously

F. Approves the Minutes of the September 8, 2026 Work Session (Councilmembers Outlaw and Willis to abstain).

Moved by Councilmember/Mayor Pro Tempore Steve Moss, **seconded by** Councilmember Emily Brown **to approve the Minutes of the September 8, 2026, Work Session.**

Yes: Councilmember Rick Eskil, Mayor Gustavo Reyna, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

5 - 0 Carried

Moved by Councilmember/Mayor Pro Tempore Steve Moss, **seconded by** Councilmember Jeffrey Robinson **to extend the meeting beyond 9:30 if necessary.**

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

7 - 0 Carried - Unanimously

G. Approve the August 2026 Accounts Payable Register.

Moved by Councilmember/Mayor Pro Tempore Steve Moss, **seconded by** Councilmember Monte A. Willis **to accept the August 2026 accounts payable register totaling $5,865,733.02, except for the following check numbers: 38137 to the Blue Mountain Action Council for $90.00**

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

7 - 0 Carried - Unanimously

Moved by Councilmember/Mayor Pro Tempore Steve Moss, **seconded by** Councilmember Rodney Outlaw **to approve the payment of check number 38137 to the Blue Mountain Action Council, with Mayor Reyna abstaining.**

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

6 - 0 Carried

H. Approve the August 2026 Payroll and Benefits Transactions.

Moved by Councilmember/Mayor Pro Tempore Steve Moss, **seconded by** Councilmember Emily Brown **to approve the Payroll Register certification for the August 31, 2026, pay period.**

Yes: Councilmember Rick Eskil, Councilmember Rodney Outlaw, Mayor Gustavo Reyna, Councilmember Monte A. Willis, Councilmember Jeffrey Robinson, Councilmember Emily Brown, Councilmember/Mayor Pro Tempore Steve Moss

7 - 0 Carried - Unanimously

6. COUNCIL MEMBER MEETING REPORTS

Councilmember Robinson reported attendance at the following:
The work session, and the CDBG Advisory Group meeting.
Councilmember Eskil reported attendance at the following:
The work session, the Blue Mt. Humane Society Board meeting, a meeting with Deputy City Manager Fredrickson and City Manager Chamberlain, watched the Planning Commission public hearing online, and the Port Economic information update.
Councilmember Willis reported attendance at the following:
The work session, and two Finance Committee meetings.
Councilmember Brown reported attendance at the following:
The work session, the Water/Wastewater Advisory Committee meeting, the Valley Transit Board meeting, the Port Economic information update, and a meeting with Port Commissioner Kelly and BMAC staff.
Councilmember Outlaw reported attendance at the following:
The work session.
Councilmember Moss reported attendance at the following:
The work session, the agenda setting, the Valley Transit Board meeting, and two Finance Committee meetings.
Mayor Reyna reported attendance at the following:
The work session, the agenda setting, the Blue Mountain Action Council Board meeting, two Finance Committee meetings, a meeting with community leaders, and the Port Economic information update.

7. UNFINISHED AND NEW BUSINESS

Council provided R.L. McFarland with the opportunity to finish his public comment regarding letters between his attorney and City Attorney Donaldson.
(City Attorney Donaldson told him that the letters had been provided to all council members.)

There was discussion on the Critical Areas Ordinance and comments received by the public including:

- The status of an extension.
- The need for an accessible map before the public hearing.
- Staff is working on an FAQ list to help clarify the meaning of reasonable use.
- How many other agencies are rejecting the CAO, and what is happening to them as a result?
- Can we collaborate with other agencies to pressure the legislature?
- There is likely to be a risk for grant funding if we're not compliant with the Growth Management Act.
- Unfunded mandates by the legislature.
- The specifics on the Planning Commission recommendation.
- MRSC links for examples of reasonable use exceptions from other cities.
- The public hearing is planned for October 14th at 6:30 p.m. on this matter.

8. MEETING ENDS - There being no further business, the meeting ended at 9:42 p.m.

Approved:

Attest:

_____
Mayor

_____
City Clerk

ar-6058 **Pgs. 23-57**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: CDBG 2025 Consolidated Review Public Hearing

Submitted For: Dani Dolphin, Development Services Department, Community Development Programs

Financial Comments:

N/A

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

A brief presentation will be shared with City Council and the public regarding the 2025 Consolidated Annual Performance Evaluation Review followed by a Public Hearing seeking public comment.

Information

HISTORY:

In 2013, the US Department of Housing and Urban Development (HUD) formally notified the City of its "...status as a potential entitlement under the Community Development Block Grant (CDBG) program and eligibility." In 2014, the City of Walla Walla approved its first 5-year Consolidated Plan and started receiving an annual allocation of Community Development Block Grant (CDBG) funds from HUD. In accordance with federal guidelines, CDBG funds are provided to projects that meet a national objective and carry out an eligible activity.

On June 26, 2024, the third 5-year Consolidated Plan (2024-2028) was approved through Resolution 2024-067.

The public was informed and given the opportunity to comment on the 2025 CAPER:

- The CAPER document and information on the corresponding public hearing were published on the City's CDBG webpage and sent out to individuals who had signed up for the CDBG listserv on June 25th, 2025
- Information regarding the CAPER document and public hearing was posted in City Hall and on the City's Facebook and neighborhood social media platform, Nextdoor, on September 25th, 2026.
- The CAPER document was published in the local newspaper, the Union Bulletin, on September 26th, 2026
- A 15-day comment period began on September 27th, 2026 and ended on October 12th, 2026.

POLICY ISSUES:

CDBG funds are administered by the City's Support Services Department. The CDBG allocation must focus on projects benefiting low-and moderate-income persons and neighborhoods. Towards that end, the City's 2024-2028 CDBG Consolidated Plan includes a needs assessment and market analysis outlining levels of need in the areas of affordable housing, homelessness, special needs, and community development. This information forms the basis of a strategic plan to address priority needs given available funding and local capacity to carry out the activities over the five-year period. Development of the CDBG Consolidated Plan and each subsequent Annual Action Plan is guided by a Resident Participation Plan (RPP) to provide for and encourage broad citizen involvement in the development of the CDBG funding priorities, substantial amendments to the CDBG Plans, and performance and evaluation reporting.

The 2025 Annual Action Plan reflected the priorities and needs identified in the 2024-2028 Consolidated Plan. The 2025 CAPER provides a review to ensure that the funds are being expended following the Annual Action Plan and Consolidated Plan goals. The 2025 CAPER is attached to this agenda report.

This public hearing requires no action.

PLAN COMPLIANCE:

STRATEGIC PLAN:
Livability Objective 1: Addressing the housing needs within the community
Initiative: Continued implementation of the Regional Housing Action Plan recommendations

Economic Health Objective 1: Collaborate with local and regional partners to achieve economic resilience in the Walla Walla Valley.
Initiative: Support community partners on addressing the childcare shortages through collaborating with licensed providers on creative solutions.

COMPREHENSIVE PLAN:
Community Character Goal 6: Walla Walla adds new and attractive features to its historic qualities as it grows.
CC Policy 6.1: Assure adequate code enforcement to protect safety and attractiveness of the City.

Land Use Goal 2: Walla Walla coordinates with neighboring communities and state agencies for the improvement of the region.
LU Policy 2.6: Cooperate regionally on the development and siting of essential public facilities to ensure that the burden, impact, and benefit is equitably distributed among neighboring communities.

Land Use Goal 3: There are a variety of uses allowed throughout Walla Walla that encourage options for housing and business.
LU Policy 3.7: Support a variety of housing types such as tiny homes, duplexes, multi-family development, cottage housing, and single family residential.

Housing Goal 1: A broad range of housing choices is available to meet the needs of people of diverse socioeconomic status, household type, and age.
H Policy 1.1: Provide an array of housing choices such as apartments, small lot single-family housing, accessory dwelling units, townhomes, manufactured homes, and cottages to meet the needs of people of all incomes throughout their lifespan.

Housing Goal 2: Attractive and functional neighborhoods are welcoming to all types of households.
H Policy 2.1: Integrate housing for lower and moderate income households and those with special needs into a variety of geographical locations throughout the city.

Parks and Recreation Goal 1: Walla Walla has a system of quality parks and recreational facilities that enhance the quality of life, develop economic opportunities, and meet the community's growing needs.
PR Policy 1.2: Provide a variety of recreational facilities and opportunities to make recreation more accessible, attainable, and attractive for all ages and abilities of users, and to build a sense of community.
PR Policy 1.3: Provide adequate funding to support new parks, recreation programs, and urban forestry programs and to maintain the existing facilities. Explore the implementation of a Park Impact Fee and identify cost sharing opportunities to fund parks and recreation projects.
PR Policy 1.10: Explore and leverage public/private partnerships and other non-traditional sources for recreational opportunities, facilities, and funding.

ALTERNATIVES:
Not Applicable

STAFF RECOMMENDATION:
No action required by City Council, this is a public hearing only.

CITY MANAGER COMMENTS:
Approved to hold a public hearing.

Attachments

2025 CDBG Consolidated Annual Performance and Evaluation Report (CAPER)

Development Services Department
Community Development Block Grant Program
55 E Moore St.
Walla Walla, WA 99362
(509) 524-4496
ddolphin@wallawallawa.gov

CR-05 - Goals and Outcomes

Progress the jurisdiction has made in implementing its strategic plan and action plan. 91.520(a)

Program Year 2025 is the second year of the City of Walla Walla's 2024-2028 Five-Year Consolidated Plan. The Program Year runs from April 1st, 2025, through March 31st, 2026. Three projects from previous Program Years were finalized during PY2025. The 2024 Coordinated Entry project was completed in December 2025, the 2023 Homeless Assistance project in April 2025, and the 2022 Home Repair - Bandra Drive project in May 2025. CDBG funds from 2025 continue to support affordable and accessible housing, community development, and basic and economic needs. Accomplishment data is not yet available for three of the four projects due to unexpected requirements, concurrent construction at project locations, and turnover with CDBG staff. Delays in project accomplishments can also be attributed to the delay in HUD funds, as contracts with partner organizations were signed in October 2025 (Development Services), and two were signed in March of 2026 (H4H and Walla Walla School District).

The Homeowner Assistance Project, in partnership with Habitat for Humanity Tri-County Partners (H4H), addresses the affordable and accessible housing goal with support for approximately seven low- and moderate-income families. The project includes construction of two duplexes and one triplex. The work includes public infrastructure improvements and new construction. H4H has completed the public infrastructure improvements, including the construction of a new private road. H4H also encountered delays due to an unexpected requirement from the City of Walla Walla's to establish an HOA for a private road due to the road dimensions. Construction of affordable housing units will begin in Fall 2026 with the projected completion of all units by June 2028, as originally planned. Construction on the homes has not begun; therefore, accomplishment data is not yet available.

To address the community development goal, a partnership with Walla Walla School District was created to develop the Early Learning and Community Playgrounds. The project will serve approximately 40 families who will benefit from the proposed activities directly through their utilization of the early learning opportunities. Additionally, approximately 2,876 families in the census tract surrounding this project will also have access to this outdoor play area, albeit in a Census tract that is not low- and moderate- income. The project takes place at the Walla Walla Center for Children and Families. Due to a concurrent playground construction project funded by non-CDBG dollars, the construction of the Early Learning and Community Playgrounds has not started yet. The construction work will begin in October 2026, which means accomplishment data is not yet available.

The Neighborhood Cleanup project supports the basic and economic needs goal. The project provides funding for neighborhood clean-up projects to increase health and safety in neighborhoods that benefit low- and moderate-income Census block groups. Three clean-ups were completed during PY2025, but only two qualified for CDBG funding. One of the clean-ups was conducted in an area not categorized as LMI and

therefore was ineligible. Funding of $12,000 was obligated to the Neighborhood Clean-up project. The project has $6,990.13 in unliquidated obligated funds. An eligible clean-up is scheduled for October 2026, and the remaining funds will be used to support this project.

The Services for Unhoused Residents project to address the basic and economic needs goal did not move forward as anticipated. The project was canceled due to the rejection of funds by our community partner, Blue Mountain Action Council. The City shifted support to develop an Emergency Home Repair project in partnership with the City's Public Works Department. The Home Repair project is still in development, and therefore only administrative funds have been spent on developing cross-departmental partnerships and needs research. Turnover with CDBG staff also impacted the Home Repair Pilot program, as the project was not finalized before previous staff left the City.

Comparison of the proposed versus actual outcomes for each outcome measure submitted with the consolidated plan and explain, if applicable, why progress was not made toward meeting goals and objectives. 91.520(g)

Categories, priority levels, funding sources and amounts, outcomes/objectives, goal outcome indicators, units of measure, targets, actual outcomes/outputs, and percentage completed for each of the grantee's program year goals.

Goal	Category	Source / Amount	Indicator	Unit of Measure	Expected – Strategic Plan	Actual – Strategic Plan	Percent Complete	Expected – Program Year	Actual – Program Year	Percent Complete
Affordable and Accessible Housing	Affordable Housing Public Housing	CDBG: $	Rental units rehabilitated	Household Housing Unit	5	0	0.00%			
Affordable and Accessible Housing	Affordable Housing Public Housing	CDBG: $	Homeowner Housing Rehabilitated	Household Housing Unit	10	0	0.00%	1	0	0.00%
Affordable and Accessible Housing	Affordable Housing Public Housing	CDBG: $	Direct Financial Assistance to Homebuyers	Households Assisted	10	0	0.00%	8	0	0.00%
Affordable and Accessible Housing	Affordable Housing Public Housing	CDBG: $	Buildings Demolished	Buildings	1	0	0.00%			

Affordable and Accessible Housing	Affordable Housing Public Housing	CDBG: $	Other	Other	1	0	0.00%			
Basic and Economic Needs	Homeless Non-Homeless Special Needs Non-Housing Community Development	CDBG: $	Public service activities other than Low/Moderate Income Housing Benefit	Persons Assisted	5000	53	1.06%	1130	53	4.69%
Basic and Economic Needs	Homeless Non-Homeless Special Needs Non-Housing Community Development	CDBG: $	Homeless Person Overnight Shelter	Persons Assisted	0	0		0	0	
Community Development	Homeless Non-Homeless Special Needs Non-Housing Community Development	CDBG: $	Public Facility or Infrastructure Activities other than Low/Moderate Income Housing Benefit	Persons Assisted	8100	108	1.33%	40	108	270.00%
Community Development	Homeless Non-Homeless Special Needs Non-Housing Community Development	CDBG: $	Homeless Person Overnight Shelter	Persons Assisted	0	0		0	0	

Community Development	Homeless Non-Homeless Special Needs Non-Housing Community Development	CDBG: $	Overnight/Emergency Shelter/Transitional Housing Beds added	Beds	0	108		0	108	
Planning and Administration	Planning and administration	CDBG: $	Other	Other	1	1	100.00%	1	1	100.00%

Table 1 - Accomplishments – Program Year & Strategic Plan to Date

Assess how the jurisdiction's use of funds, particularly CDBG, addresses the priorities and specific objectives identified in the plan, giving special attention to the highest priority activities identified.

The use of CDBG funds directly addresses the priorities and objectives identified in the Consolidated Plan. In 2025, CDBG funds went toward Homeownership Assistance, which addresses priority need number one, affordable and accessible housing. The need for more affordable housing of all types is the highest priority as determined through the housing market analysis, feedback from community partners, and citizen participation. The multi-year project will continue in 2026, creating housing to support LMI community members. Dedicating public service funds to support neighborhood clean-ups improves the health and safety of LMI neighborhoods. The allocation of funds to this project is consistent with priorities two and three, basic and economic needs and suitable living environments. The Early Learning and Community Playgrounds also addresses the suitable living environments priority and associated community development goal through the development of a physical space that will impact the physical, social, and emotional well-being of individuals, households, and communities in the location.

CR-10 - Racial and Ethnic composition of families assisted

Describe the families assisted (including the racial and ethnic status of families assisted). 91.520(a)

	CDBG
White	159
Black or African American	1
Asian	0
American Indian or American Native	1
Native Hawaiian or Other Pacific Islander	0
Total	**161**
Hispanic	46
Not Hispanic	115

Table 2 – Table of assistance to racial and ethnic populations by source of funds

Narrative

Of the families served in 2025, 29% were Hispanic. Additionally, 71% of families served were non-Hispanic-White, slightly higher than our City's 65% non-Hispanic-White population. This calculation excludes multi-racial households and those of two different races. Additionally, this number does not reflect public infrastructure projects or neighborhood organization public services that focus specifically on communities with a high Hispanic population.

CR-15 - Resources and Investments 91.520(a)

Identify the resources made available

Source of Funds	Source	Resources Made Available	Amount Expended During Program Year
CDBG	public - federal	408,743	

Table 3 - Resources Made Available

Narrative

Identify the geographic distribution and location of investments

Target Area	Planned Percentage of Allocation	Actual Percentage of Allocation	Narrative Description
City Wide	100		

Table 4 – Identify the geographic distribution and location of investments

Narrative
N/A

Leveraging

Explain how federal funds leveraged additional resources (private, state, and local funds), including a description of how matching requirements were satisfied, as well as how any publicly owned land or property located within the jurisdiction was used to address the needs identified in the plan.

N/A

CR-20 - Affordable Housing 91.520(b)

Evaluation of the jurisdiction's progress in providing affordable housing, including the number and types of families served, the number of extremely low-income, low-income, moderate-income, and middle-income persons served.

	One-Year Goal	Actual
Number of Homeless households to be provided affordable housing units	0	0
Number of Non-Homeless households to be provided affordable housing units	10	0
Number of Special-Needs households to be provided affordable housing units	0	0
Total	**10**	**0**

Table 5 – Number of Households

	One-Year Goal	Actual
Number of households supported through Rental Assistance	0	0
Number of households supported through The Production of New Units	0	0
Number of households supported through Rehab of Existing Units	0	0
Number of households supported through Acquisition of Existing Units	0	0
Total	**0**	**0**

Table 6 – Number of Households Supported

Discuss the difference between goals and outcomes and problems encountered in meeting these goals.

Due to the delay in HUD funds, contracts with H4H were not signed until March 31st, 2026. H4H also encountered delays due to the City's requirement to establish an HOA for a private road due to the road dimensions. H4H has not created an HOA before and therefore needed to navigate a new process, which caused delays. Construction of affordable housing units will begin in Fall 2026 with the projected completion of all units by June 2028, as originally planned.

Discuss how these outcomes will impact future annual action plans.

Unclear how these outcomes may impact future annual action plans.

Include the number of extremely low-income, low-income, and moderate-income persons served by each activity where information on income by family size is required to determine the eligibility of the activity.

Number of Households Served	CDBG Actual	HOME Actual
Extremely Low-income	0	0
Low-income	0	0
Moderate-income	0	0
Total	**0**	**0**

Table 7 – Number of Households Served

Narrative Information

The non-homeless households that will receive affordable housing units are not yet determined. Our partner entity, H4H, is currently taking applications for the housing units and seeking connections with local organizations to find suitable low-income families. The Community Development Programs Coordinator will continue to support H4H in identifying eligible households for the housing units.

CR-25 - Homeless and Other Special Needs 91.220(d, e); 91.320(d, e); 91.520(c)

Evaluate the jurisdiction's progress in meeting its specific objectives for reducing and ending homelessness through:

Reaching out to homeless persons (especially unsheltered persons) and assessing their individual needs

In 2023, the CDBG program partnered with area agencies for outreach to our homeless population or individuals at risk of becoming homeless; those entities include the Blue Mountain Action Council Foodbank, the Walla Walla Community College food pantry, the Christian Aid Center, and the Walla Walla Homeless Alliance. With their help, 113 survey responses were gathered, of which 56 of the respondents self-identified as homeless.

Through this survey, the jurisdiction received information on their identified housing needs, the top five of which were a permanent place to live, help with paying rent, a safe place to live, help with a rent deposit, and help paying a utility bill. Respondents also identified services or support they or their family needed, the top five of which were help with getting food, finding a job, help with transportation, help with a legal problem, and a place to eat a meal.

The City participates in the local Continuum of Care and Council on Housing, whose goals are to address the needs of individuals and families experiencing homelessness. Additionally, the City continues involvement with the Walla Walla Alliance for the Homeless, who ensure accurate data entry in HMIS, track when housing placements are secured by their residents, and encourages participation in the Exit Homelessness program.

Addressing the emergency shelter and transitional housing needs of homeless persons

- The City of Walla Walla supported emergency shelter for the Christian Aid Center through a letter of support and through financial contributions of $250,000, in addition to CDBG funds, to go toward the expansion of their renovated shelter. The Christian Aid Center previously expanded capacity and has a 52-bed shelter available for women and children, which opened in 2018 and continues to operate.
- The City continues to support the Walla Walla Alliance for the Homeless (WWAH) and their emergency shelter. In 2024, the WWAH expanded their offering to include transitional housing, which the City also supported financially by funding 10 pallet shelters. The WWAH oversees a sleep site that consists of 31 Conestoga wagon huts that sleep roughly 40 people and have overflow capacity for up to 8 people.
- The first emergency shelter, The Loft, for youth ages 12-17 had its seventh fully operational year in 2025. Through Catholic Charities, a Homeless Youth Board meets regularly to discuss their prioritized needs and how best to address them and has tremendous success in robust participation. Additionally, funds have been confirmed to open a resource center for homeless youth.

- Waypoint, a transitional housing facility for persons dealing with mental health crises, opened in 2018 and continues to operate.
- The City of Walla Walla continues to support and explore efforts to increase affordable housing stock, transitional housing, and permanent supportive housing by participating in the Council on Housing, the local Continuum of Care oversight body.
- Walla Walla County provides funds to community entities able to provide emergency shelter during extreme weather events, and these entities are subject to change.
- The STAR Project helps connect individuals recently released from incarceration with housing and essential tools to successfully reintegrate into the community.

Helping low-income individuals and families avoid becoming homeless, especially extremely low-income individuals and families and those who are: likely to become homeless after being discharged from publicly funded institutions and systems of care (such as health care facilities, mental health facilities, foster care and other youth facilities, and corrections programs and institutions); and receiving assistance from public or private agencies that address housing, health, social services, employment, education, or youth needs.

- Blue Mountain Action Council provides Pro-Bono Legal Services which help individuals and families avoid becoming homeless by supporting them in understanding their leases and providing eviction services. BMAC also has a Systems of Care program for youth exiting public institutions to connect them to social services and housing.
- The YWCA of Walla Walla provides beds for women and their families who are experiencing domestic violence. While they are there, they have the opportunity to take classes provided by the YWCA that include everything from self-esteem to resume writing skills, ultimately graduating them with a new set of clothes for a job interview.
- The City has added a code enforcement position within the Planning Department. This position endeavors not only to cite violations but rather work with families to locate resources to ensure safe and accessible homes for their families.
- The Anchor Community Initiative continues to develop and, in 2020, completed the by-name list scorecard and achieved quality data. This initiative created a community-wide system that ensures youth experiencing homelessness or at risk of homelessness are quickly identified, monitored, and provided the needed assistance to secure housing – a yes-to-yes system. The City of Walla Walla is recognized at the state level for our successful cross-agency collaboration in this project.
- Monthly Housing Provider meetings continue to take place and provide a space for local providers to come together to discuss challenges, barriers, suggest ideas, and become more familiar with the struggles low-income families and individuals face while navigating the housing market. This meeting is a good example of multiple agencies coming together to identify who can best meet the needs of a particular client at any

given time.

- Comprehensive Healthcare, the primary local mental health provider, continued to operate a facility that is a 16-bed acute inpatient clinic, and 3 to 4 respite beds are also available.
- Due to the Coronavirus pandemic, the City received COVID-CV funds and partnered with the Blue Mountain Action Council to provide direct assistance to prevent low-income families from becoming homeless by paying for past-due rent, mortgage, and utility bills. This service is in direct response to the pandemic, and it continued through 2022, though it is not expected to continue on an ongoing basis.
- The City is actively exploring other alternatives to support families and individuals at risk of becoming homeless as they align with the goals identified in the Consolidated Plan.

Helping homeless persons (especially chronically homeless individuals and families, families with children, veterans and their families, and unaccompanied youth) make the transition to permanent housing and independent living, including shortening the period of time that individuals and families experience homelessness, facilitating access for homeless individuals and families to affordable housing units, and preventing individuals and families who were recently homeless from becoming homeless again.

- CDBG funded a Homeless Assistance Program in 2023, which includes case management for homeless individuals and families as well as those at risk of being homeless. This support is both helping with transition and continued success in living situations as well as supporting individuals and families to avoid becoming homeless again.
- The second code enforcement position the City maintains is within the Police Department, and this position interacts regularly with homeless individuals. Again, their highest goal is not only to cite violations but rather to work with individuals or families to locate resources to ensure safe and accessible homes.
- The City created a Community Paramedic position in 2021 within the Fire Department. Initially, this position was funded by the region's hospital, Providence St. Mary, and more recently supported by a Greater Columbia Accountable Community of Health and Emergency Medical Services Innovative grant.
- This position works with housed and unhoused individuals to identify resources to help them improve their situation, which in some instances is putting them in contact with case managers to help them become housed.
- The Walla Walla Alliance for the Homeless, as mentioned above, has added transitional housing options, which give individuals the opportunity to practice skills of home care and responsibility before transitioning them to independent living.

CR-30 - Public Housing 91.220(h); 91.320(j)

Actions taken to address the needs of public housing

Walla Walla Housing Authority is an independent, public corporation and HUD-designated "high performer." They administer federally, state, and privately funded housing assistance programs, including physical rental units and rental assistance programs. The City continues to be an active partner in support of its development and rehabilitation activities and works collaboratively to affirmatively further fair housing around the City.

Actions taken to encourage public housing residents to become more involved in management and participate in homeownership

The Walla Walla Housing Authority offers self-sufficiency and personal finance workshops to encourage participants in taking steps toward homeownership.

Actions taken to provide assistance to troubled PHAs

Not applicable

CR-35 - Other Actions 91.220(j)-(k); 91.320(i)-(j)

Actions taken to remove or ameliorate the negative effects of public policies that serve as barriers to affordable housing such as land use controls, tax policies affecting land, zoning ordinances, building codes, fees and charges, growth limitations, and policies affecting the return on residential investment. 91.220 (j); 91.320 (i)

In 2025, the City adopted code amendments to increase housing diversity such as middle housing and reduce parking minimums. The City now allows for up to two 1,000 sq. ft. ADUs per lot, and townhomes are now allowed in the Public Reserve Zone. The City changed off-street parking standards to reduce the number of parking spots required based on type and square footage in accordance with Senate Bill 5184. Creating more flexible parking mandates and reducing the number of spots required reduces the cost to produce larger developments, like apartment complexes and multifamily dwelling units. Notably, parking requirements for multifamily dwelling units were reduced from 1.5 to 0.5 per unit, and single-family and all other housing types in residential zones were reduced from 2 to one space per unit. Parking requirements were removed for affordable housing.

In 2023, the City specified that up to four residences per lot are permitted in the Neighborhood Residential zone; added “stacked flats” to the list of housing types allowed in residential areas; and for ADU’s, the City removed the requirement that ADU entrances could only be on the side or rear of the main house, increasing options for infill and increasing density. The City of Walla Walla also created protective zoning for manufactured home communities and increased opportunities for the placement of these communities in Walla Walla. Manufactured homes are shown to be some of the most affordable housing in the City of Walla Walla.

In 2022, the City of Walla Walla took several actions to protect and provide affordable housing. Measures include:

- Adopting building code standards for the construction of Tiny Houses.
- Modifying the definition of “family” to comply with state law and eliminate occupancy limit requirements for unrelated individuals.
- Increasing the allowable size of accessory dwelling units to 900 square feet and removing the minimum parking requirement for accessory dwelling units.
- Developing comprehensive plan and zoning code amendments to provide protective zoning for manufactured home communities and other related changes to the zoning code regarding the placement of manufactured homes within the City (such code changes were adopted in early 2023).

In 2021, an amendment was made to the City code to allow residential units on the first floor or above within the City's central commercial zone, which had previously only been allowed on the second floor. This zoning code amendment allows for existing hotels and motels to convert

their 1st-floor units to residential units, which previously would not have been allowed within the central commercial zone. This amendment allows for expanded affordable housing opportunities for underperforming hotels and motels and creates many additional one-bedroom or studio apartments.

In 2018, the City's zoning code was updated, implementing the goals and policies of the most recent Comprehensive Plan. The new code loosened residential zones, creating one neighborhood residential zone while eliminating minimum lot sizes and lot dimensions, changing maximum lot coverage, and adding new provisions for cottage housing and accessory dwelling units. Multifamily Residential development potential was also increased and established density requirements, increased allowed lot coverage and building height, reduced the level of review, and decreased parking code requirements. This is a very significant overhaul to the zoning code, and the City is in the process of monitoring the impact on housing development.

Actions taken to address obstacles to meeting underserved needs. 91.220(k); 91.320(j)
The City continues the dialogue with the public and service providers to ensure that City policies and practices are in concert with community efforts to overcome obstacles to employment and housing.

In 2024, City staff joined the Broadband Action Team to contribute to and support efforts to increase internet equity. The Team identified the connectivity and accessibility needs of the region. Connectivity needs within the City's jurisdiction are low.

The STAR Program is a local nonprofit that works with formerly incarcerated people who are transitioning back into the community. Additionally, they provide a Ready to Rent class that is available to the entire community, which is a 6-week course that guides participants through how to be successful renters.

The City created and continues to expand the Community Assistance Referral and Education Services (CARES) team to serve as a mobile integrated health care unit assisting at a patient's location, many of whom are homeless or struggling with substance use disorder.

The City also uses cross-department collaboration to hold Neighborhood Cleanups, increasing relationship building between neighbors as well as between neighbors and City staff. This increases safety and security in some of the City's lower-income neighborhoods.

Language barriers are addressed by holding public meetings in Spanish in low-income neighborhoods. Outreach material for the CDBG program is provided in English and Spanish in print and on the City's website. Interpretation is offered at public hearings and other CDBG-related public meetings. The City also updated its Title VI Plan, which included provisions for

Environmental Justice and Limited English Proficiency policies and procedures that apply to all City programs, services, and activities. The City has also updated the ADA Transition Plan to better serve the needs of people with disabilities throughout the City, specifically referring to the U.S. Department of Transportation's Transportation Disadvantaged Census Tract Data to make more informed and equitable decisions.

Actions taken to reduce lead-based paint hazards. 91.220(k); 91.320(j)
When undertaking housing rehab, the City will incorporate remediation of lead-based paint hazards, when conditions dictate. The City has partnered with Catholic Charities Eastern Washington to perform lead-based paint remediation and repainting of affordable veterans housing in 2027.

Actions taken to reduce the number of poverty-level families. 91.220(k); 91.320(j)
The City offers discounted utility payments for low-income families.

Actions taken to develop institutional structure. 91.220(k); 91.320(j)
Council on Housing, our area's Continuum of Care, successfully continues to increase inclusion and representation on its board and in decision-making. Additionally, the Council on Housing's work identified a need to increase communication between our behavioral health providers. The identified value of this regularly convening group has led to the formal formation of a new Behavioral Health Council as a standing committee of the Community Health Advisory Board.

Coordination of services and information sharing is facilitated by the Coordinated Entry System in Walla Walla and monthly Housing Provider meetings where service providers come together with the goal of sharing resources, information, and addressing their clients' challenges together.

Providence St. Mary Population Health Department is another partner actively working to support outreach and other efforts to address the needs of people experiencing homelessness and other low-income populations. They have a Community Health Worker whose job is to extend health education and outreach within our Latino communities and especially for low-income families.

The City continues to work with community partners in identifying which services are best delivered by which entity, public or private, in an efficient and cost-effective manner. Addressing the rising need for mental health and substance abuse services is part of the dialogue between City, county, and community partners, and how those needs can be addressed through supportive housing.

Actions taken to enhance coordination between public and private housing and social service agencies. 91.220(k); 91.320(j)

- BMAC leads the Coordinated Entry system and conducts intake at its main office and at

shelter sites in Walla Walla, including the Loft, Christian Aid Center, Walla Walla Alliance for the Homeless Sleep Center, and the YWCA. Intake can be conducted in English or Spanish.

- Regular monthly meetings of Housing Providers organized by the Walla Walla County Department of Community Health keep housing providers in the know of issues and struggles facing low-income individuals and families seeking housing.
- Blue Mountain Action Council, the local Community Action agency, continues to provide low-income housing and job training opportunities and administers a CDBG Public Service activity.
- Implementation of the Walla Walla County Homeless Housing Plan continues to be a community-wide, multi-agency effort that requires continual collaboration between the public sector and service providers.
- The CDBG Advisory Group brings together public and private housing representatives and representatives from the community to ensure housing and other social service needs are being planned in a way that is complementary to other ongoing community-wide housing and social service efforts.
- A housing- ad-hoc committee meets regularly to address how to make housing more affordable in Walla Walla through policy changes.
- The City of Walla Walla's Police Department has begun to hold quarterly Social Worker Networking events to foster comprehensive understanding of the various roles in the field, to enhance professional connections, and exchange knowledge within the social worker community.
- VITAL Wines funds the Community Health Worker position at Providence St. Mary's. VITAL has also funded a new Farmworker Engagement Coordinator at Blue Mountain Action Council to help with health and social service navigation.

Identify actions taken to overcome the effects of any impediments identified in the jurisdiction's analysis of impediments to fair housing choice. 91.520(a)

In 2024, the public library put together a display that was shared throughout the month of April, which is Fair Housing Month. It included information on what Fair Housing is, community partners who could help with housing issues, Fair Housing brochures and posters, and a list of resources for further research.

CR-40 - Monitoring 91.220 and 91.230

Describe the standards and procedures used to monitor activities carried out in furtherance of the plan and used to ensure long-term compliance with requirements of the programs involved, including minority business outreach and the comprehensive planning requirements.

The City of Walla Walla Advisory Board approved the CDBG Policy and Procedure manual, which guides the Community Development Programs (CDP) Coordinator and subrecipients. Similarly, our jurisdiction has a subrecipient monitoring plan which includes a checklist to measure compliance. Subrecipients will be monitored every year through desk monitoring or on-site monitoring. Additionally, technical assistance is provided as needed.

The CDBG Advisory Group meets to review the Annual CAPER and Action Plan and ensure they are in line with the Consolidated Plan. They also make recommendations to accomplish goals identified in the strategic plan and the action plan. The CDBG application process confirms eligibility and overall risk assessment.

All CDBG projects that go out for bid are published on the Washington State Office of Minority and Women's Business Enterprises site.

Subrecipients are required to submit progress reports updating the CDP Coordinator on project progress and impacts made. These allow us to fairly and accurately communicate our progress towards City and CDBG goals. Conversations with partners and grant subrecipients explore ways to ensure that the City captures how the CDBG grant is preventing homelessness.

Citizen Participation Plan 91.105(d); 91.115(d)

Describe the efforts to provide citizens with reasonable notice and an opportunity to comment on performance reports.

For the 2024 CAPER, the public was informed and allowed to review this document by:

- **The CAPER document was posted on the City website and CDBG page on September 25th, 2026, and was published in the local newspaper, the Union Bulletin, on September 26th, 2026.**
- **The CAPER document and information on the corresponding public hearing were sent out to individuals who had signed up for the CDBG listserv on September 25th, 2026.**
- **Information regarding the public hearing and the posted document was posted at City Hall and on the City's Facebook and neighborhood social media platform, Nextdoor, on September 25th, 2026.**
- **A 15-day comment period began on September 27th, 2026, and ended on October 12th, 2026.**

Comments from the comment period and the public hearing include:

CR-45 - CDBG 91.520(c)

Specify the nature of, and reasons for, any changes in the jurisdiction's program objectives and indications of how the jurisdiction would change its programs as a result of its experiences.

Previously, the home repair project was managed and administered through a partnership with the Blue Mountain Action Council. Due to increased resources required to meet federal requirements, the partnership was discontinued. The CDBG coordinator continues to develop a partnership with the City of Walla Walla's Public Works department to establish the Home Repair Pilot project and support LMI households with persistent sewer issues and delinquent accounts in order to meet our Affordable and Accessible Housing goal.

Does this Jurisdiction have any open Brownfields Economic Development Initiative (BEDI) grants?

No

[BEDI grantees] Describe accomplishments and program outcomes during the last year.

CR-58 – Section 3

Identify the number of individuals assisted and the types of assistance provided

Total Labor Hours	CDBG	HOME	ESG	HOPWA	HTF
Total Number of Activities	0	0	0	0	0
Total Labor Hours					
Total Section 3 Worker Hours					
Total Targeted Section 3 Worker Hours					

Table 8 – Total Labor Hours

Qualitative Efforts - Number of Activities by Program	CDBG	HOME	ESG	HOPWA	HTF
Outreach efforts to generate job applicants who are Public Housing Targeted Workers					
Outreach efforts to generate job applicants who are Other Funding Targeted Workers.					
Direct, on-the-job training (including apprenticeships).					
Indirect training such as arranging for, contracting for, or paying tuition for off-site training.					
Technical assistance to help Section 3 workers compete for jobs (e.g., resume assistance, coaching).					
Outreach efforts to identify and secure bids from Section 3 business concerns.					
Technical assistance to help Section 3 business concerns understand and bid on contracts.					
Division of contracts into smaller jobs to facilitate participation by Section 3 business concerns.					
Provided or connected residents with assistance in seeking employment, including: drafting resumes, preparing for interviews, finding job opportunities, connecting residents to job placement services.					
Held one or more job fairs.					
Provided or connected residents with supportive services that can provide direct services or referrals.					
Provided or connected residents with supportive services that provide one or more of the following: work readiness, health screenings, interview clothing, uniforms, test fees, transportation.					
Assisted residents with finding child care.					
Assisted residents to apply for, or attend, community college or a four-year educational institution.					
Assisted residents to apply for or attend vocational/technical training.					
Assisted residents to obtain financial literacy training and/or coaching.					
Bonding assistance, guaranties, or other efforts to support viable bids from Section 3 business concerns.					
Provided or connected residents with training on computer use or online technologies.					
Promoting the use of a business registry designed to create opportunities for disadvantaged and small businesses.					

Outreach, engagement, or referrals with the state one-stop system, as designed in Section 121(e)(2) of the Workforce Innovation and Opportunity Act.					
Other.					

Table 9 – Qualitative Efforts - Number of Activities by Program

Narrative

N/A

PART I: SUMMARY OF CDBG RESOURCES	
01 UNEXPENDED CDBG FUNDS AT END OF PREVIOUS PROGRAM YEAR	0.00
02 ENTITLEMENT GRANT	408,743.00
03 SURPLUS URBAN RENEWAL	0.00
04 SECTION 108 GUARANTEED LOAN FUNDS	0.00
05 CURRENT YEAR PROGRAM INCOME	0.00
05a CURRENT YEAR SECTION 108 PROGRAM INCOME (FOR SI TYPE)	0.00
06 FUNDS RETURNED TO THE LINE-OF-CREDIT	0.00
06a FUNDS RETURNED TO THE LOCAL CDBG ACCOUNT	0.00
07 ADJUSTMENT TO COMPUTE TOTAL AVAILABLE	0.00
08 TOTAL AVAILABLE (SUM, LINES 01-07)	408,743.00
PART II: SUMMARY OF CDBG EXPENDITURES	
09 DISBURSEMENTS OTHER THAN SECTION 108 REPAYMENTS AND PLANNING/ADMINISTRATION	95,879.50
10 ADJUSTMENT TO COMPUTE TOTAL AMOUNT SUBJECT TO LOW/MOD BENEFIT	0.00
11 AMOUNT SUBJECT TO LOW/MOD BENEFIT (LINE 09 + LINE 10)	95,879.50
12 DISBURSED IN IDIS FOR PLANNING/ADMINISTRATION	81,748.00
13 DISBURSED IN IDIS FOR SECTION 108 REPAYMENTS	0.00
14 ADJUSTMENT TO COMPUTE TOTAL EXPENDITURES	0.00
15 TOTAL EXPENDITURES (SUM, LINES 11-14)	177,627.50
16 UNEXPENDED BALANCE (LINE 08 - LINE 15)	231,115.50
PART III: LOWMOD BENEFIT THIS REPORTING PERIOD	
17 EXPENDED FOR LOW/MOD HOUSING IN SPECIAL AREAS	0.00
18 EXPENDED FOR LOW/MOD MULTI-UNIT HOUSING	0.00
19 DISBURSED FOR OTHER LOW/MOD ACTIVITIES	95,879.50
20 ADJUSTMENT TO COMPUTE TOTAL LOW/MOD CREDIT	0.00
21 TOTAL LOW/MOD CREDIT (SUM, LINES 17-20)	95,879.50
22 PERCENT LOW/MOD CREDIT (LINE 21/LINE 11)	100.00%
LOW/MOD BENEFIT FOR MULTI-YEAR CERTIFICATIONS	
23 PROGRAM YEARS(PY) COVERED IN CERTIFICATION	PY: 0 PY: 0 PY: 0
24 CUMULATIVE NET EXPENDITURES SUBJECT TO LOW/MOD BENEFIT CALCULATION	0.00
25 CUMULATIVE EXPENDITURES BENEFITING LOW/MOD PERSONS	0.00
26 PERCENT BENEFIT TO LOW/MOD PERSONS (LINE 25/LINE 24)	0.00%
PART IV: PUBLIC SERVICE (PS) CAP CALCULATIONS	
27 DISBURSED IN IDIS FOR PUBLIC SERVICES	67,371.47
28 PS UNLIQUIDATED OBLIGATIONS AT END OF CURRENT PROGRAM YEAR	6,990.13
29 PS UNLIQUIDATED OBLIGATIONS AT END OF PREVIOUS PROGRAM YEAR	55,253.43
30 ADJUSTMENT TO COMPUTE TOTAL PS OBLIGATIONS	0.00
31 TOTAL PS OBLIGATIONS (LINE 27 + LINE 28 - LINE 29 + LINE 30)	19,108.17
32 ENTITLEMENT GRANT	408,743.00
33 PRIOR YEAR PROGRAM INCOME	0.00
34 ADJUSTMENT TO COMPUTE TOTAL SUBJECT TO PS CAP	0.00
35 TOTAL SUBJECT TO PS CAP (SUM, LINES 32-34)	408,743.00
36 PERCENT FUNDS OBLIGATED FOR PS ACTIVITIES (LINE 31/LINE 35)	4.67%
PART V: PLANNING AND ADMINISTRATION (PA) CAP	
37 DISBURSED IN IDIS FOR PLANNING/ADMINISTRATION	81,748.00
38 PA UNLIQUIDATED OBLIGATIONS AT END OF CURRENT PROGRAM YEAR	0.00
39 PA UNLIQUIDATED OBLIGATIONS AT END OF PREVIOUS PROGRAM YEAR	0.00
40 ADJUSTMENT TO COMPUTE TOTAL PA OBLIGATIONS	0.00
41 TOTAL PA OBLIGATIONS (LINE 37 + LINE 38 - LINE 39 +LINE 40)	81,748.00
42 ENTITLEMENT GRANT	408,743.00
43 CURRENT YEAR PROGRAM INCOME	0.00
44 ADJUSTMENT TO COMPUTE TOTAL SUBJECT TO PA CAP	0.00
45 TOTAL SUBJECT TO PA CAP (SUM, LINES 42-44)	408,743.00
46 PERCENT FUNDS OBLIGATED FOR PA ACTIVITIES (LINE 41/LINE 45)	20.00%

LINE 17 DETAIL: ACTIVITIES TO CONSIDER IN DETERMINING THE AMOUNT TO ENTER ON LINE 17

No data returned for this view. This might be because the applied filter excludes all data.

LINE 18 DETAIL: ACTIVITIES TO CONSIDER IN DETERMINING THE AMOUNT TO ENTER ON LINE 18

No data returned for this view. This might be because the applied filter excludes all data.

LINE 19 DETAIL: ACTIVITIES INCLUDED IN THE COMPUTATION OF LINE 19

Plan	IDIS	IDIS	Voucher	Activity Name	Matrix Code	National Objective	Drawn Amount
2024	3	150	7016391	Christian Aid Center Shelter Project	03C	LMC	$376.22
2024	3	150	7029454	Christian Aid Center Shelter Project	03C	LMC	$118.65
2024	3	150	7038442	Christian Aid Center Shelter Project	03C	LMC	$118.65
2024	3	150	7048393	Christian Aid Center Shelter Project	03C	LMC	$927.99
2024	3	150	7073225	Christian Aid Center Shelter Project	03C	LMC	$231.84
2024	3	150	7086590	Christian Aid Center Shelter Project	03C	LMC	$173.88
2024	3	150	7094841	Christian Aid Center Shelter Project	03C	LMC	$115.91
					03C	**Matrix Code**	**$2,063.14**
2023	4	132	7016452	Public Facility - Jefferson Park Shelter	03F	LMA	$266.99
					03F	**Matrix Code**	**$266.99**
2025	1	155	7118040	Early Learning and Community Playground	03M	LMC	$566.65
2025	1	155	7130675	Early Learning and Community Playground	03M	LMC	$59.55
2025	1	155	7155224	Early Learning and Community Playground	03M	LMC	$535.81
					03M	**Matrix Code**	**$1,162.01**
2025	5	158	7104548	Neighborhood Cleanups	05V	LMA	$4,953.21
2025	5	158	7118040	Neighborhood Cleanups	05V	LMA	$56.66

					05V	**Matrix Code**	**$5,009.87**
2023	5	147	7016452	Homeless Assistance Program	05Z	LMC	$4,840.55
2024	2	152	7016391	Public Service - Coordinated Entry	05Z	LMC	$2,724.27
2024	2	152	7029454	Public Service - Coordinated Entry	05Z	LMC	$4,418.23
2024	2	152	7048393	Public Service - Coordinated Entry	05Z	LMC	$8,964.49
2024	2	152	7073225	Public Service - Coordinated Entry	05Z	LMC	$26,633.42
2024	2	152	7077576	Public Service - Coordinated Entry	05Z	LMC	$115.91
2024	2	152	7086590	Public Service - Coordinated Entry	05Z	LMC	$5,347.48
2024	2	152	7094841	Public Service - Coordinated Entry	05Z	LMC	$4,876.18
2024	2	152	7116243	Public Service - Coordinated Entry	05Z	LMC	$3,435.28
2024	2	152	7118052	Public Service - Coordinated Entry	05Z	LMC	$886.71
2024	2	152	7130691	Public Service - Coordinated Entry	05Z	LMC	$119.08
					05Z	**Matrix Code**	**$62,361.60**
2025	2	156	7118040	Homeownership Assistance - H4H Peyton Lane	13B	LMH	$283.32
2025	2	156	7155224	Homeownership Assistance - H4H Peyton Lane	13B	LMH	$178.60
					13B	**Matrix Code**	**$461.92**
2022	1	154	7029452	Home Repair - Bandra Drive	14A	LMH	$20,998.16
					14A	**Matrix Code**	**$20,998.16**
2022	1	136	7029447	Rehabilitation Admin - Contract 2023	14H	LMC	$2,499.94
2022	1	136	7038409	Rehabilitation Admin - Contract 2023	14H	LMC	$139.25
2025	3	160	7118040	Home Repair Administration	14H	LMH	$169.99
2025	3	160	7130688	Home Repair Administration	14H	LMH	$119.08
2025	3	160	7140107	Home Repair Administration	14H	LMH	$329.86
2025	3	160	7153565	Home Repair Administration	14H	LMH	$297.69
					14H	**Matrix Code**	**$3,555.81**
Total							**$95,879.50**

LINE 27 DETAIL: ACTIVITIES INCLUDED IN THE COMPUTATION OF LINE 27

Plan Year	IDIS Project	IDIS Activity	Voucher Number	Activity to prevent	Activity Name	Grant Number	Fund Type	Matrix Code	National Objective	Drawn Amount
2025	5	158	7104548	No	Neighborhood Cleanups	B25MC530025	EN	05V	LMA	$4,953.21
2025	5	158	7118040	No	Neighborhood Cleanups	B25MC530025	EN	05V	LMA	$56.66
								05V	**Matrix Code**	**$5,009.87**
2023	5	147	7016452	No	Homeless Assistance Program	B23MC530025	EN	05Z	LMC	$4,840.55
2024	2	152	7016391	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$2,724.27
2024	2	152	7029454	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$4,418.23
2024	2	152	7048393	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$8,964.49
2024	2	152	7073225	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$26,633.42
2024	2	152	7077576	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$115.91
2024	2	152	7086590	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$5,347.48
2024	2	152	7094841	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$4,876.18
2024	2	152	7116243	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$3,435.28
2024	2	152	7118052	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$886.71
2024	2	152	7130691	No	Public Service - Coordinated Entry	B24MC530025	EN	05Z	LMC	$119.08
								05Z	**Matrix Code**	**$62,361.60**
				No	**Activity to prevent, prepare for, and respond to Coronavirus**					**$67,371.47**
Total										**$67,371.47**

LINE 37 DETAIL: ACTIVITIES INCLUDED IN THE COMPUTATION OF LINE 37

Plan Year	IDIS Project	IDIS Activity	Voucher Number	Activity Name	Matrix Code	National Objective	Drawn Amount
2025	6	157	7096590	Administration and Planning	21A		$81,748.00
					21A	**Matrix Code**	**$81,748.00**
Total							**$81,748.00**

DRAFT MEMO

TO Department of Housing and Urban Development (HUD)
FROM City of Walla Walla, Community Development Block Grant (CDBG) Program
DATE October 14, 2026
SUBJECT CDBG 2025 PR26 Adjustments

To whom it may concern:
As required for the submission of HUD's Consolidated Annual Performance and Evaluation Report (CAPER), the PR26 Report must be completed and submitted. This report demonstrates that the requirements of HUD are met, which include maintaining a cap on the use of funds toward public service and administration and planning.

Adjustments made to the 2025 PR26 are the following:

- Line 28 - Calculated by subtracting vouchers located on PR07 form
- A total of $5,009.87 was drawn from vouchers 7104548 and 7118040 for public services.
- $12,000 was obligated for the public service project, leaving $6,990.13 in unliquidated obligations at the end of the 2025 program year.
- Line 29 - Number brought over from the submitted 2024 PR26 Form.
- Line 31 – Recalculated line to account for changes to line 28 and 29.
- Line 36 – Recalculated line to account for changes to line 31.

With these adjustments, the City of Walla Walla CAPER is in full compliance with HUD's requirements.

Thank you,

Dani Dolphin
Community Development Programs Coordinator
City of Walla Walla

COMMUNITY DEVELOPMENT BLOCK GRANT

2025 CONSOLIDATED ANNUAL PERFORMANCE AND EVALUATION REPORT (CAPER)

Dani Dolphin
October 14, 2026
wallawallawa.gov

A WONDERFUL PLACE TO LIVE WORK PLAY

WHAT IS THE CAPER?

Overview:

- Required to report yearly accomplishments to HUD
  - Program Year: April 1st, 2025 – March 31st, 2026
- Share outcomes and encourage public participation

Performance:

- Ensure that annual and 5-year spending and activity goals are on target and being met

2024 CAPER: TAKE AWAYS

Public Services:

- Neighborhood Clean-ups: 254/250 Households
- Homeowner housing rehabilitated: 0/1 Households
  - Delay due to need for new partnership

Public facilities:

- Early Learning Outdoor Area: 0/40 Households
  - Delay due to concurrent construction project

Affordable Housing

- Direct financial assistance to homebuyers: 0/8 Households
  - Delay due to additional legal requirements

SUCCESSFUL PROJECTS

Neighborhood Clean-up







IN-PROGRESS PROJECTS

Habitat for Humanity Homeowner Assistance





Walla Walla Public Schools Early Learning Outdoor Area





*Homeowner Repair Pilot is still in the development phase

SUGGESTED READING

CR-25 – Homeless and Other Special Needs
CR-35 – Other Actions (to support affordable housing)

Example Prompts:

- Evaluate the jurisdiction's progress in… reducing and ending homelessness
- Actions taken to remove or ameliorate the negative effects of public policies that serve as barriers to affordable housing
- Actions taken to enhance coordination between public and private housing and social service agencies

THANK YOU!



Dani Dolphin
Community Development Programs Coordinator
ddolphin@wallawallawa.gov
509-524-4496

ar-6063 **Pgs. 58-88**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: Public Hearing on the Formation of the Woodlawn/Chestnut LID

Submitted For: Elizabeth Chamberlain, City Manager Office

Financial Comments:

$475,938 sewer extension cost estimate

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

Public Hearing on the formation of the Woodlawn/Chestnut LID

Information

HISTORY:

Background

The City met with property owners along Chestnut Street and Woodlawn about the extension of sewer and what that may look like. Options were discussed and a local improvement district (LID) was suggested by city staff as a path forward to finance the sewer extension needs for their properties. The City received a petition to form a local improvement district on June 15, 2026 (petition dated April 16, 2026). Reviewing the area of sewer extension and which properties are not currently connected to the sewer, the proposed LID boundary does include properties that have not signed the petition. The proposed LID would be for a sewer extension along Chestnut Street, Woodlawn Street, and Statesman Street for a total of 1,190 linear feet of 8" PVC sewer main (see attached map for detail).

Staff brought forward a resolution of intent to form a local improvement district based on the interest and support of seven property owners wanting to extend sewer to their properties. As noted above, staff recommended the inclusion of 4 additional properties into the proposed LID boundary that were logical to include based where the sewer would be extended. At the August 26, 2026 regular council meeting, the City Council adopted Resolution 2026-076 declaring the Council's intent to form a LID and set October 14, 2026 as the public hearing date.

Public Notice

A draft public notice was included with the adoption of Resolution 2026-075 and the notice template was followed. Individual notices were mailed to the affected property owners of record, as shown on the rolls of the county assessor, by the City Clerk on September 15, 2026. Also required is to publish the resolution within two consecutive editions of the city's designated official newspaper, the Union Bulletin. Those two consecutive publication days were September 19 and 22, 2026.

Staff has heard from the property owners that were included in the proposed LID but who did not sign the petition indicating support. The reason for the inclusion of those properties was to include properties that are in the vicinity of the proposed sewer extension and do construction once. There is no requirement that the four parcels added to the proposed boundary be included.

POLICY ISSUES:

RCW 35.43.-140-.150 outlines the process for a formation of an LID through the resolution of intent method.

City Council to conduct the public hearing at the regular council meeting on October 14, 2026 and take testimony regarding the formation of the proposed Woodlawn/Chestnut LID.

The sewer extension is exempt from SEPA under Walla Walla Municipal Code 21.08.180, which incorporates by reference WAC 197-11-800(23)(b). WAC 197-11-800(16) states that formation of an LID is exempt because it seeks to fund the construction of a facility (sewer extension) that is SEPA exempt. This has been confirmed by the Development Services Department on September 9, 2026.

PLAN COMPLIANCE:

COMPREHENSIVE PLAN:
Capital Facilities and Utilities Goal 2: Capital facilities and utilities are located in such a way as to provide safe and efficient service to all residents.

ALTERNATIVES:

1. Not form the LID and the property owners would be responsible to construct the improvements through an alternative financing method (outside the LID process).
2. Delay the improvements and formation of the LID until a later date.

STAFF RECOMMENDATION:

Conduct the public hearing and proceed with the formation of the Woodlawn/Chestnut LID with the original seven properties, currently scheduled for the November 18, 2026 regular meeting.

CITY MANAGER COMMENTS:

Concur with the staff recommendation.

Attachments

Draft ORD 26-XXX Woodlawn LID

Resolution 2026-075 Intent to Form LID and Set Public Hearing Date

Current Proposed LID Boundary

Engineers Estimate Proposed LID

Public Notice Certification

SEPA Exemption Determination

Parker Comment Letter

ORDINANCE NO. 2026-[__]

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF WALLA WALLA, WASHINGTON, DISPOSING OF ALL COMPLAINTS AND PROTESTS TO THE FORMATION OF A LOCAL IMPROVEMENT DISTRICT; CREATING LOCAL IMPROVEMENT DISTRICT NO. 2026-01 FOR THE PURPOSE OF ACQUIRING, CONSTRUCTING AND INSTALLING CERTAIN IMPROVEMENTS TO STREETS, SEWER FACILITIES AND WATER FACILITIES WITHIN THE BOUNDARIES OF SUCH DISTRICT; DESCRIBING THE AREA AND BOUNDARIES OF SUCH DISTRICT; PROVIDING FOR THE LETTING OF CONSTRUCTION BIDS AND THE DOING OF SUCH WORK BY CONTRACT; PROVIDING FOR THE PUBLICATION AND EFFECTIVE DATE OF THIS ORDINANCE; AND PROVIDING FOR OTHER MATTERS PROPERLY RELATED THERETO

CITY OF WALLA WALLA
Walla Walla County, Washington

LOCAL IMPROVEMENT DISTRICT NO. 2026-01

THE CITY COUNCIL OF THE CITY OF WALLA WALLA, WASHINGTON, DOES ORDAIN as follows:

WHEREAS, the City of Walla Walla, Washington (the "**City**"), is a code city duly organized and existing under and by virtue of the Constitution and the laws of the state of Washington (the "**State**");

WHEREAS, the City Council of the City (the "**Council**") has determined that it is advisable and necessary for the public health, safety and welfare to acquire, design, construct and install certain improvements to certain City streets, sewer and water facilities as provided in Section 3 hereof;

WHEREAS, the Council hereby determines that it is economically feasible to construct such improvements and that a local improvement district be created and assessments be levied therein to pay all or a portion of the costs of acquiring, designing, constructing and installing such improvements;

WHEREAS, the Council has determined that the most equitable way to finance such improvements is by the creation of a local improvement district;

WHEREAS, pursuant to Article VII, Section 9 of the Constitution of the state of Washington, and chapters 35A.43 and 35.43 RCW, the City is authorized to create local improvement districts for the purpose of financing certain improvements within the City;

WHEREAS, the Council adopted Resolution No. 2026-075 on August 26, 2026, specifying its intention to create a local improvement district to finance a portion of the costs of such improvements;

WHEREAS, Resolution No. 2026-075 was published in two consecutive issues of the City's official newspaper, with the first publication at least 15 days before the date of the formation hearing referenced below;

WHEREAS, estimates of the costs and expenses of the proposed improvements, a description of the boundaries of the local improvement district, a statement of what portion of the costs and expenses of the improvements would be borne by the property within the proposed local improvement district, and a diagram showing the lots, tracts and parcels to be benefited and other information pertaining to the proposed local improvement district, have been filed with the City Clerk and certified to the Council;

WHEREAS, notice of the hearing on the formation of the proposed local improvement district was given by mail to the owners or reputed owners (as shown on the tax rolls of the Walla Walla County Assessor) of all lots, tracts and parcels of land or other property to be specially benefited by the proposed improvements as provided by law;

WHEREAS, such hearing was held at 6:30 p.m. on October 14, 2026, in the Council Chambers at the Walla Walla City Hall, located at 15 North 3rd Avenue, Walla Walla, Washington;

WHEREAS, at such hearing City staff gave a presentation on the formation of the local improvement district, which included descriptions of the method of assessment, the parcels affected, the amount of the proposed assessments and the proposed improvements;

WHEREAS, at such hearing, all interested persons were given the opportunity to speak in favor of or to protest the formation of the local improvement district, and after due consideration thereof, the Council closed the hearing and determined to pass on all protests and objections at a regularly scheduled meeting on November 18, 2026;

WHEREAS, after due consideration of all protests and objections and the information presented by City staff, the Council has determined to create the local improvement district and order the improvements described herein; and

WHEREAS, the Council hereby finds that the method of assessment set forth in Resolution No. 2026-075 and in this Ordinance more fairly reflects the special benefits accruing on property within the local improvement district than does any other method of assessment;

NOW, THEREFORE, BE IT FURTHER ORDAINED as follows:

Section 1: Protests. The Council hereby passes upon all protests and objections for the reasons given in explanation and rebuttal to each protest or objection recorded in the proceedings of such hearing and the meeting of November 18, 2026, and hereby ratifies and confirms the action heretofore taken with respect to the protests and objections.

Section 2: Creation of Local Improvement District No. 2026-01. There is hereby established and created within the City a local improvement district to be known as Local Improvement District No. 2026-01 ("**LID 2026-01**"). All of the costs of the Improvements, as hereinafter defined, shall be assessed against the property within LID 2026-01.

Section 3: Improvements Ordered. The following improvements are hereby ordered:

(a) Sewer and street improvements along East Chestnut Street from its intersection with Statesman Street to 725 East Chestnut Street, along Woodlawn Street between 1031 Woodlawn Street and 1111 Woodlawn Street, and along Statesman Street from its intersection with East Chestnut Street to 1032 Statesman Street;

(b) such other work as may be necessary in conjunction with the development, including construction, reconstruction, repair or renewal of drains, sewers, sewer appurtenances, underground and above-ground utilities, roadways, landscaping, pedestrian enhancement, streetscape, lighting, traffic safety and drainage, architectural, engineering, surveying, supervision, and inspection for the design and installation of the aforesaid improvements;

(c) the cost of all legal, municipal advisor, administrative and other miscellaneous expenses; and

(d) other work as may be necessary in conjunction with the development of LID 2026-01 (collectively, the "**Improvements**").

The plans for the acquisition, design, construction and installation of the Improvements shall be subject to changes as to detail as such changes shall be authorized by the Council either prior to or during the course of construction. The City shall acquire by gift, purchase, franchise, lease or condemnation all property, both real and personal or any interest therein and all right-of-way, franchises, permits and easements which may be found necessary to acquire, construct and install the Improvements.

The Improvements listed above will be located within the City and shall be constructed and installed within LID 2026-01. The Improvements are more fully described in the preliminary maps, plans and specifications (the "**Plans**"), as prepared by the City's Engineer and filed in the office of the City Clerk. The Plans shall be subject to such changes as to detail, as such changes shall be authorized by the Council either prior to or during the course of construction.

Section 4: Description of LID 2026-01 Boundaries. The boundaries of LID 2026-01 shall be as set forth in Exhibit "A" to this Ordinance, which is hereby incorporated herein by reference. It is hereby found that such boundaries embrace as nearly as practicable all property that will be specially benefited by the Improvements.

Section 5: Payment of Costs. There is hereby created a fund of the City to be known as the "Local Improvement District No. 2026-01 Fund" for the purpose of paying the cost of the Improvements provided for in this Ordinance and into which there shall be paid all of the assessments collected in LID 2026-01 as and when directed by ordinance of the City.

Section 6: Method of Assessment. As provided for in RCW 35.44.047, the properties within LID 2026-01 shall be assessed by a method or combination of methods which fairly reflects the special benefits to be derived from the improvement.

Section 7: Construction Bids. The Public Works Director is hereby directed to advertise for bids for the acquisition, construction and installation of the Improvements, reserving to the City the right to reject any and all bids. In the event a satisfactory bid is received and accepted, the contract for the Improvements shall provide that the same shall be completed and all things done in accordance with the Plans. In case no satisfactory bid is received, the Improvements may be commenced and completed by the City by day labor, as allowed under State law, unless otherwise ordered by the Council.

Section 8: Protest. Owners of property within LID 2026-01 subject to 60 percent or more of the total cost of the Improvements including federally-owned or other nonassessable property as shown and determined by the preliminary estimates and assessment roll of LID 2026-01 may divest the Council of jurisdiction to create LID 2026-01 by filing protests with the Council within 30 days from the date of the passage of this Ordinance.

Section 9: Publication. This Ordinance shall be effective from and after its adoption and five days after its publication in the official newspaper of the City.

Passed on November 18, 2026 by the Walla Walla City Council.

_____
Mayor

Attest:

_____
City Clerk

Approved as to form:

_____
City Attorney

EXHIBIT A

LOCAL IMPROVEMENT DISTRICT 2026-01 BOUNDARY DESCRIPTION

RESOLUTION NO. 2026-075

A RESOLUTION OF THE CITY COUNCIL OF THE CITY WALLA WALLA, WASHINGTON, DECLARING ITS INTENTION TO FORM A LOCAL IMPROVEMENT DISTRICT; TO ORDER IMPROVEMENTS TO STREETS AND SEWER FACILITIES WITHIN THE BOUNDARIES OF THE PROPOSED LOCAL IMPROVEMENT DISTRICT; DESCRIBING THE NATURE AND TERRITORIAL EXTENT OF SUCH PROPOSED IMPROVEMENTS; FIXING THE DATE, TIME AND PLACE FOR A PUBLIC HEARING ON THE FORMATION OF A LOCAL IMPROVEMENT DISTRICT; DIRECTING THAT CERTAIN NOTICES BE GIVEN; AND PROVIDING FOR OTHER MATTER PROPERLY RELATING THERETO

WHEREAS, the Walla Walla City Council passed Municipal Ordinance A-2405 on May 13, 1970 which classified the City of Walla Walla as a nonchartered code city under Title 35A of the Revised Code Washington (RCW); and

WHEREAS, residents in the vicinity described in section 2 hereof have requested that the Walla Walla City Council establish a local improvement district; and

WHEREAS, the Walla Walla City Council has determined that it is advisable and necessary for the public health, safety and welfare to acquire, design, construct and install certain improvements to certain city streets and sewer facilities as provided in section 2 hereof; and

WHEREAS, the Council hereby determines that it is economically feasible to construct said improvements and that a local improvement district be created and assessments be levied therein to pay for all or a portion of the costs of acquiring, designing, constructing and installing such improvements; and

WHEREAS, the Council has determined that the most equitable way to finance such improvements is by the creation of a local improvement district; and

WHEREAS, the Council is authorized to conduct such proceedings pursuant to chapters 35A.43 and 35.43 RCW; and

WHEREAS, the Walla Walla City Council considered this matter during a regularly and duly called public meeting of said Council, has given said matter careful review and consideration, and finds that good government and the best interests of the City of Walla Walla will be served by passage of this resolution;

NOW THEREFORE, the City Council of the City of Walla Walla resolves as follows:

Section 1: It is the intention of the City to order the acquisition, construction and installation of the Improvements (as defined below) and to form a local improvement district within which special assessments shall be levied to pay all or a portion of the costs of the Improvements. The assessments shall be for the sole purpose of payment into such revenue bond fund as may be specified the Walla Walla City Council for the payment of

revenue bonds issued to defray the cost of such Improvements or any portion thereof.

Section 2: The nature of the improvements will consist generally of sewer and street improvements along East Chestnut Street from its intersection with Statesman Street to 725 East Chestnut Street, along Woodlawn Street between 1031 Woodlawn Street and 1111 Woodlawn Street, and along Statesman Street from its intersection with East Chestnut Street to 1032 Statesman Street, together with such other work as may be necessary in conjunction with the development of the proposed local improvement district including construction, reconstruction, repair or renewal of drains, sewers, sewer appurtenances, underground and above-ground utilities, roadways, landscaping, and traffic safety (the "Improvements"). The plans for the acquisition, design, construction and installation of the Improvements shall be subject to changes as to detail as such changes shall be authorized by the Walla Walla City Council either prior to or during construction. The City of Walla Walla shall acquire by gift, purchase, franchise, lease or condemnation all property, both real and personal or any interest therein and all right-of-way, franchises, permits and easements which may be found necessary to acquire, construct and install the Improvements.

Section 3: The proposed local improvement district shall include all parcels of land within the boundaries described in Exhibit "A" attached hereto and hereby incorporated by this reference. The territorial extent of the Improvements shall be limited to the boundaries of the proposed local improvement district.

Section 4: The Engineering Division of the City of Walla Walla Public Works Department is hereby authorized and directed to prepare or cause to be prepared: (a) a description of the boundaries of the proposed local improvement district; (b) an estimate of the costs and expense of the Improvements; and (c) a statement of the proportion of such cost and expense that should be payable from assessments.

Section 5: Actual assessments against the property within the proposed local improvement district may vary from estimated assessments so long as the actual assessments do not exceed an amount that is equal to the increased true and fair value the Improvements add to such property.

Section 6: A public hearing is hereby set for 6:30 p.m. on October 14, 2026, at the City Council Chambers of the Walla Walla City Hall, located at 15 North 3rd Avenue, Walla Walla, Washington, at which time and place the Walla Walla City Council will conduct a public hearing on the formation of the proposed local improvement district (the "Formation Hearing").

Section 7: All people who desire to object to the formation of the proposed local improvement district must present their objections at the Formation Hearing.

Section 8: The City shall give notice of the Formation Hearing, and such notice shall be substantially in the form of Exhibit "B" attached hereto. Such notice of the Formation Hearing shall: (a) describe the nature of the Improvements; (b) set forth the estimated cost of the Improvements; (c) set forth the estimated benefits to the particular lot, tract or parcel; and (d) state that actual assessments against the property within the proposed local improvement district may vary from estimated assessments so long as the actual assessments do not exceed an amount that is equal to the increased true and fair value the Improvements add to such property.

The Walla Walla City Clerk shall cause such notice to be sent: (a) by first-class mail, at least 15 days before the Formation Hearing, to all owners and reputed owners of property within the proposed local improvement district (as shown on the tax rolls of the Walla Walla County Assessor), (b) by first-class mail, at least 15 days before the Formation Hearing, to all owners of property that: (i) is located outside the boundaries of the proposed local improvement district; and (ii) must be connected to the Improvements to qualify for a Federal Housing Administration loan, if any; and (c) with respect to property owned by the state of Washington by registered or certified mail, at least 30 days before the Formation Hearing, to the Director of the Office of Financial Management and the chief administrative officer of the state agency having jurisdiction over the property. Proof of mailing shall be by affidavit of the mailer.

Section 9: This Resolution shall be published in two consecutive issues of the City of Walla Walla's official newspaper, provided that the first such publication shall be at least 15 days before the Formation Hearing.

Section 10: All actions not inconsistent with the provisions of this Resolution heretofore taken by the Walla Walla City Council and the city's employees in connection with the adoption of this Resolution and the marketing, sale, issuance and delivery of the Bonds is hereby and, in all respects, ratified, approved and confirmed.

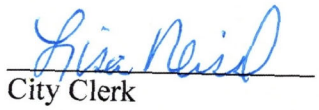
Section 11: All resolutions or parts thereof in conflict herewith are, to the extent of such conflict, hereby repealed, and shall have no further force or effect.

Section 12: This Resolution shall be in full force and effect upon and after its adoption.

PASSED by the Walla Walla City Council on August 26, 2026.

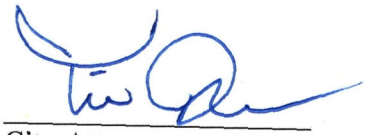
Mayor

Attest:

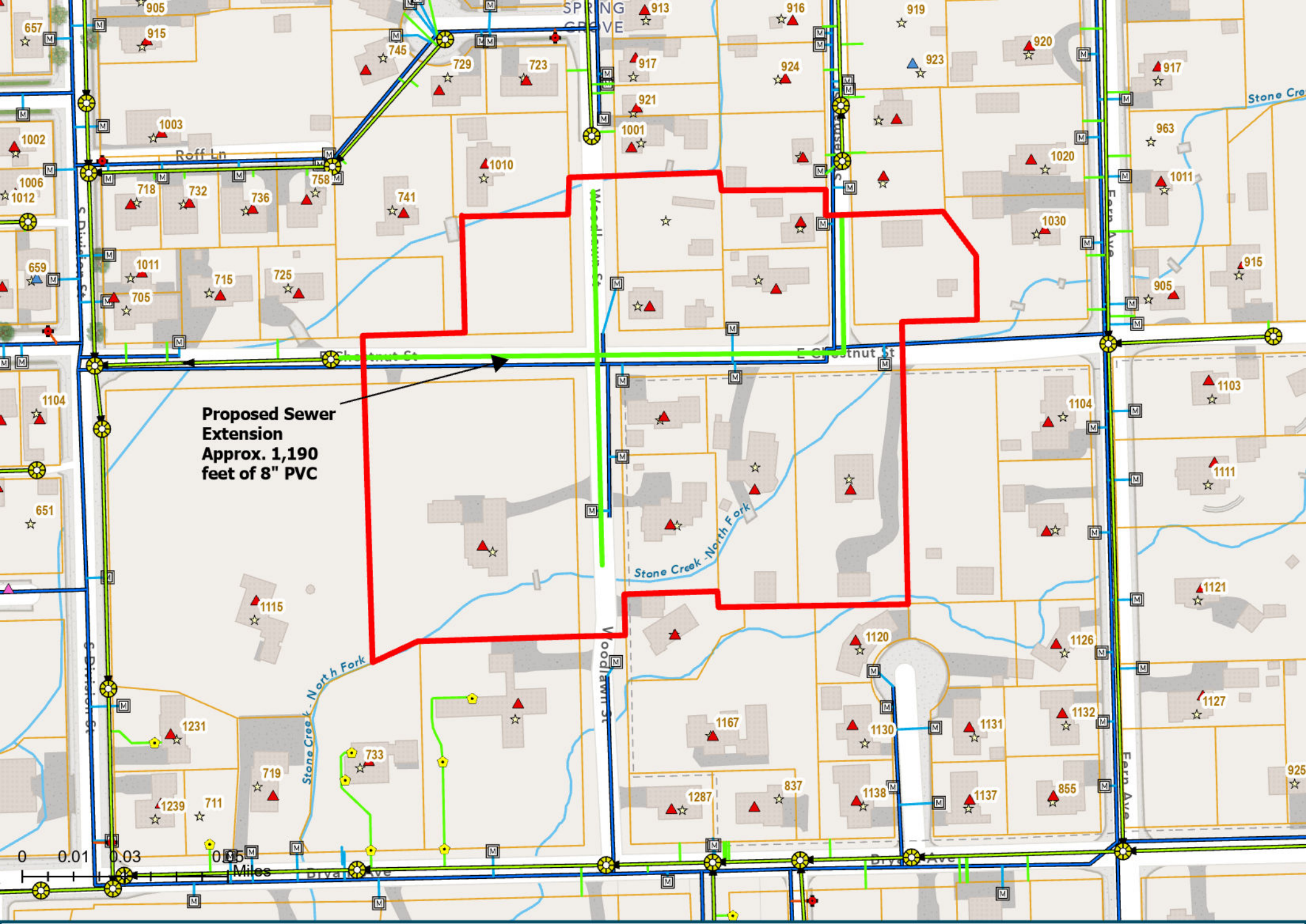


City Clerk

Approved as to form:



City Attorney



Proposed Woodlawn/Chestnut Local Improvement District

The City of Walla Walla does not warrant, guarantee or accept any liability for the accuracy, precision or completeness of any information shown or described hereon or for any inferences made therefrom. Any use made of this information is solely at the risk of the user.

City of Walla Walla GIS

CITY OF WALLA WALLA

ENGINEER'S CONSTRUCTION ESTIMATE
Chestnut Street Sewer Extension LID

Fiscal Year: 2027
Project Engineer: Doug Eaton
Project Location: Chestnut Street
Project Number: TBD

Project Scope: Extend sewer main on Chestnut east of Division

ITEM	WSDOT SPEC	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	EXTENSION
	SCHEDULE A-General					
1.	1-09	MOBILIZATION	1	LS	$ 10,000.00	$ 10,000.00
2.	1-05*	SURVEYING	1	LS	$ 3,500.00	$ 3,500.00
3.	1-05*	RECORD DRAWINGS	1	LS	$ 500.00	$ 500.00
4.	1-07*	ARCHAEOLOGICAL AND HISTORICAL SALVAGE	0	EST	$ -	$ -
5.	1-07	SPCC PLAN	1	LS	$ 500.00	$ 500.00
6.	1-10*	PROJECT TEMPORARY TRAFFIC CONTROL	1	LS	$ 4,000.00	$ 4,000.00
7.	2-01*	ROOT TRIMMING	0	LS	$ 500.00	$ -
8.	8-01	ESC LEAD	20	DAY	$ 100.00	$ 2,000.00
9.	8-01*	INLET PROTECTION	2	EA	$ 200.00	$ 400.00
10.	8-01*	SWPPP	1	LS	$ 500.00	$ 500.00
11.	8-02*	LANDSCAPING AND IRRIGATION RESTORATION	1	FA	$ 6,000.00	$ 6,000.00
12.	1-04.4(1)	MINOR CHANGE	1	FA	$ 5,000.00	$ 5,000.00
					SUB TOTAL:	$ 32,400.00

ITEM	WSDOT SPEC	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	EXTENSION
	SCHEDULE B-STREET					
1.	2-03*	ROADWAY EXCAVATION, INCL. HAUL	220	CY	$ 30.00	$ 6,611.11
2.	3-04	AGGREGATE COMPLIANCE PRICE ADJUSTMENT	1	CALC	$ (1.00)	$ (1.00)
3.	4-04	CRUSHED SURFACING BASE COURSE	359	TON	$ 22.00	$ 7,908.54
4.	5-04*	HMA CL. 1/2 IN. PG 64-28 (1" thick)	77	TON	$ 175.00	$ 13,536.25
5.	5-04	JOB MIX COMPLIANCE PRICE ADJUSTMENT	1	CALC	$ (1.00)	$ (1.00)
					SUB TOTAL:	$ 28,053.90

ITEM	WSDOT SPEC	DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	EXTENSION
	SCHEDULE E - SEWER					
1.	7-08*	REMOVE AND REPLACE UNSUITABLE MATERIAL	1,322	CY	$ 35.00	$ 46,277.78
2.	7-05*	ADJUST UTILITY CASTING	1	EA	$ 500.00	$ 500.00
3.	7-05	MANHOLE TYPE 1, 48-IN DIAM.	5	EA	$ 5,500.00	$ 27,500.00
4.	7-08*	TRENCH DEWATERING	1,190	LF	$ 20.00	$ 23,800.00
5.	7-08*	TRENCH DEWATERING MOBILIZATION	1	LS	$ 4,000.00	$ 4,000.00
6.	7-08*	SHORING AND TRENCH SAFETY	1,630	LF	$ 5.00	$ 8,150.00
7.	7-08*	UNMARKED UTILITY ENCOUNTER	1	EA	$ 500.00	$ 500.00
8.	7-08*	CONNECTION TO EXISTING SEWER MANHOLE	1	EA	$ 1,500.00	$ 1,500.00
9.	7-17	PVC SANITARY SEWER PIPE, 8-IN. DIAM.	1,190	LF	$ 80.00	$ 95,200.00
10.	7-17*	PVC SANITARY SEWER SERVICE PIPE, 4-IN. DIAM.	480	LF	$ 40.00	$ 19,200.00
11.	7-17*	PVC SANITARY SEWER SERVICE CLEAN OUT AND BACKWATER VALVE	12	EA	$ 500.00	$ 6,000.00
12.	7-18*	SEWER SERVICE LINE CONNECTION	12	EA	$ 500.00	$ 6,000.00
13.	7-19*	CAST IRON CLEANOUT CASTING	12	EA	$ 500.00	$ 6,000.00
					SUB TOTAL:	$ 244,627.78
					Tax (8.9%):	$ 21,771.87
					Total:	$ 266,399.65

Total Construction Cost:	$ 305,082
Construction Other	
Taxes:	$ 21,772
TOTAL CONSTRUCTION ESTIMATE:	$ 326,854
PE (30%):	$ 98,056
CE (15%):	$ 49,028

Signature:

Doug Eaton

Last Revised: 8/14/2026

	CE: Record Drawings	$	2,000
WA PE # 49443	**TOTAL PROJECT COST:**	**$**	**475,938**

City of Walla Walla

Certificate of Notification

Woodlawn/Chestnut Local Improvement District Formation Public Hearing
Site Addresses:

- 805 E. Chestnut St
- 806 E. Chestnut St
- 818 E. Chestnut St
- 821 E. Chestnut St
- 830 E. Chestnut St
- 1010 Woodlawn St
- 1030 Fern St
- 1031 Woodlawn St
- 1032 Statesman St
- 1106 Woodlawn St
- 1111 Woodlawn St

Type of Notice: **Public Hearing Notice**

Proof of Posting
I certify under the penalty of perjury under the laws of the State of Washington that Resolution 2026-075 was published:

☒ In the Walla Walla Union Bulletin on the following dates: 9/19/2026 & 9/22/2026

Lisa Neissl
Printed Name

Lisa Neissl
Signature

9-17-2026
Date

Proof of Mailing
I certify under the penalty of perjury under the laws of the State of Washington that the content of the above form of notice was:

☒ Mailed to the property owners of record for addresses identified above on September 15, 2026

Lisa Neissl
Signature

9-15-2026
Date

Lisa Neissl
Printed Name

Rahm Family Trust
1111 Woodlawn St
Walla Walla WA 99362

Nicole & Erik Gryler
1106 Woodlawn St
Walla Walla WA 99362

Jeraldine J. Emerick
1032 Statesman St
Walla Walla WA 99362

Mariah & Timothy Donahue
730 Wallowa Drive
Walla Walla WA 99362

Debra R. & Robert D. Williams
1030 Fern St
Walla Walla WA 99362

Kathryn J. Millgard
1010 Woodlawn St
Walla Walla WA 99362

Lenore L. & Paul E. Parker
830 E. Chestnut St
Walla Walla WA 99362

Estee E. & Ricky R. Pummel
821 E. Chestnut St
Walla Walla WA 99362

Anthony James Dickman
& Mitzi Jensen Trust
818 E. Chestnut St
Walla Walla WA 99362

Michael P. Uhren
& Lynn Anderson Kyree
806 E. Chestnut St
Walla Walla WA 99362

Katherine M. Platis
805 E. Chestnut St
Walla Walla WA 99362

Rahm Family Trust
1111 Woodlawn St
Walla Walla WA 99362

Nicole & Erik Gryler
1106 Woodlawn St
Walla Walla WA 99362

Jeraldine J. Emerick
1032 Statesman St
Walla Walla WA 99362

7018 0680 0001 3553 4775

7018 0680 0001 3553 4782

7018 0680 0001 3553 4799

Mariah & Timothy Donahue
730 Wallowa Drive
Walla Walla WA 99362

Debra R. & Robert D. Williams
1030 Fern St
Walla Walla WA 99362

Kathryn J. Millgard
1010 Woodlawn St
Walla Walla WA 99362

7018 0680 0001 3553 4805

7018 0680 0001 3553 4812

7018 0680 0001 3553 4829

Lenore L. & Paul E. Parker
830 E. Chestnut St
Walla Walla WA 99362

Estee E. & Ricky R. Pummel
821 E. Chestnut St
Walla Walla WA 99362

Anthony James Dickman
& Mitzi Jensen Trust
818 E. Chestnut St
Walla Walla WA 99362

7018 0680 0001 3553 4836

7018 0680 0001 3553 4843

7018 0680 0001 3553 4850

Michael P. Uhren
& Lynn Anderson Kyree
806 E. Chestnut St
Walla Walla WA 99362

Katherine M. Platis
805 E. Chestnut St
Walla Walla WA 99362

7018 0680 0001 3553 4867

7018 0680 0001 3553 4874

Walla Walla Union-Bulletin

PO Box 3627
Seattle, WA 98124

City Of Walla Walla
Lisa Neissl
15 N 3rd Ave
Walla Walla, WA 99362
USA

Order Confirmation

Order #:	119707
Order Ref #:	
Date:	9/14/2026
Advertiser #:	22120
Advertiser Name:	City Of Walla Walla
Agency #:	
Agency Name:	
Account Manager:	Simon Sizer ssizer@yakimaherald.com

Print - Order Name: RESOLUTION NO. 2026-075

Ad No.	Date	Description	Position	Format	Net Amount
566976	9/19/2026	RESOLUTION NO. 2026-075	Walla Walla Union Bulletin Broadsheet - CL-Real Estate	7.04 × 21.50 in × 4.0000 col.	$ 1,142.08

Summary	
Total Net Amount	**$ 1,142.08**
Taxes	$ 0.00
Total Amount	$ 1,142.08

Remittance Address:

Walla Walla Union-Bulletin
PO Box 3627
Seattle, WA 98124
Tel: (206) 464-2550

RESOLUTION NO. 2026-075

A RESOLUTION OF THE CITY COUNCIL OF THE CITY WALLA WALLA, WASHINGTON, DECLARING ITS INTENTION TO FORM A LOCAL IMPROVEMENT DISTRICT; TO ORDER IMPROVEMENTS TO STREETS AND SEWER FACILITIES WITHIN THE BOUNDARIES OF THE PROPOSED LOCAL IMPROVEMENT DISTRICT; DESCRIBING THE NATURE AND TERRITORIAL EXTENT OF SUCH PROPOSED IMPROVEMENTS; FIXING THE DATE, TIME AND PLACE FOR A PUBLIC HEARING ON THE FORMATION OF A LOCAL IMPROVEMENT DISTRICT; DIRECTING THAT CERTAIN NOTICES BE GIVEN; AND PROVIDING FOR OTHER MATTER PROPERLY RELATING THERETO

WHEREAS, the Walla Walla City Council passed Municipal Ordinance A-2405 on May 13, 1970 which classified the City of Walla Walla as a nonchartered code city under Title 35A of the Revised Code Washington (RCW); and

WHEREAS, residents in the vicinity described in section 2 hereof have requested that the Walla Walla City Council establish a local improvement district; and

WHEREAS, the Walla Walla City Council has determined that it is advisable and necessary for the public health, safety and welfare to acquire, design, construct and install certain improvements to certain city streets and sewer facilities as provided in section 2 hereof; and

WHEREAS, the Council hereby determines that it is economically feasible to construct said improvements and that a local improvement district be created and assessments be levied therein to pay for all or a portion of the costs of acquiring, designing, constructing and installing such improvements; and

WHEREAS, the Council has determined that the most equitable way to finance such improvements is by the creation of a local improvement district; and

WHEREAS, the Council is authorized to conduct such proceedings pursuant to chapters 35A.43 and 35.43 RCW; and

WHEREAS, the Walla Walla City Council considered this matter during a regularly and duly called public meeting of said Council, has given said matter careful review and consideration, and finds that good government and the best interests of the City of Walla Walla will be served by passage of this resolution;

NOW THEREFORE, the City Council of the City of Walla Walla resolves as follows:

Section 1: It is the intention of the City to order the acquisition, construction and installation of the Improvements (as defined below) and to form a local improvement district within which special assessments shall be levied to pay all or a portion of the costs of the Improvements. The assessments shall be for the sole purpose of payment into such revenue bond fund as may be specified the Walla Walla City Council for the payment of revenue bonds issued to defray the cost of such Improvements or any portion thereof.

Section 2: The nature of the improvements will consist generally of sewer and street improvements along East Chestnut Street from its intersection with Statesman Street to 725 East Chestnut Street, along Woodlawn Street between 1031 Woodlawn Street and 1111 Woodlawn Street, and along Statesman Street from its intersection with East Chestnut Street to 1032 Statesman Street, together with such other work as may be necessary in conjunction with the development of the proposed local improvement district including construction, reconstruction, repair or renewal of drains, sewers, sewer appurtenances, underground and above-ground utilities, roadways, landscaping, and traffic safety (the "Improvements"). The plans for the acquisition, design, construction and installation of the Improvements shall be subject to changes as to detail as such changes shall be authorized by the Walla Walla City Council either prior to or during construction. The City of Walla Walla shall acquire by gift, purchase, franchise, lease or condemnation all property, both real and personal or any interest therein and all right-of-way, franchises, permits and easements which may be found necessary to acquire, construct and install the Improvements.

Section 3: The proposed local improvement district shall include all parcels of land within the boundaries described in Exhibit "A" attached hereto and hereby incorporated by this reference. The territorial extent of the Improvements shall be limited to the boundaries of the proposed local improvement district.

Section 4: The Engineering Division of the City of Walla Walla Public Works Department is hereby authorized and directed to prepare or cause to be prepared: (a) a description of the boundaries of the proposed local improvement district; (b) an estimate of the costs and expense of the Improvements; and (c) a statement of the proportion of such cost and expense that should be payable from assessments.

Section 5: Actual assessments against the property within the proposed local improvement district may vary from estimated assessments so long as the actual assessments do not exceed an amount that is equal to the increased true and fair value the Improvements add to such property.

Section 6: A public hearing is hereby set for 6:30 p.m. on October 14, 2026, at the City Council Chambers of the Walla Walla City Hall, located at 15 North 3rd Avenue, Walla Walla, Washington, at which time and place the Walla Walla City Council will conduct a public hearing on the formation of the proposed local improvement district (the "Formation Hearing").

Section 7: All people who desire to object to the formation of the proposed local improvement district must present their objections at the Formation Hearing.

Section 8: The City shall give notice of the Formation Hearing, and such notice shall be substantially in the form of Exhibit "B" attached hereto. Such notice of the Formation Hearing shall: (a) describe the nature of the Improvements; (b) set forth the estimated cost of the Improvements; (c) set forth the estimated benefits to the particular lot, tract or parcel; and (d) state that actual assessments against the property within the proposed local improvement district may vary from estimated assessments so long as the actual assessments do not exceed an amount that is equal to the increased true and fair value the Improvements add to such property.

The Walla Walla City Clerk shall cause such notice to be sent: (a) by first-class mail, at least 15 days before the Formation Hearing, to all owners and reputed owners of property within the proposed local improvement district (as shown on the tax rolls of the Walla Walla County Assessor), (b) by first-class mail, at least 15 days before the Formation Hearing, to all owners of property that: (i) is located outside the boundaries of the proposed local improvement district; and (ii) must be connected to the Improvements to qualify for a Federal Housing Administration loan, if any; and (c) with respect to property owned by the state of Washington by registered or certified mail, at least 30 days before the Formation Hearing, to the Director of the Office of Financial Management and the chief administrative officer of the state agency having jurisdiction over the property. Proof of mailing shall be by affidavit of the mailer.

Section 9: This Resolution shall be published in two consecutive issues of the City of Walla Walla's official newspaper, provided that the first such publication shall be at least 15 days before the Formation Hearing.

Section 10: All actions not inconsistent with the provisions of this Resolution heretofore taken by the Walla Walla City Council and the city's employees in connection with the adoption of this Resolution and the marketing, sale, issuance and delivery of the Bonds is hereby and, in all respects, ratified, approved and confirmed.

Section 11: All resolutions or parts thereof in conflict herewith are, to the extent of such conflict, hereby repealed, and shall have no further force or effect.

Section 12: This Resolution shall be in full force and effect upon and after its adoption.

PASSED by the Walla Walla City Council on August 26, 2026.

_____

Mayor

Attest:

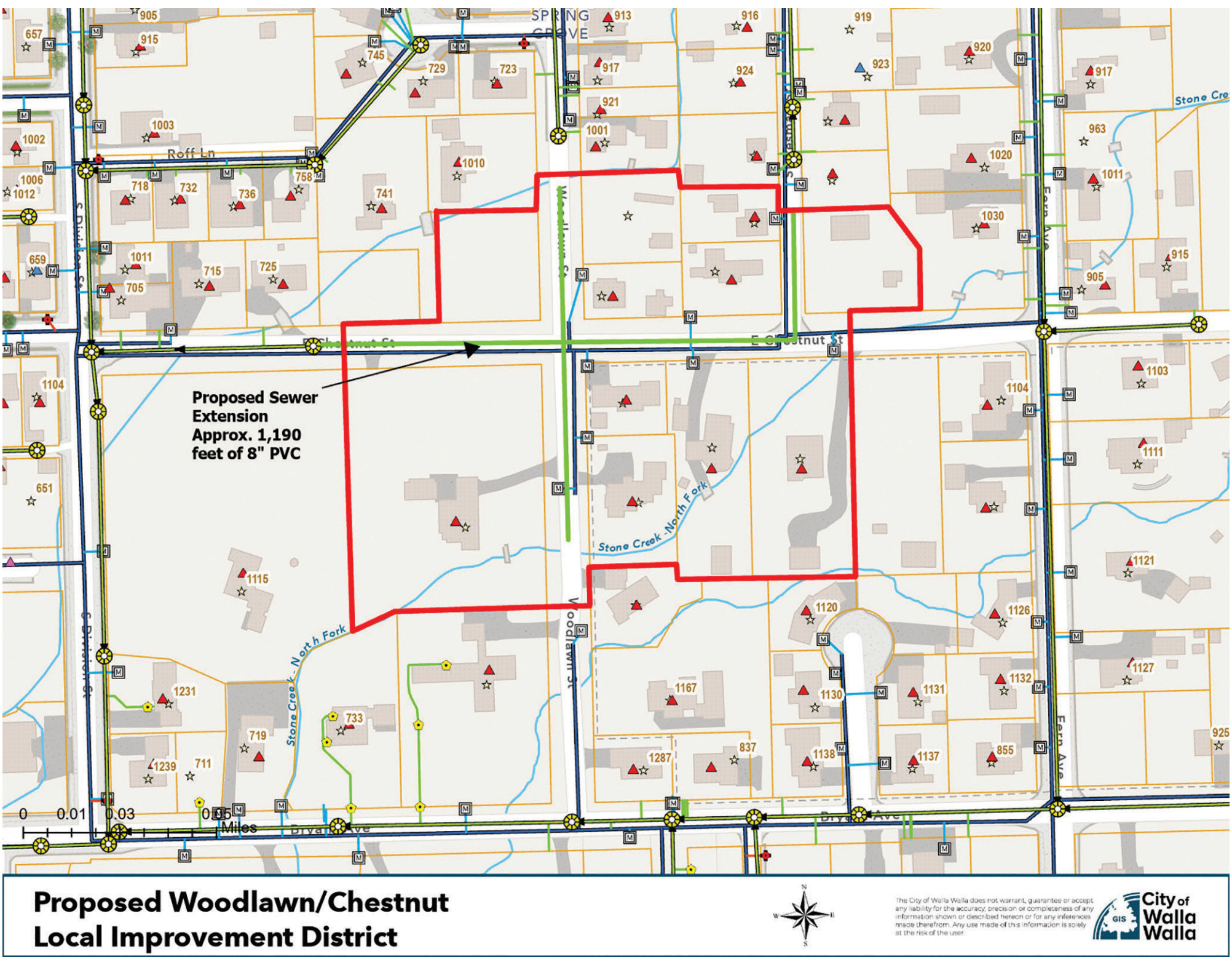
_____

City Clerk

Approved as to form:

_____

City Attorney



Proposed Woodlawn/Chestnut Local Improvement District

The City of Walla Walla does not warrant, guarantee or accept any liability for the accuracy, precision or completeness of any information shown or described hereon or for any inferences made therefrom. Any use made of this information is solely at the risk of the user.

City of Walla Walla GIS

WW-348105

Walla Walla Union-Bulletin

PO Box 3627
Seattle, WA 98124

City Of Walla Walla
Lisa Neissl
15 N 3rd Ave
Walla Walla, WA 99362
USA

Order Confirmation

Order #:	119764
Order Ref #:	
Date:	9/15/2026
Advertiser #:	22120
Advertiser Name:	City Of Walla Walla
Agency #:	
Agency Name:	
Account Manager:	Simon Sizer ssizer@yakimaherald.com

Print - Order Name: RESOLUTION NO. 2026-075

Ad No.	Date	Description	Position	Format	Net Amount
567185	9/22/2026	RESOLUTION NO. 2026-075	Walla Walla Union Bulletin Broadsheet - CL-Real Estate	7.04 × 21.50 in × 4.0000 col.	$ 1,142.08

Summary	
Total Net Amount	**$ 1,142.08**
Taxes	$ 0.00
Total Amount	$ 1,142.08

Remittance Address:

Walla Walla Union-Bulletin
PO Box 3627
Seattle, WA 98124
Tel: (206) 464-2550

RESOLUTION NO. 2026-075

A RESOLUTION OF THE CITY COUNCIL OF THE CITY WALLA WALLA, WASHINGTON, DECLARING ITS INTENTION TO FORM A LOCAL IMPROVEMENT DISTRICT; TO ORDER IMPROVEMENTS TO STREETS AND SEWER FACILITIES WITHIN THE BOUNDARIES OF THE PROPOSED LOCAL IMPROVEMENT DISTRICT; DESCRIBING THE NATURE AND TERRITORIAL EXTENT OF SUCH PROPOSED IMPROVEMENTS; FIXING THE DATE, TIME AND PLACE FOR A PUBLIC HEARING ON THE FORMATION OF A LOCAL IMPROVEMENT DISTRICT; DIRECTING THAT CERTAIN NOTICES BE GIVEN; AND PROVIDING FOR OTHER MATTER PROPERLY RELATING THERETO

WHEREAS, the Walla Walla City Council passed Municipal Ordinance A-2405 on May 13, 1970 which classified the City of Walla Walla as a nonchartered code city under Title 35A of the Revised Code Washington (RCW); and

WHEREAS, residents in the vicinity described in section 2 hereof have requested that the Walla Walla City Council establish a local improvement district; and

WHEREAS, the Walla Walla City Council has determined that it is advisable and necessary for the public health, safety and welfare to acquire, design, construct and install certain improvements to certain city streets and sewer facilities as provided in section 2 hereof; and

WHEREAS, the Council hereby determines that it is economically feasible to construct said improvements and that a local improvement district be created and assessments be levied therein to pay for all or a portion of the costs of acquiring, designing, constructing and installing such improvements; and

WHEREAS, the Council has determined that the most equitable way to finance such improvements is by the creation of a local improvement district; and

WHEREAS, the Council is authorized to conduct such proceedings pursuant to chapters 35A.43 and 35.43 RCW; and

WHEREAS, the Walla Walla City Council considered this matter during a regularly and duly called public meeting of said Council, has given said matter careful review and consideration, and finds that good government and the best interests of the City of Walla Walla will be served by passage of this resolution;

NOW THEREFORE, the City Council of the City of Walla Walla resolves as follows:

Section 1: It is the intention of the City to order the acquisition, construction and installation of the Improvements (as defined below) and to form a local improvement district within which special assessments shall be levied to pay all or a portion of the costs of the Improvements. The assessments shall be for the sole purpose of payment into such revenue bond fund as may be specified the Walla Walla City Council for the payment of revenue bonds issued to defray the cost of such Improvements or any portion thereof.

Section 2: The nature of the improvements will consist generally of sewer and street improvements along East Chestnut Street from its intersection with Statesman Street to 725 East Chestnut Street, along Woodlawn Street between 1031 Woodlawn Street and 1111 Woodlawn Street, and along Statesman Street from its intersection with East Chestnut Street to 1032 Statesman Street, together with such other work as may be necessary in conjunction with the development of the proposed local improvement district including construction, reconstruction, repair or renewal of drains, sewers, sewer appurtenances, underground and above-ground utilities, roadways, landscaping, and traffic safety (the "Improvements"). The plans for the acquisition, design, construction and installation of the Improvements shall be subject to changes as to detail as such changes shall be authorized by the Walla Walla City Council either prior to or during construction. The City of Walla Walla shall acquire by gift, purchase, franchise, lease or condemnation all property, both real and personal or any interest therein and all right-of-way, franchises, permits and easements which may be found necessary to acquire, construct and install the Improvements.

Section 3: The proposed local improvement district shall include all parcels of land within the boundaries described in Exhibit "A" attached hereto and hereby incorporated by this reference. The territorial extent of the Improvements shall be limited to the boundaries of the proposed local improvement district.

Section 4: The Engineering Division of the City of Walla Walla Public Works Department is hereby authorized and directed to prepare or cause to be prepared: (a) a description of the boundaries of the proposed local improvement district; (b) an estimate of the costs and expense of the Improvements; and (c) a statement of the proportion of such cost and expense that should be payable from assessments.

Section 5: Actual assessments against the property within the proposed local improvement district may vary from estimated assessments so long as the actual assessments do not exceed an amount that is equal to the increased true and fair value the Improvements add to such property.

Section 6: A public hearing is hereby set for 6:30 p.m. on October 14, 2026, at the City Council Chambers of the Walla Walla City Hall, located at 15 North 3rd Avenue, Walla Walla, Washington, at which time and place the Walla Walla City Council will conduct a public hearing on the formation of the proposed local improvement district (the "Formation Hearing").

Section 7: All people who desire to object to the formation of the proposed local improvement district must present their objections at the Formation Hearing.

Section 8: The City shall give notice of the Formation Hearing, and such notice shall be substantially in the form of Exhibit "B" attached hereto. Such notice of the Formation Hearing shall: (a) describe the nature of the Improvements; (b) set forth the estimated cost of the Improvements; (c) set forth the estimated benefits to the particular lot, tract or parcel; and (d) state that actual assessments against the property within the proposed local improvement district may vary from estimated assessments so long as the actual assessments do not exceed an amount that is equal to the increased true and fair value the Improvements add to such property.

The Walla Walla City Clerk shall cause such notice to be sent: (a) by first-class mail, at least 15 days before the Formation Hearing, to all owners and reputed owners of property within the proposed local improvement district (as shown on the tax rolls of the Walla Walla County Assessor), (b) by first-class mail, at least 15 days before the Formation Hearing, to all owners of property that: (i) is located outside the boundaries of the proposed local improvement district; and (ii) must be connected to the Improvements to qualify for a Federal Housing Administration loan, if any; and (c) with respect to property owned by the state of Washington by registered or certified mail, at least 30 days before the Formation Hearing, to the Director of the Office of Financial Management and the chief administrative officer of the state agency having jurisdiction over the property. Proof of mailing shall be by affidavit of the mailer.

Section 9: This Resolution shall be published in two consecutive issues of the City of Walla Walla's official newspaper, provided that the first such publication shall be at least 15 days before the Formation Hearing.

Section 10: All actions not inconsistent with the provisions of this Resolution heretofore taken by the Walla Walla City Council and the city's employees in connection with the adoption of this Resolution and the marketing, sale, issuance and delivery of the Bonds is hereby and, in all respects, ratified, approved and confirmed.

Section 11: All resolutions or parts thereof in conflict herewith are, to the extent of such conflict, hereby repealed, and shall have no further force or effect.

Section 12: This Resolution shall be in full force and effect upon and after its adoption.

PASSED by the Walla Walla City Council on August 26, 2026.

_____

Mayor

Attest:

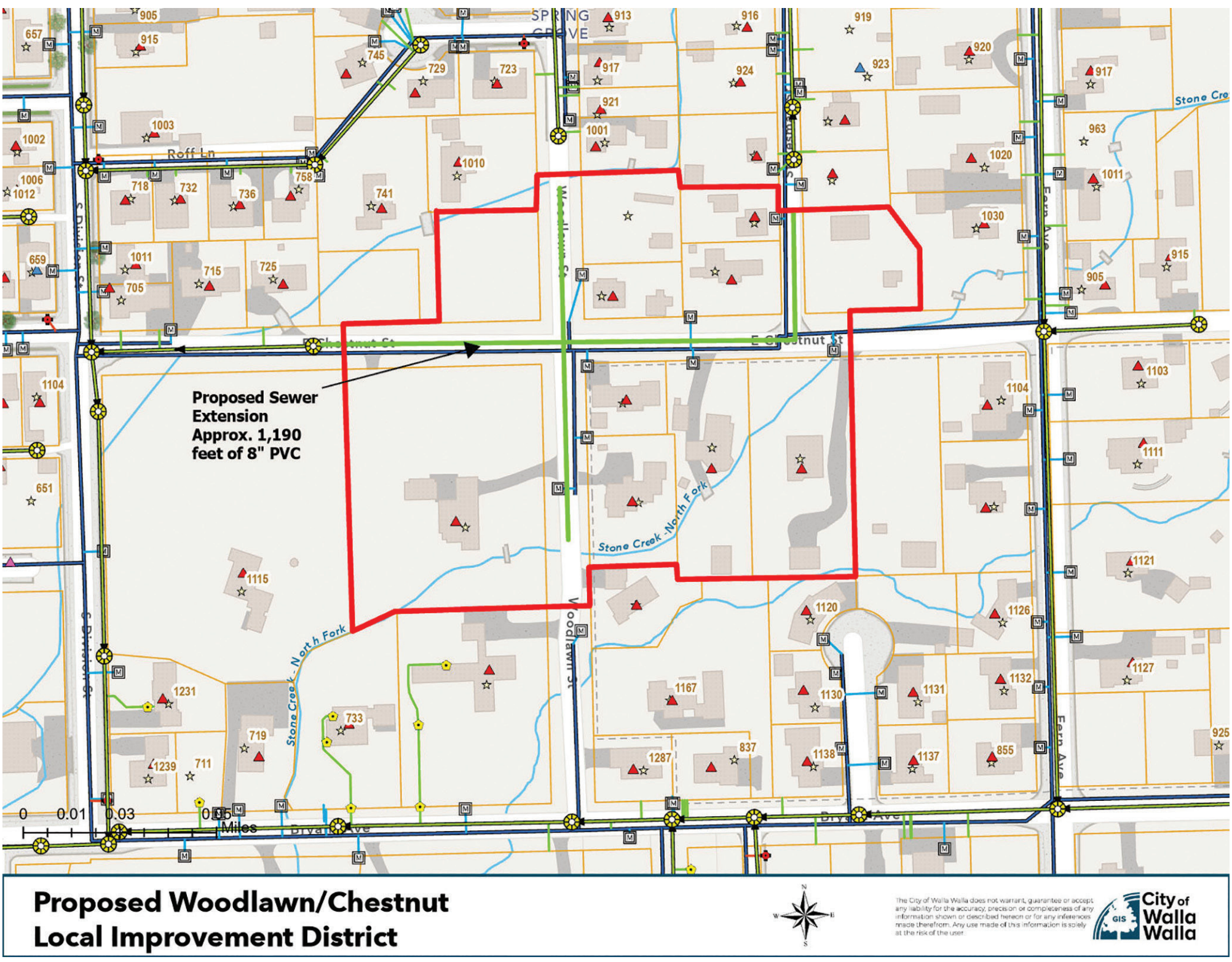
_____

City Clerk

Approved as to form:

_____

City Attorney



Proposed Woodlawn/Chestnut Local Improvement District

The City of Walla Walla does not warrant, guarantee or accept any liability for the accuracy, precision or completeness of any information shown or described hereon or for any inferences made therefrom. Any use made of this information is solely at the risk of the user.

City of Walla Walla GIS

WW-348105

From: Preston Frederickson
To: Elizabeth Chamberlain; Emily Arteche
Subject: RE: SEPA Exemption Concurrence
Date: Wednesday, September 9, 2026 2:21:22 PM
Attachments: image003.png
image005.png

Hi Elizabeth,

I have reviewed the relevant Municipal Code and WAC references, and I concur that the proposed project is SEPA except under WWMC 21.08.180, which incorporates by reference WAC 197-11-800(23)(b), because the proposed project it is a sewer utility (that does not cross bodies of water) and is less than 12' in size (designed to be 8"). The roadway patching is also exempt as it is a utility-related action part of the "installation and construction" of the sewer.

Furthermore, WAC 197-11-800(16) states that for Formation of an LID is SEPA exempt because it seeks to fund the construction of a facility (sewer extension) that is SEPA exempt.

While not SEPA related, I believe this sewer utility work is an "allowed activity" under the City's current critical areas ordinance (See WWMC 21.04.085(5) as it is the "... "installation or construction of utility facilities, lines pipes, mains, equipment, or appurtenances, not including substations, which such facilities are located within the existing improved portion of the public right-of-way (road surface, shoulder, sidewalk, and fill slopes..."

Please let me know if you need anything else or wish to discuss further.

PRESTON FREDERICKSON
Deputy City Manager

509.524.4345
wallawallawa.gov

City of Walla Walla

A WONDERFUL PLACE TO
LIVE WORK PLAY

From: Elizabeth Chamberlain <echamberlain@wallawallawa.gov>

Sent: Wednesday, September 9, 2026 9:40 AM
To: Emily Arteche <earteche@wallawallawa.gov>; Preston Frederickson <pfred@wallawallawa.gov>
Subject: SEPA Exemption Concurrence

Good Morning Emily and Preston,

I am working on the Sewer LID for Woodlawn/Chestnut. The proposed construction is 8" sewer extension (see attached map), sewer laterals to the affected properties, and trench patching. The proposed construction will not involve creek crossings. I am seeking concurrence that the sewer main extension is exempt from SEPA under WWMC 21.08.180 and WAC 197-11-800(23)(b).

If you need additional information, please let me know.

Thank you,

ELIZABETH CHAMBERLAIN
City Manager

509.527.4522
wallawallawa.gov

City of Walla Walla

A WONDERFUL PLACE TO
LIVE WORK PLAY

* * * * * * SPECIAL PUBLIC DISCLOSURE NOTICE TO RECIPIENT(S): Information contained in any communication to or from the City of Walla Walla, including attachments, may be subject to the disclosure requirements of Washington's Public Records Act, Ch. 42.56 RCW.
* * * * * * SPECIAL PUBLIC DISCLOSURE NOTICE TO RECIPIENT(S): Information contained in any communication to or from the City of Walla Walla, including attachments, may be subject to the disclosure requirements of Washington's Public Records Act, Ch. 42.56 RCW.

Paul and Lenore Parker
830 E. Chestnut St
(509)540-5334

Re: opposition to proposed LID

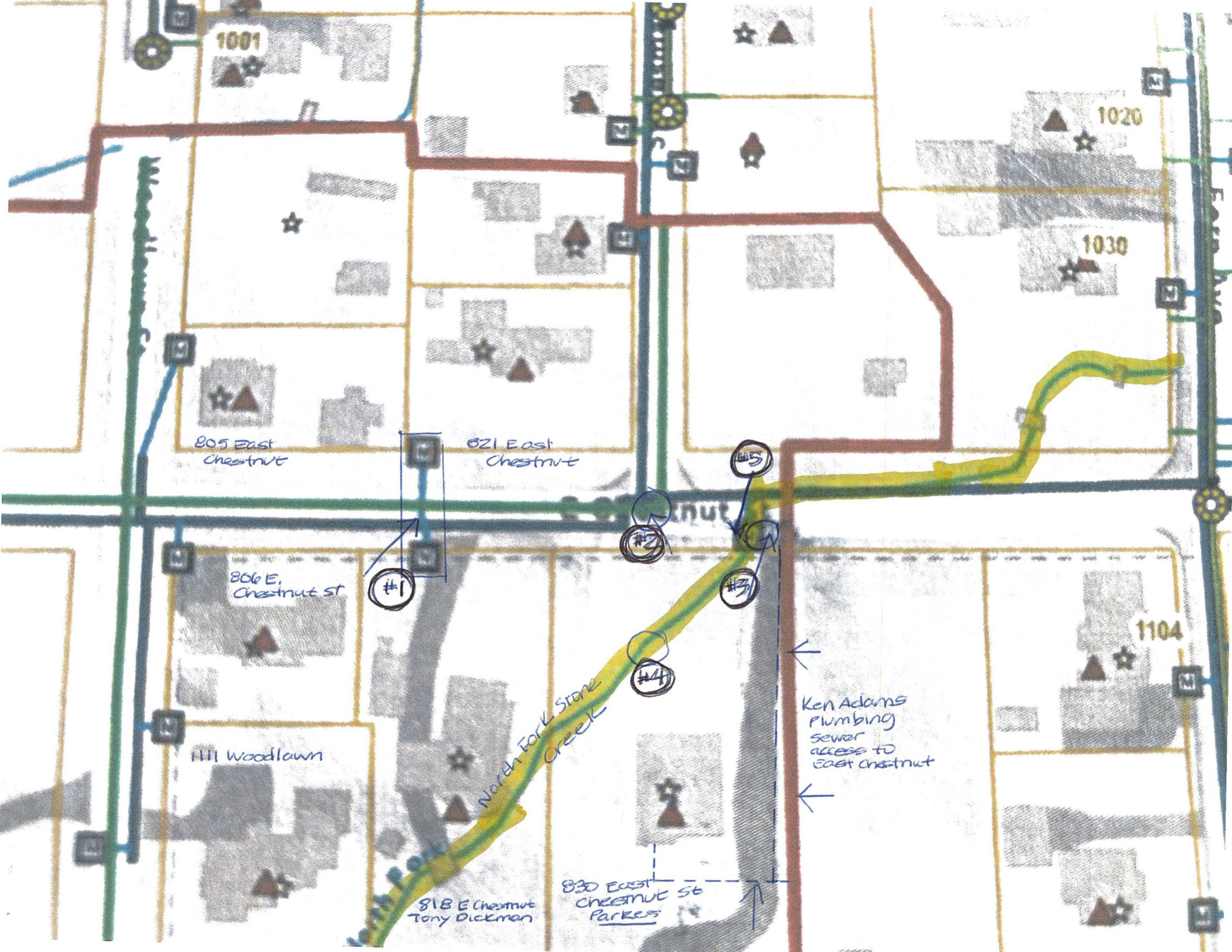
Key:

1. Where I would propose terminating the eastern aspect of the LID; 120 feet less than the current proposal.
2. Current termination of sewer line on Chestnut and site of my access to the sewer line proposed, per discussion with the city engineer. Note this site is 85 ft down the road and across the stone creek culvert from the feasible site proposed by my plumber.
3. Proposed site to bring my sewer line to the road per Ken Adams plumbing
4. Sewer line stream crossing to access the sewer line connection proposed by city engineer which would require an HPA for Stone Creek which is a Type F fish bearing stream which the WDFW lists as a priority habitat
5. Stone creek culvert which would require a HPA to cross

I believe the LID for the 8 properties initially presented to the city council on 8/26/2026 offers benefit to property holders with access to city sewer along the frontage of their property.
I have conferred with Ken Adams Plumbing and have been advised that the only feasible access would be up my driveway(300 ft) to the road and with the current proposal turning left crossing the Stone creek culvert and moving 85 ft further along the road to access point 2. They feel that a direct line across Stone Creek is problematic relative to permits and that once across the creek that trenching past the mature sycamore and maple trees would not be feasible. In addition if a line were placed in this location the future risk of line disruption by root regrowth would exist.
I believe the best connection for my property would be to come to the road from my driveway and proceed east to connect on Fern St avoiding the necessity of crossing Stone Creek at any point. This would also allow future sewer access to the one acre plot to the east of my home.
My understanding is that the 2 properties on Statesman St would like to be removed from the LID and I would propose that my property be removed and the LID be extended only to point 1. This would allow benefit to the 8 property holders in the initial proposal without involving the 3 eastmost properties saving the LID 300 ft of sewer line placement.
Should I be coerced into the LID I would request the city extend the sewer line to point 3 such that I can access it without running 85 ft up the street and crossing the stone creek culvert; a scenario no other property owner is being asked to shoulder on their own.

Pictures
1,2,3-direct line to my proposed connection on the corner to Chestnut and Statesman showing creek and mature trees(each tree separated by approx 15 ft) making access infeasible per my plumber
4-picture from my private property access(Ken Adams plumbing proposal) down the city controlled roadway 85 ft across the Stone Creek culvert to access my proposed connection
5-picture of access east(in the future) to Fern Ave
6-picture, plumber's proposed sewer line access
7-frontage showing four mature sycamore trees - making trenching infeasible

(Paul Parker)
Lenore Parker
10/04/2026


1001
1020
1030
1104
805 East Chestnut
821 East Chestnut
806 E. Chestnut St
111 Woodlawn
#1
#2
#3
#4
#5
North Fork Stone Creek
Ken Adams Plumbing sewer access to East Chestnut
818 E Chestnut Tony Dickman
830 East Chestnut St Parkes

SOUTH



PICTURE #1

STREET VIEW OF 830 EAST CHESTNUT

NORTH



HPA for Stone Creek

WDFW priority habitat

PICTURE #2

OUR PROPERTY VIEW OF 830 EAST CHESTNUT ST FROM OUR HOUSE



PICTURE #3

NORTH

OUR PROPERTY VIEW OF 830 EAST CHESTNUT
STANDING ON

PICTURE #4



EAST

PICTURE #5



FERN

STREETVIEW OF OUR PARCEL # 360728710516

PROPOSED SITE TO BRING OUR SEWER LINE / KEN ADAMS PLUMBING

PICTURE #6

SOUTH

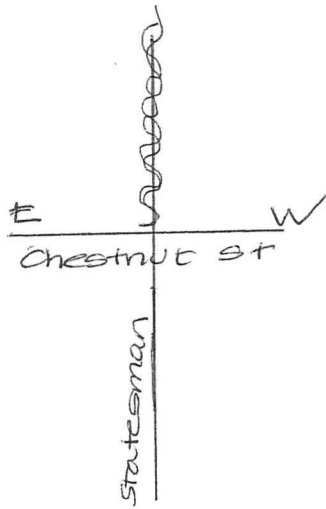


DRIVEWAY ENTRANCE TO 830 EAST CHESTNUT FROM THE ROAD

PROPOSED SEWER LINE ACCESS BY KEN ADAMS PLUMBING FROM OUR HOME (DRIVEWAY) TO CHESTNUT ST.

PICTUREE #7





Maple 15 feet behind east most sycamore

Sycamor

Sycamor

Sycamor

Sycamor

Frontage showing four mature Sycamore trees spaced 13-15 feet apart making trenching infeasible/ Ken Adams Plumb

ar-6055 **Pgs. 89-736**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: Walla Walla 2046 - Comprehensive Plan Update - Public Hearing

Submitted For: Lisa Wasson-Seilo, Development Services Department

Financial Comments:

N/A

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

Public hearing for the Periodic Comprehensive Plan Update - Walla Walla 2046

Information

HISTORY:

The City of Walla Walla is required to conduct a periodic review update of its Comprehensive Plan every 10 years, per RCW 36.70A (Growth Management Act), and complete the update by December 31, 2026. The project was kicked off with consultants, SCJ Alliance, in October 2024. Public engagement for the project began in January 2025, with orientation interviews with 20 key community stakeholders. A visioning survey was open from June 2025 through January 2026, and two open houses were held at the Walla Walla Public Library on July 10, 2025 and October 15, 2025. City staff spoke to and delivered comprehensive plan presentations to 9 local organizations from August 2025 to March 2026, and mini poll surveys were open from January to February 2026. A complete list of public engagement events can be found below.

The City Council and Planning Commission held a joint work session on November 3, 2025 to review and discuss the draft comprehensive plan.

The City accepted comprehensive plan map amendment applications as part of the City's required periodic update until the established deadline of July 1, 2025. There are seven site-specific amendments to the comprehensive plan land use map and a complete list is attached to this agenda report.

On April 2, 2026, the draft comprehensive plan update and development regulations were submitted to the Washington State Department of Commerce and other state agencies for the 60-day state review period. The City issued an adoption addendum to its State Environmental Policy Act (SEPA) determination of the City of Walla Walla Comprehensive Plan, Walla Walla 2040, and the Final Environmental Impact Statement (FEIS), on April 30, 2026. On July 1, 2026, the Walla Walla Valley Metropolitan Planning Organization Policy Board approved the plan review and certification.

Staff presented a preliminary review draft of the Plan to the Planning Commission on June 1, 2026, and the Commission held Public Hearings on the draft comprehensive plan on June 1, 2026; June 22, 2026; and July 6, 2026. Additionally, the Planning Commission held public meetings on the comprehensive plan update on March 3, April 13, May 4, June 1, June 22, July 6, and August 3, 2026. The Planning Commission made its recommendation on the periodic update to the comprehensive plan and development regulations on August 3, 2026.

Event Date	Event Type	Event Location
November 4, 2024	City Council Work Session and Planning Commission Workshop	City Hall
January 28 – February 6, 2025	Orientation interviews with 20 key community stakeholders	Virtual
March 3, 2025	Planning Commission Workshop	City Hall

May 17, 2025	Return to the River Event	Walla Walla Community College
June 5, 2025	West Ward Community Party and Town Hall	Washington Park
June 10, 2025	Windermere “State of the City” Presentation	Windermere Real Estate Office
June 17, 2025	Presentation to City Leadership Team	City Hall
July 10, 2025	Kickoff Open House	Walla Walla Public Library
August 5, 2025	Presentation to Hayden Homes	Virtual
September 8, 2025	Presentation to Blue Mountain Action Council	Virtual
September 18, 2025	Presentation to Walla Walla Valley Association of Realtors	Association of Realtors’ Office
September 25, 2025	Presentation to Walla Walla Noon Rotary	Elks Lodge
October 1, 2025	Presentation to Walla Walla Sunrise Rotary	St Francis Church
October 15, 2025	Open House	Walla Walla Public Library
November 3, 2025	Joint Planning Commission and City Council Work Session	City Hall
November 4, 2025	Presentation to Home Builders Association of Tri-Cities and Walla Walla	Community Room at Police Station
March 5, 2026	Presentation to Walla Walla High School Latino Club	Walla Walla High School
March 18, 2026	Presentation to Walla Walla Downtown Foundation and Downtown stakeholders	Marcus Whitman Hotel

*Please note: Due to a withdrawal of an application for a comprehensive plan future land use map amendment associated with parcel #'s 360731510205 and 360731310052, the future land use map in the Walla Walla 2046 Comprehensive Plan, will be updated prior to the regular meeting on October 28, 2026, when Council will take action.

POLICY ISSUES:

As required by RCW 36.70A, the City is to conduct a periodic review of its Comprehensive Plan and update it accordingly. The planning horizon for the Comprehensive Plan is the next 20 years, until 2046. The goals, policies, and implementation strategies will set the overall direction for the City during this 20-year planning horizon.

The staff report to the Planning Commission outlines the policy issues, compliance with the Growth Management Act, and, for the individual future land use map amendments, compliance with the City's draft plan.

Common themes heard throughout the process include:
1. Housing affordability and diversity of housing types: We don't have enough housing to meet our current and future demand.
2. Recruitment and retention of a strong workforce depends on providing attainable housing and supportive services. Walla Walla's long-term prosperity depends on attracting new businesses and growing family-wage jobs, so that the local economy becomes increasingly self-sustaining.
3. Arts in the City is a cultural asset that should be celebrated, protected, and uplifted.
4. Environmental quality and climate resilience: concerns about resource management, wildfire risk, and sustainability.
5. Transportation safety and accessibility, with residents seeking more sidewalks, bike lanes, and transit service.

Walla Walla 2046 — Comprehensive Plan includes goals, policies, and implementation strategies addressing the common themes identified above.

PLAN COMPLIANCE:

STRATEGIC PLAN:
Livability - Objective 1 - Address the housing needs within the community (see needs assessment Regional Housing Action Plan).

Economic Health - Objective 1 - Collaborate with local and regional partners to achieve economic resilience in the Walla Walla Valley.

COMPREHENSIVE PLAN:
Please see Walla Walla 2046 - Comprehensive Plan update and Future Land Use Map Amendments for plan compliance.

ALTERNATIVES:
Public hearing only - no action.

STAFF RECOMMENDATION:

Staff recommends that City Council open the public hearing and collect all public testimony.

CITY MANAGER COMMENTS:
Concur with the staff recommendation and approved to hold the public hearing.

Attachments

Walla Walla 2046 Comprehensive Plan
Ordinance 2026-XX - 2046 Comprehensive Plan
SEPA Adoption Addendum - Walla Walla 2046 Comprehensive Plan
Comprehensive Plan Future Land Use Map Amendments



2046 Walla Walla Comprehensive Plan

Ordinance 2026-XX

October 28, 2026

City of Walla Walla

SCJ Alliance

Project Information

Project:	City of Walla Walla Comprehensive Plan Update
Prepared for:	City of Walla Walla 15 N 3rd Ave Walla Walla, WA 99362



Acknowledgements

City Staff

City Manager - Elizabeth F. Chamberlain, AICP

Deputy City Manager – J Preston Frederickson

Community Development Deputy Director – Emily Arteche, AICP

Senior Planner - Jonathan Maland, AICP

Senior Planner - Lisa Wasson-Seilo

Administrative Permit Coordinator - Pamela Ransier

City of Walla Walla Planning Commission

Jeff Strickler

John Gahbauer

Kristin Jensen

Liz Jessee

Jennifer Walden

Arlene Alen

Jim Williams

Monte A. Willis- City Council representative

City Council Members

Mayor Gustavo Reyna

Mayor Pro Tempore Steve Moss

Councilmember Rodney Outlaw - Central Ward

Councilmember Rick Eskil - South Ward

Councilmember Monte A. Willis - East Ward

Councilmember Jeffrey Robinson - West Ward

Councilmember Emily Brown

Table of Contents

Background Information 1

Geography 1

History 1

Vision Statement 3

Plan Structure, Use, and Success 4

Washington's Growth Management Act (GMA) 4

Plan Components and Structure 4

Plan Intended Use 5

Plan Success 5

Element Summaries 6

Public Outreach and Engagement 6

Community Character 6

Land Use 6

Housing 7

Economic Development 7

Historic Preservation 7

Parks and Recreation 7

Environment and Natural Resources 8

Shoreline 8

Transportation 8

Capital Facilities and Utilities 9

Climate Resilience 9

Public Outreach and Engagement 10

Public Involvement 10

Key Takeaways from Engagement 17

What We Heard 19

Community Character 20

Introduction 20

Today and Tomorrow 20

Goals and Policies 27

Translating Policy into Action 29

Land Use **30**
Introduction 30
Today and Tomorrow 30
Walla Walla's Plan 34
Future Land Use Map 35
Goals and Policies 36
Translating Policy into Action 39
Housing **40**
Conditions Today 40
Housing Conditions 45
Goals and Policies 54
Translating Policy into Action 56
Economic Development **57**
Introduction 57
Today and Tomorrow 57
Goals and Policies 67
Translating Policy into Action 70
Historic Preservation **71**
Introduction 71
Funding 74
Today and Tomorrow 75
Walla Walla's Plan 78
Goals and Policies 79
Translating Policy into Action 81
Parks and Recreation **82**
Introduction 82
Today and Tomorrow 83
Walla Walla's Plan 87
Parks and Recreation Inventory Map 88
Goals and Policies 89
Translating Policy into Action 92
Environment and Natural Resources **93**
Introduction 93
Today and Tomorrow 93

Walla Walla's Plan 116
Goals and Policies 117
Translating Policy into Action 119
Shoreline 120
Introduction 120
Goals and Policies 122
Translating Policy into Action 131
Transportation 132
Introduction 132
Existing Conditions 133
Future Conditions 141
Transportation Improvements 145
Funding 151
Transportation Standards Summary 158
Goals and Policies 162
Translating Policy into Action 166
Capital Facilities and Utilities 167
Introduction 167
Today and Tomorrow 168
Walla Walla's Plan 184
Goals and Policies 184
Translating Policy into Action 187
Climate Resilience Element 188
Introduction 188
Today and Tomorrow 190
Walla Walla's Plan 197
Maps 197
Goals and Policies 203
Translating Policy into Action 207
Appendices A1
References A412

Table of Figures

Figure 1. Engagement Board at the Summer Open House....14
Figure 2. The scene at the Fall Open House....15
Figure 3. Community Character Map....21
Figure 4. Walla Walla Population Over Time....30
Figure 5. Future Land Use Map....35
Figure 6. Age Distribution in the City of Walla Walla and Washington....41
Figure 7. Renter and Owner-Occupied Households by Size....43
Figure 8. Household Income Categories - The City of Walla Walla....44
Figure 9. Housing Units by Type....46
Figure 10. Alignment Between Household Sizes and Size of Units in the City of Walla Walla....47
Figure 11. Cost Burden by Housing Tenure, the City of Walla Walla....48
Figure 12. Market Asking Rent for Multifamily Apartments....48
Figure 13. Renter Cost Burden by Income Category....49
Figure 14. The City of Walla Walla Median Home Price, 2015-2025....50
Figure 15. Owner Cost Burden by Income Category....50
Figure 16. Areas of Economic Activity in the City of Walla Walla....58
Figure 17. The City of Walla Walla Jobs by Sector, 2012-2022....59
Figure 18. Washington State Workforce Development Areas....61
Figure 19. Historic Preservation Sites....76
Figure 20. City Parks and Recreation Areas....88
Figure 21. Wetlands and Surface Water Map....107
Figure 22. Frequently Flooded Areas Map....109
Figure 23. Fish and Wildlife Habitat Conservation Areas Map....111
Figure 24. Geologically Hazardous Areas Map....112
Figure 25. Critical Aquifer Recharge Areas Map....113
Figure 26. Existing Bicycle Facilities....134
Figure 27. Existing Pedestrian Facilities and Conditions....135
Figure 28. Existing Transit Routes....136
Figure 29. Street Jurisdiction....137
Figure 30. Functional Classification....138
Figure 31. Existing Freight Routes....139
Figure 32. Bridge Conditions....140
Figure 33. Existing Traffic Signals and Other ITS Systems....141
Figure 34. Existing Study Intersection Operations/Conditions.....142
Figure 35. Bicycle Facility Improvement Opportunities....143
Figure 36. Pedestrian/ADA Priority Areas....144
Figure 37. Transportation Improvement Projects....146
Figure 38. Functional Class Hierarchy....158
Figure 39. Updated Freight Route Map.....159
Figure 40. Water Mains, Wells, and Sewers Map....172
Figure 41. Aerial of the Walla Walla Regional Airport....182
Figure 42. Climate Impacts in Walla Walla....190
Figure 43. Historical Annual Average Temperatures, City of Walla Walla....191
Figure 44. Climate Vulnerability Framework....195
Figure 45. Percent of Low-Income Population by Census Block Group....197

Figure 46. Percent of Population Over 65 Years by Census Block Group 198
Figure 47. Heat Severity, Tree Canopy, and Green Spaces in Walla Walla 199
Figure 48. Wildfire Risk Reduction Zones 200
Figure 49. Aboriginal Title Lands Map 201
Figure 50. Traditional Use by the Cayuse, Umatilla, and Walla Walla Tribes Map 202

Table of Tables

Table 1. Community Character Implementation Action 29
Table 2. Acreage of Land by Zone 31
Table 3. Acreage of Land Designated by Purpose 32
Table 4. Land Use Implementation Action 39
Table 5. Population Over Time, 2000-2025 40
Table 6. Households with a Senior Householder in the City of Walla Walla 41
Table 7. Gender, Race, and Ethnicity 42
Table 8. Housing Structures by Decade Built 45
Table 9. Renter Households Affording Median Rent 49
Table 10. The City of Walla Walla Housing Capacity by Income Band, 2020-2046 52
Table 11. The City of Walla Walla Housing Capacity by Income Band Detail, 2020-2046 52
Table 12. Existing Housing Stock 53
Table 13. Housing Implementation Actions 56
Table 14. Employment Forecasts by Sector, Eastern Washington Workforce Development Area 62
Table 15. Employment Land Capacity in the City of Walla Walla, 2026-2046 64
Table 16. Economic Development Implementation Actions 70
Table 17. Inventoried and Registered Resources 75
Table 18. Historic Preservation Implementation Action 81
Table 19. Parks and Recreation Implementation Action 92
Table 20. Water Resource Planning Efforts 100
Table 21. Impaired Waterways 104
Table 22. Environment and Natural Resources Implementation Actions 119
Table 23. Shoreline Implementation Actions 131
Table 24. Summary of Proposed Projects by Category 146
Table 25. 20-year Transportation Funding Estimates 152
Table 26. Proposed Projects- Total Cost Estimate 152
Table 27. Project List 154
Table 28. City of Walla Walla Operational Standards 160
Table 29. Transportation Policy Implementation Timeline and Responsibility 166
Table 30. Population in the City of Walla Walla by Year 168
Table 31. City-Owned Services, Facilities, and Functional Plans 169
Table 32. Forecast Water Use (With Conservation) by Millions of Gallons per Day 171
Table 33. Future Needs and Adopted Level of Service by Facility Type 180
Table 34. Capital Facilities Documents Update Schedule 187
Table 35. Precipitation Drought in Walla Walla County 192
Table 36. Wildfire Danger in Walla Walla County 193
Table 37. Total Annual Precipitation Projections 194
Table 38. Climate Resilience Implementation Action and Responsibility 207



Background Information

Geography

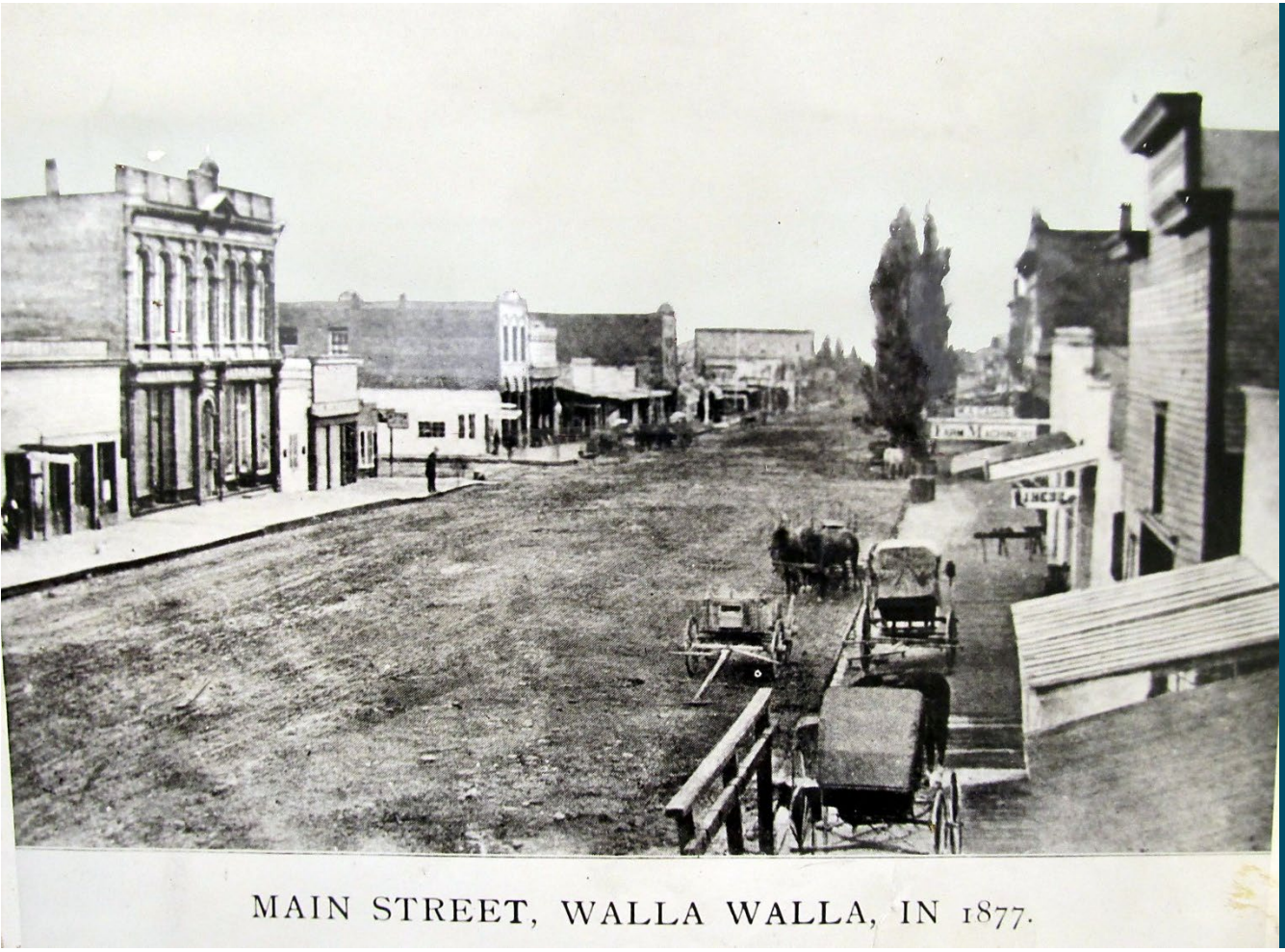
The City of Walla Walla, in Walla Walla County, sits in the southeastern quadrant of Washington State, near the borders of Oregon and Idaho. It is located between the Cascade and Rocky Mountains in the Columbia Basin. The characteristics of the topography are a result of past geologic epochs (Miocene and Pleistocene) that created the east-west trending series of folded rock layers that resulted in the existing terrain called the Yakima Fold Belt. It is these series of folded, and subsequently faulted, layers that provide much of the valley with its sole water source and the City with an important supplement to its primary source, which is Mill Creek. The City's location reinforces it as a tight-knit urban settlement sitting in the lap of the remarkably diverse and productive agricultural Walla Walla Valley. The City of Walla Walla is and has always been self-reliant.

Mill Creek traverses east-west through the City of Walla Walla and through College Place before its confluence with Walla Walla River. Walla Walla means "many waters" in the Sahaptin language of the local Native American tribe. The city of many waters includes various tributaries of the Walla Walla River including Mud Creek, Yellowhawk Creek, Birch Creek, Cottonwood Creek, Caldwell Creek, Russell Creek, and various other small streams.

History

Walla Walla's site was a traditional meeting place for Native American tribes of the region. This location was in the path of Lewis and Clark's Corps of Discovery and contact with local tribes was made in October 1805 and again in April 1806. Fur traders established what would become Fort Walla Walla near the confluence of the Walla Walla and Columbia Rivers in 1818, and the Whitman Mission was established in 1836. Walla Walla County was established in 1854, and the Treaty of 1855 was signed one year later, forcing the tribes onto reservations and out of the desirable Walla Walla Valley. The United States military established a military fort also bearing the name of Fort Walla Walla on the site of the current Jonathan M. Wainwright VA Medical Center in 1858, and the community of Walla Walla began forming adjacent to the fort.

At its incorporation in 1862, Walla Walla was principally involved in supplying miners in Idaho but by the late 1880s, railroads and the side hill harvester transformed the economy and the rolling hills surrounding Walla Walla into vast wheat fields.



MAIN STREET, WALLA WALLA, IN 1877.

Agriculture continues to be an important economic player in the Valley. Wheat is still king, but it is joined by livestock and other crops, including fruits and vegetables. The development of the signature Walla Walla onion and the emergence of grapes and wine production have more recently further diversified Walla Walla's bounty and added to its appeal as a destination for tourists as well as residents.

Many buildings within the City of Walla Walla that date back to the 1800s and early 1900s have been restored and are being used as restaurants, galleries, shops, and wine tasting venues.

As the Cradle of Northwest History, Walla Walla created and has sustained a diverse and active culture, supporting the longest-continuously operating symphony orchestra west of the Mississippi; Whitman College, a top-ranked liberal arts college; Walla Walla County Fairgrounds historic Fort Walla Walla and Fort Walla Walla Museum; and an award-winning Main Street program downtown.

Walla Walla Then and Now

Walla Walla has grown into a stable and proud community. While its remote location initially helped to define it as a community, it is ever more accessible in the 21st century, with daily flights to and from Seattle, ensuring its continued evolution. Through this Comprehensive Plan, Walla Walla seeks to take charge of its future, building on its past and present for a sustainable future.



Vision Statement

Walla Walla — the best of the best of the Northwest.

Residents see Walla Walla as a tourist destination, a farming hub, a college town and a retirement community, often all at once. They agree that the City's natural character is what makes Walla Walla unique and worth preserving. It's what draws people here, encourages them to stay, and welcomes them home after time away. Without that natural character, Walla Walla would be just another small city.

The elements of the comprehensive plan together portray a Walla Walla that:

- Preserves its identity and livability while adapting to change.
- Is inclusive of all people and celebrates its diverse community.
- Fosters an atmosphere of economic diversity.
- Preserves and builds on its history and culture.
- Enhances the natural environment.
- Supports transparency and collaboration in government.





Plan Structure, Use, and Success

Washington's Growth Management Act (GMA)

The Growth Management Act (GMA) is a Washington State law that guides how communities plan for growth. It requires the city to develop and adopt a comprehensive plan and establish a framework for managing growth, protecting resources, and coordinating public services. Adopted in 1990, the GMA sets specific requirements for adopting, amending, and periodically reviewing the plan. We must regularly evaluate our plan to ensure it aligns with Statewide goals and that it remains responsive to our changing conditions.

Plan Components and Structure

Each element of this Plan contains goals, followed by policies that support those goals. Elements also include policy connections to illustrate how they relate to and reinforce other elements in the Plan. In addition, the Plan provides guidance on how policies translate into action, outlining the City's approach to implementation over the lifespan of the Plan. Appendices offer detailed data and analysis that inform and provide context for the goals and policies and all source citations referenced throughout the Plan are compiled in the References section.

- Goals describe the outcomes the City aims to achieve over the 20-year life of the Comprehensive Plan, i.e., the year 2046. They express our long-term aspirations, whether stated as measurable targets or general directions for future change. Goals are not guarantees or mandates; they represent what we are striving toward over time.
- Policies should be understood as if they begin with "Our general approach is to…" Policies provide guidance for developing or revising specific rules and strategies, such as development regulations, budgets, and program or facility plans. When city officials make decisions, they typically rely on ordinances, resolutions, budgets, or plans that incorporate and reflect the Comprehensive Plan's policies, rather than referring directly to the Plan itself.

Plan Intended Use

The Plan is intended to be used by the entire community. Residents, businesses, developers, city staff, and city officials can rely on this plan to understand and support the city's long-term vision. It serves as our 20-year guide for how we will grow and change through 2046.

Because the Comprehensive Plan is a long-range policy document, it is not a regulatory code. Instead, it provides direction for future updates to development regulations, public investments, and local programs. As a broad blueprint, the Plan may not align perfectly with every individual permit decision. The Walla Walla Municipal Code is the primary tool for implementing the Plan's goals and policies. When zoning regulations and the Comprehensive Plan conflict, Washington law requires that zoning govern land use decisions.

Plan Success

Looking ahead to 2046, the success of this Plan means:

- Transit access, pedestrian and bicycle safety, and regional connectivity support mobility and accessibility.
- Transportation, utilities, and public services serve the community.
- Growth reflects the city's identity, including its historic core, distinctive neighborhoods, and human-scale design.
- Housing is available and attainable across income levels and life stages, and existing neighborhoods are strong and vibrant.
- The local economy is resilient and diverse, supporting industries from agriculture and wine to small businesses and emerging sectors of technology and manufacturing.
- Climate considerations are integrated into the city.
- Transit access, pedestrian and bicycle safety, and regional connectivity.
- City staff and officials use the Plan to guide the development of municipal code regulations.





Element Summaries

The 2046 Comprehensive Plan Elements are briefly described below. Each Element can be understood on its own, but they are best viewed in the context of the City's Vision Statement and as interconnected components of the Comprehensive Plan, including its supporting appendices and references.

Public Outreach and Engagement

The Public Outreach and Engagement section highlights how community input actively guided the development of the Comprehensive Plan. Through meaningful engagement, residents helped shape the planning process itself, and their feedback directly informed the goals and policies found throughout the other elements. This section reflects the essential role the community played in setting the direction for Walla Walla's future.

Community Character

The Community Character Element addresses the look and feel of Walla Walla and how people interact with their environment and each other. The policies in this section will help ensure that as Walla Walla continues to grow, the character remains unchanged.

Land Use

The zoning code is largely grounded in the Land Use Element. Its goals and policies guide responsible growth by directing development to areas with services, coordinating planning within the Urban Growth Area, supporting a range of housing and mixed-use options, and ensuring compatibility between land uses. Together, these principles help maintain quality of life, protect natural resources, and promote healthy, connected, and equitable neighborhoods.



Housing

Walla Walla faces a growing need for housing across all income levels, including households with extremely low, very low, low, and moderate incomes. Statewide projections show significant demand for new affordable homes, especially for residents in the lower income bands. The Housing Element responds to this need by supporting a wider range of housing types, increasing the community's ability to meet projected housing demand and offering more affordable options for all households.



Economic Development

The Economic Development Element focuses on sustaining the City of Walla Walla's long-term prosperity. While agriculture, tourism, the arts, education, and downtown commerce remain core strengths, the goals and policies support diversifying the economy by encouraging growth in stable, year-round sectors such as light manufacturing, technology, professional services, skilled trades, creative industries including film and media production, and value-added agriculture.



Historic Preservation

The City of Walla Walla's historic character is reflected in the architecture of its downtown and original neighborhoods. The Historic Preservation Element carries forward the goals and policies from the City's Historic Preservation Plan, focusing on protecting significant buildings and celebrating the community's heritage. This element supports continued recognition through local and national listings and encourages the repair and rehabilitation of historic and contributing properties.



Parks and Recreation

The City of Walla Walla's parks and recreation system is one of the community's most valued assets. The Parks and Recreation Element carries forward the goals and policies from the Parks and Recreation Comprehensive Plan, focusing on maintaining the high level of service provided

by existing parks, facilities, and programs. It also supports planning for future needs as the community grows and recreation preferences evolve.



Environment and Natural Resources

The Environment and Natural Resources Element focuses on the City of Walla Walla's natural setting. Policies center on protecting water, air, soil, and other features of our natural environment for now and the future by meeting current needs without sacrificing the needs of future generations.



Shoreline

The City of Walla Walla's Shoreline Master Program (SMP) is captured within the Shoreline Element. The goals and policies carried forward from the SMP focus on preventing harm from uncoordinated shoreline development while also protecting the rights of property owners. Together, they guide balanced, responsible stewardship of the city's shoreline areas.



Transportation

Safe, multi-modal, well-connected transportation systems within the City of Walla Walla are the main goals of the Transportation Element, which is a condensed version of the full Transportation Plan developed in tandem with the Comprehensive Plan.

Capital Facilities and Utilities

The Capital Facilities and Utilities Element is centered upon ensuring that the City of Walla Walla will have adequate public facilities and utilities to provide for future growth while maintaining high levels of service for residents and customers.

Climate Resilience

The Climate Resilience Element outlines the City of Walla Walla's goals and policies to prepare the community for climate related risks. It emphasizes strengthening community resilience, protecting people and infrastructure, and adapting to changing conditions. This work supports Washington State's broader climate resilience goal by aligning local actions with statewide efforts to build safer, more resilient communities and to help meet emission-reduction targets by 2050.



Public Outreach and Engagement

Public Involvement

Engagement activities were conducted throughout 2025 and early 2026 to share information, gather input, and involve residents, stakeholders, and decision-makers in the Comprehensive Plan update. These efforts included stakeholder interviews, an online community survey, mini polls, open houses, written comments, and ongoing presentations and outreach.

Early engagement began with orientation interviews, which helped identify key issues and priorities. Broader outreach was achieved through open houses, the online survey, and targeted efforts, providing multiple opportunities for participation. Materials for major public events were available in both English and Spanish to support broader access.

The City also conducted presentations with boards, commissions, community organizations, and partner agencies, and accepted written comments throughout the process. Together, these efforts provided a strong foundation of input to guide the plan. To see full results and an in-depth summary, refer to Appendix VII. Engagement Report.



Engagement Activity & Response Summary

The comprehensive plan public engagement survey was available for approximately six months and received 281 complete responses and 185 partial responses. Four mini polls that were focused on community vision, community character, economic development, and housing each received more than a hundred responses. Orientation interviews included 20 stakeholders representing a broad range of perspectives.

The July 2025 open house collected 243 penny poll votes, and the October 2025 open house collected 147, providing the public with additional opportunities to review and respond to emerging ideas. The City also conducted over 40 presentations and targeted outreach with more than 20 different agencies and organizations to broaden participation and gather additional input.

Stakeholder Interviews

Orientation interviews were conducted with 20 stakeholders in early 2025. Participants represented a broad cross-section of community interests, including business, housing, education, healthcare, transportation, historic preservation, and social services.

Housing was consistently identified as a top priority. Stakeholders noted a shortage of housing across income levels and household types, along with barriers related to infrastructure, cost, and regulatory requirements. Many emphasized the connection between housing availability and the ability to attract and retain workers.

Key Priorities

- **Economic disparities persist**
- **Growth is uneven and constrained**
- **Water resources are under pressure**
- **Cultural amenities are improving**
- **Economic sustainability is uncertain**
- **Coordination and communication need improvement**

Transportation was also a key topic. While recent improvements were recognized, stakeholders identified ongoing needs related to transit access, pedestrian and bicycle safety, and regional connectivity. Economic development discussions focused on diversifying the local economy, supporting family-wage jobs, and strengthening coordination among local partners.

Stakeholders also discussed parks, facilities, and community identity. Walla Walla's parks system and overall quality of life were viewed as strengths, though participants noted opportunities to expand access, improve connectivity, and better reflect the community's cultural diversity.

Community Survey and Mini Polls

The community survey and mini polls provided a broad snapshot of community priorities and concerns. Survey responses highlighted strong support for maintaining Walla Walla's character while planning for future growth. Respondents identified pace of life, community identity, and access to nature as defining qualities of the city. Many emphasized the importance of supporting local businesses, maintaining a vibrant downtown, and providing a mix of housing options.

Respondents indicated that there are not enough rental and ownership options to meet community needs, and many reported challenges related to availability, cost, and quality. Responses to questions about future housing showed a range of perspectives, reflecting both recognition of the need for additional housing and differing views on where and how growth should occur.

Survey results also identified concerns related to growth, including increased demand for services, rising costs, traffic, and environmental impacts. In addition, respondents expressed interest in expanding economic opportunities, improving parks and recreation access, and maintaining the community's overall livability.

Key Priorities

Community Character

- **Pace of life (23.4%), identity (19.8%), and access to nature (19.7%) are top community values.**
- **Parks generally meet needs (24.3%), with demand for accessibility (14.3%) and trails (13.8%).**

Community Vision

- **Vision alignment is strong, with 56.1% rating it "well" or "spot on".**
- **Preserving identity while adapting (29.1%) and inclusivity (21.3%) are top priorities.**
- **Perceptions of transparency (21.8%) and inclusivity (19.7%) are mixed.**
- **Supporting local businesses is widely valued (78.5%), more than transportation access (37.1%).**
- **Growth concerns center on services (19.4%), housing (17.0%), and traffic (16.2%)**

Housing

- **Most respondents own (65.0%) or rent (31.2%) their homes.**
- **Housing supply is insufficient across incomes (62.5% rental, 68.7% ownership).**
- **Affordability is a key issue (17.0%), especially for younger residents (26.1%).**
- **Rental challenges include availability (21.5%) and quality (17.5%).**

- Preferences are mixed with support for all housing types (31.0%) and limiting neighborhood growth (29.5%).

Economics and Workforce

- Desired growth industries include agriculture (19.6%), retail (18.6%), and healthcare (16.7%).
- Retaining young people depends on housing (26.1%), jobs (20.5%), and local businesses (20.3%).
- Business support priorities include amenities (17.2%), training (15.6%), and incubators (15.2%).



Summer Open House

The first open house was held on July 10, 2025, at the Walla Walla Public Library. The event introduced the planning process, shared information about upcoming opportunities for involvement, and invited participants to provide input through interactive activities. Materials were provided in both English and Spanish.

The open house included a penny poll, map-based activities, and open-ended comment opportunities. Housing affordability and availability received the highest level of interest in the penny poll, followed by social services and economic vitality. Additional topics receiving support included environmental protection, parks and recreation, and infrastructure.

Participants also provided location-based feedback on large maps and shared input on what makes Walla Walla unique. Comments highlighted the importance of housing, transportation improvements, local businesses, and maintaining a safe and connected community.

Key Priorities

- **Strong support for existing investments and expanding parks and infrastructure.**
- **Desire to diversify the economy beyond tourism and support local businesses.**
- **Housing affordability and availability are urgent concerns.**
- **Preference for infill development and more transparent, equitable land use decisions.**
- **Need for more parks, recreation options, and neighborhood access to open space.**



Figure 1. Engagement Board at the Summer Open House



Figure 2. The scene at the Fall Open House

Fall Open House

A second open house was held on October 15, 2025, at the Walla Walla Public Library. The event provided an update on the planning process and allowed participants to review and comment on emerging ideas.

Housing affordability and availability again ranked as the highest priority. Parks and recreation, environmental considerations, and transportation were also identified as important topics. Written comments emphasized support for infill development, interest in additional housing options such as accessory dwelling units, and the importance of preserving historic character.

Participants also identified needs related to pedestrian and bicycle infrastructure, traffic calming, utilities, and continued investment in existing neighborhoods.

Key Priorities

- Strong interest in affordable, flexible housing solutions, including ADUs and small-scale housing types.
- Preference for infill development and limiting expansion of the Urban Growth Area.
- Support for economic development that combines local business growth with community benefit.
- Emphasis on environmental protection, including floodplains, agriculture, and watershed health.
- Desire for expanded parks, trails, and recreation opportunities for all ages.

Written Comments

The City received written comments from community members throughout 2026. These comments reflected interest in staying informed and involved, while also raising specific ideas and concerns related to housing, redevelopment, downtown conditions, economic development, and quality of life.

Several comments focused on practical strategies to support development, including reducing barriers to housing, encouraging redevelopment in targeted areas, and addressing parking and infrastructure needs. Others highlighted concerns related to noise, air quality, and overall community livability.

These comments provided additional input from community members who may not have participated in other engagement activities and helped reinforce key themes identified throughout the process.

Key Priorities

- **Strong interest in staying informed and involved in the planning process.**
- **Housing affordability and redevelopment are key concerns.**
- **Downtown parking and economic development remain ongoing issues.**
- **Environmental factors like noise and air quality are important to residents.**
- **Overall quality of life is a central theme across feedback.**

City-Led Presentations

City staff conducted presentations and briefings throughout the planning process to share updates and gather input. These included Planning Commission and City Council meetings, community events, and presentations to local organizations, service clubs, schools, and development groups.

Staff also coordinated with tribal governments, state agencies, and regional partners by sharing draft materials and inviting feedback. Additional outreach included participation in community events and direct engagement with local organizations.

These efforts helped expand awareness of the Comprehensive Plan update, reach new audiences, and provide additional opportunities for input outside of formal public meetings.

Key Takeaways from Engagement

Housing

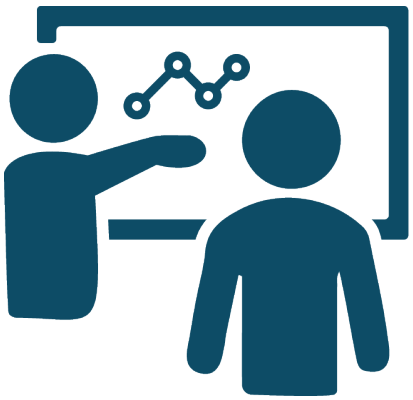
Housing was most consistently identified as a priority across interviews, surveys, open houses, and written comments. Residents and stakeholders described affordability and availability as major concerns, while also raising questions about where and how new housing should be accommodated.

- Housing affordability and availability were the top priority at both open houses.
- 62.5% of respondents said there are not enough rental housing options for a range of incomes and family sizes.
- 68.7% of respondents said there are not enough ownership housing options for a range of incomes and family sizes.
- Stakeholders identified housing affordability as one of the most urgent issues facing the community.

Community Character and Livability

Community members expressed strong interest in preserving the qualities that make Walla Walla distinct while planning for future growth. Comments repeatedly emphasized balancing change with quality of life, small-town character, and local identity.

- The pace of life (23.4%), community identity (19.8%), and access to nature and green spaces (19.7%) were the aspects of Walla Walla most important to respondents.
- The top growth concerns were increased demand for services (19.4%), housing affordability (17.0%), traffic congestion (16.2%), environmental impacts, and loss of small-town character (15.5%).
- Write-in comments emphasized affordability, public safety, parks and trails, a vibrant downtown, and preserving community character while managing growth.



Transportation and Connectivity

Transportation emerged as a recurring concern, particularly around safety, access, and connectivity. Community members and stakeholders alike identified the need for a more connected, efficient, and comfortable transportation system.

- Transportation access and safety were identified as one of the top three overall themes from the fall open house.
- 37.1% of respondents said it is very important that Walla Walla has public transportation and non-motorized modes of travel that are easily accessible and available, while 40.8% said this is somewhat important.
- Stakeholders noted ongoing needs related to transit access, pedestrian and bicycle safety, and regional connectivity.

Economic Opportunity

The engagement process showed broad support for a strong local economy that provides jobs, supports local businesses, and helps retain residents over time. Comments often linked economic opportunity to housing, affordability, and long-term community stability.

- Desired industry expansion included agriculture (19.6%), retail (18.6%), and healthcare (16.7%).
- The top priorities for retaining young people were affordable housing (26.1%), access to jobs (20.5%), and local businesses (20.3%).
- Respondents said business development would be best supported through amenities that attract business (17.2%), training programs (15.6%), and incubators (15.2%).
- Write-in comments emphasized economic diversification, living-wage jobs, streamlined permitting, affordable commercial space, and addressing vacant storefronts.



Parks, Recreation, and Environment

Parks, recreation, and environmental stewardship were important parts of how residents described both Walla Walla's identity and priorities for the future. Feedback showed support for maintaining and improving access to recreational amenities while also protecting natural systems.

- Parks and recreation and environmental protection both received notable support in open house engagement, and parks, recreation, and open space were identified as a top three theme at the fall open house.
- The top park improvement priorities were improved accessibility for all ages and abilities (14.3%) and more natural areas, habitat restoration, and/or trails (13.8%).
- 24.3% of respondents said Walla Walla's current parks and recreation amenities already meet their needs.
- Stakeholders described the parks system as a community strength, while also identifying opportunities to improve access and connectivity.

What We Heard

Taken together, the engagement results show that residents want Walla Walla to remain livable, distinctive, and community oriented as the city grows. Across engagement methods, people consistently pointed to the need for more housing options, better affordability, safer and more connected transportation, strong local economic opportunity, and continued investment in the places and qualities that define Walla Walla.





Community Character

Introduction

This Element focuses on the community's physical qualities and the ways people experience the built environment. Community character emerges from the interplay of architectural styles, scenic views, streetscapes, transportation systems, parks and open spaces, special attractions, landmarks, and natural features.

Community character shapes the daily lives of Walla Walla residents and visitors, influencing physical activity, public health, personal safety, and economic vitality. Considering community character requires looking beyond appearance to understand how well the community functions. More broadly, community design is informed by other comprehensive planning elements and serves as a valuable tool for thinking holistically about a community while addressing a wide range of social and functional goals. The city's beauty and livability will be key to maintaining and attracting residents, visitors, and businesses.

Today and Tomorrow

Conditions Today

The City is known for its exciting history. Often referred to as the Cradle of Inland Northwest History, the City of Walla Walla's rich Native American heritage includes the Cayuse, Umatilla, and Walla Walla tribes. Pioneer history features include the Whitman Mission and Fort Walla Walla.

The City's unique and diverse neighborhoods include an active, pedestrian-oriented historic downtown, thriving residential areas, viable industrial areas, and a variety of open spaces. The City's edge and beyond is surrounded by agriculture and the foothills of the Blue Mountains. It is useful to think of these distinct areas as "character areas."

Character Areas Defined

Defining Character Areas helps us better understand the evolution of the city and its overall personality. Analyzing the components that define local neighborhoods also helps to guide future zoning as well as to preserve and celebrate the city's neighborhoods.

Character Areas are areas or districts with identifiable characteristics that contribute to the City's identity, livability, and diversity. The general locations of each area are identified on the accompanying map.

Methodology

Character areas were defined by reviewing the zoning map, land use plan, aerial photography, and field observations. Detailed characteristics may include land use, lot size, setbacks, building style, landscape, streetscape, age of development, signage, fencing, architectural appurtenances, and streets.

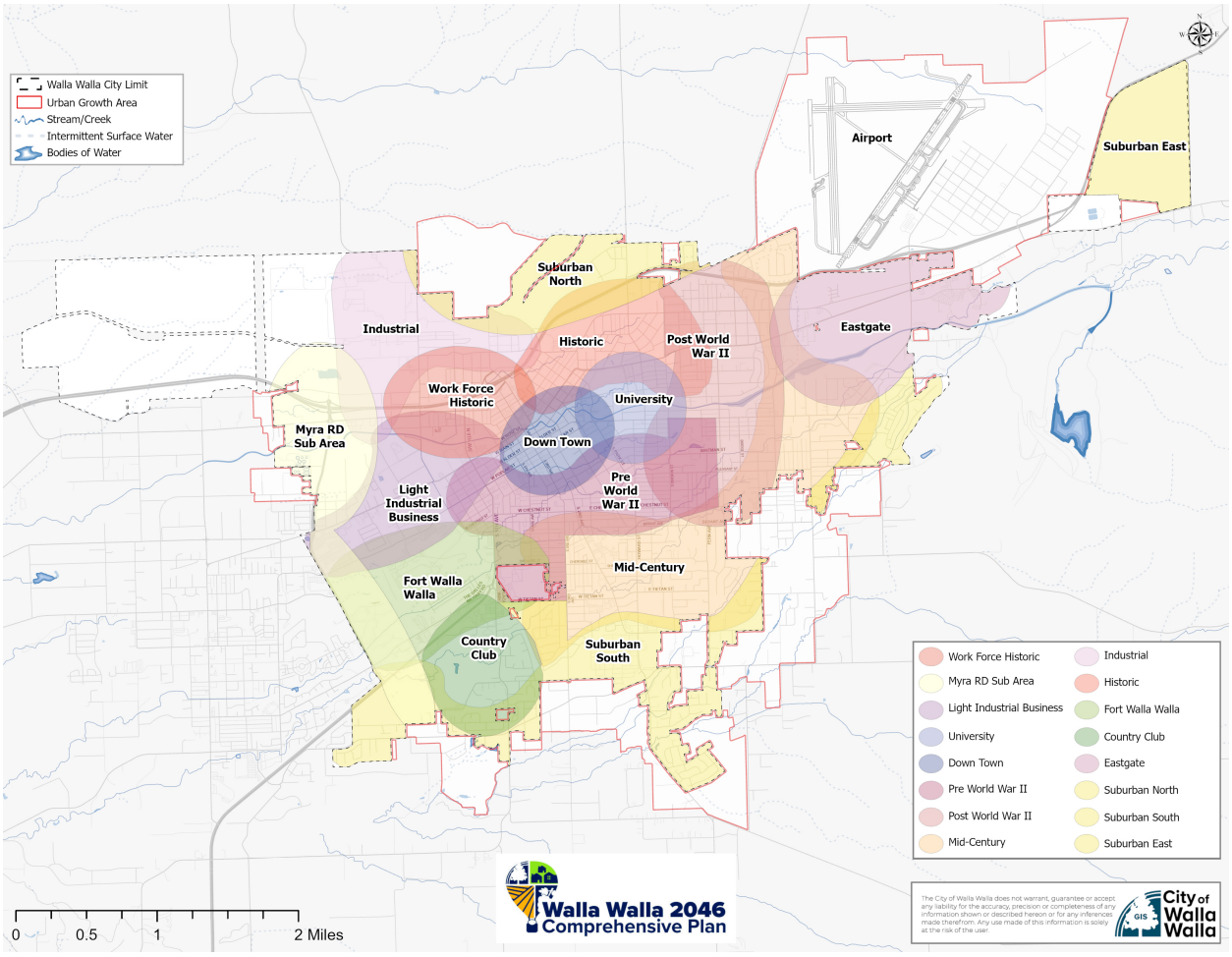


Figure 3. Community Character Map

Summary of Character Areas

Workforce Historic

The workforce historic area constitutes a district defined by pre-World War II cottage-style homes of approximately 600 - 1,200 square feet. There are few architectural details except for porches, and most homes are constructed of horizontal wood siding. The area is predominantly single-family residential, although some homes have been converted to duplexes. Front yard setbacks are small and closer to the street. Front yards are often fenced. Street improvements include sidewalks, wide right-of-way widths, and parking on both sides. Generally, trees in the streetscape are smaller in diameter.

Light Industrial/Business

The light industrial and business area is home to a variety of office and commercial businesses, as well as light industrial and warehousing. Large front and side yard setbacks are common. These areas are often used for outdoor storage and display of goods.

Land uses include auto-related, office, warehousing, sales, manufacturing, business park, and commercial. Structures within this area typically consist of metal siding, stucco, tilt-up concrete panels, and wood. Residential uses include multi-family residential as well as manufactured homes. As redevelopment occurs, streetscape and landscaping are incorporated.

Fort Walla Walla

The area surrounding Fort Walla Walla is defined by its expansive open spaces, mature vegetation, and strong institutional and historic character. Key facilities include a major veterans' medical center and related institutional uses, along with limited commercial activity and minimal residential presence. Buildings in the area tend to be large in scale and set back significantly from the street, reinforcing the spacious, campus-like environment.

Fort Walla Walla Museum occupies a portion of the Fort Walla Walla grounds and serves as a regional hub for interpreting local and Inland Northwest history. The broader Fort grounds offer a wide range of recreational amenities, including picnic shelters, reservable picnic areas, playgrounds, sports courts, and an extensive natural preserve with trails. Specialized facilities—such as remote-control vehicle areas, a BMX track, skate park, disc golf course, an amphitheater, and an off-leash dog park—add to the diversity of activities available.

The site also contains numerous commemorative and historic features, including war memorials, historic artillery pieces, a military cemetery, and the monument honoring Gold Star families. Together, these elements create a landscape that blends heritage, recreation, and institutional uses within a distinctive open-space setting.

Suburban North and South

The Suburban North and South areas are bound by the urban growth boundary and are expected to accommodate additional residential subdivisions. The South area includes

prominent community features such as the Walla Walla High School campus, currently in the UGA, and the public Mountain View Cemetery, while Suburban North includes the Veterans Memorial golf course. Lot sizes and setbacks are larger in some locations, reflecting the area's transitional character. Land uses consist of smaller pockets of agriculture and livestock, single-story ranch-style homes, and newer residential development concentrated along Taumarson Road and Cottonwood Road.

Streetscapes are minimal with new development offering curbs, gutters, sidewalks, and street trees. Many streets are unimproved and are drained by swales with no streetlights or sidewalks. Cul-de-sacs and irregular subdivision roads have replaced the adjacent urban street grid. In newer residential areas, the rear of homes and backyards face the collector streets, while the fronts of homes are served by internal, neighborhood streets. These residences typically have a privacy fence along the rear property boundary line, creating a walled effect along the collector streets.

Country Club

The Country Club area is primarily the private golf course and adjacent residential uses. Closest to the golf course, homes consist of 1960s to 1980s single-family and attached residences at higher densities than most suburban single-family residential. The area also includes newer residential developments and is accommodating further subdivisions and residential development. Open space and mature vegetation are characteristic landscape features. Sidewalks are present in newer developments and are lacking along Village Way, Country Club Road, Plaza Way, and other mid-to-late-century developments.

Mid-Century

The area offers a broad mix of uses, including single-family residential, multi-family residential, with stand-alone commercial and strip development along primary corridors, including South 2nd Avenue and Tietan Street. Building materials offer a mixture of stucco, brick, wood, and wood shingle siding. Porches are the main architectural feature.

Homes are a mix of styles from the 1920s to the 1970s, including craftsman, ranch, split-level, mid-century, and others. Mature street trees and lawns dominate the residential landscape and streetscape. Street parking is not predominant. Sidewalks are lacking on most residential streets, with the exception of the Meadow View and Neimeyers Eastview plats, situated southeast of Tietan Street and South 3rd Avenue, and west of South 2nd Avenue.

Pre-World War II

This area is characterized by pre-World War II homes, featuring residences of varying sizes on lots averaging 5,000 to 8,000 square feet. Development occurred between the late 1800s and the 1940s. Most buildings are clad in horizontal wood siding and display defining architectural elements such as porches, exposed rafters, decorative front entries, alley access, and columns.

Land uses are primarily single and multi-family residential, complemented by pockets of commercial mixed-use development. Commercial parking is often located at grade

within the planter strip, an area typically intended for landscaping while residential parking is generally provided at the rear via alley access or in detached garages positioned along extended driveways behind the home.

The street network follows a traditional urban grid. Streets are relatively wide, include generous planting strips, and accommodate on-street parking on both sides in some locations and on one side in others. Curbs and streetlights are present throughout. Mature street trees, along with abundant residential landscaping, strongly shape the neighborhood's visual character.

University

The area within the vicinity of Whitman College offers a mixture of homes, sizes, and styles, and many of them are stately and well-maintained. The University and Historic character areas overlap and contain similar features and styles. Front yard setbacks are small, creating a strong relationship with the street. The homes are generally older and include historic homes, with architectural styles including Tudor, Colonial Revival, American Foursquare, and others. Architectural features include historic details, porches, turrets, and balconies. Most are single-family with some multi-family homes, including the stately Clinton Court Apartments at Boyer Avenue and Clinton Street.

Characteristic sizes are in the range of 2,000 square feet or greater. Primary materials are horizontal wood siding, brick, and stucco. The residential landscape and streetscape are dominated by mature vegetation and include curvilinear streets with generous planting strips and mature street trees

Historic

The historic area constitutes a mix of house sizes and styles; however, there is a dominant historic flavor. This character area includes the historic Green's Park Addition, which was platted in 1903. Large multiple-story homes of wood construction with broad overhangs and grand porches characterize these buildings, dating back from the late 19th century through World War I. The neighborhood is reflective of the City Beautiful movement, and includes curvilinear, tree-lined streets with wide planter strips and mature street trees. The Green's Park Addition was platted around this new City Beautiful philosophy and was planned by community-minded developers who wanted to create a beautiful neighborhood. Homes were erected in popular styles of the time, including Classical, Colonial Revival, American Foursquare, and Arts and Crafts.

Post-World War II

Some lots are smaller, and homes are single-story. Homes were constructed in the 1950s to 1960s and are primarily built of wood and offer few architectural features and little detailing. Home sizes range from 800-1,200 square feet on lots that average 8,000 square feet. Some streets are laid out on a traditional grid, but others, such as Francis Drive, Boyer Drive, University, and Cambridge Drive, form a curvilinear network with cul-de-sacs. Setbacks are minimal, but they fail to create a strong relationship with the street. The landscaping strips are narrow, and street trees are minimal, although some feature sidewalks. Some streets are unimproved, lacking pedestrian access and on-street parking, including Wilson, White, Lewis, Clark, J, and K Streets. Driveways leading to carports are a common feature.

Eastgate

The Eastgate area includes a mixture of commercial, retail, strip mall development, higher-density residential, manufactured homes, mid and late 20th-century residential, and the Walla Walla Community College campus. Mill Creek and the recreational trail bisect the neighborhood. Commercial sites are dominated by parking areas and outdoor storage and offer minimal landscape. Collector streets support freestanding commercial buildings and commercial strips that are dominated by a wide variety of commercial signs.

Airport

Although not included in the city limits, the airport area, within the urban growth area, the airport area supports the Walla Walla Regional Airport, as well as industrial, commercial, and airport-related land uses. The airport also utilizes many of the original World War II base buildings with non-aviation uses in its industrial park, including a number of properties leased to wineries and other businesses. The area includes the Port of Walla Walla incubator buildings, which provide reasonably priced production space for startup beverage-related businesses to improve their chances for business success. The streets are unimproved with no pedestrian facilities, a sense of vast open space, and long sight lines to the Blue Mountains across the agricultural landscape.

Industrial

Historic warehouses and massive grain elevators visually dominate the industrial area. The Washington State Penitentiary campus is the northwestern corner, at the western edge of the city limits. Building construction is primarily single-story metal, concrete, or brick masonry. Land uses include newer warehousing and industry; there is a minimal amount of mixed-use, which includes a recreational trailer park. Wide streets, large setbacks, and no landscape or street trees characterize the area. There are pre-existing single-family residential uses in this area, which predate zoning ordinances and the construction of Highway 12.

Downtown

Downtown Walla Walla showcases a wide variety of architectural styles, many of them distinctive and historic. The area includes the Walla Walla Downtown National Historic District and an award-winning Main Street. Buildings are predominantly brick, multi-story structures. Land uses span mixed-use, commercial, residential, retail, office, hotel, and institutional spaces.

Many of the downtown structures date back to the late 1800s and early 1900s, giving the district a strong historic character. The streetscape is defined by minimal setbacks, at-grade parking, generous sidewalks, and mature street trees. Key public amenities include Heritage Square, Walawála Plaza, and Crawford Park, home to the Downtown Farmers Market and the transit center. Mill Creek weaves through the downtown, flowing both underground and above grade.



Challenges and Opportunities

Downtown as a Destination for All

Downtown should be an inclusive attraction where all people feel welcome, which will help integrate both residents and visitors of different cultures and income levels. Key to this strategy is maintaining our flexible gathering spaces for festivals and events, and updating as needed to meet evolving conditions.

Physical Conditions of Older Neighborhoods

The City's housing stock includes many homes constructed before World War II. As these neighborhoods age, they face challenges related to declining building quality and ongoing maintenance needs. To support continued reinvestment in public infrastructure, in particular streetscapes and pedestrian facilities, the City may consider a range of improvement programs. The City's Transportation Improvement Program identifies planned street upgrades, while the Community Development Block Grant provides funding opportunities for home repair projects.

Reintegrate Mill Creek as a Connecting Corridor Through the City

Restoring portions of Mill Creek to a more natural condition could include walking and biking pathways to help connect the east and west portions of the city. This is an important opportunity to add a key amenity to the city.

Reflecting the Full Range of Cultures

Walla Walla is a vibrant and diverse community, representing Indigenous, French, German, Mexican, Italian, Chinese, and many other groups. These cultures should be celebrated and recognized as part of the city's identity by incorporating art and design elements that represent all cultures and their histories.

Goals and Policies

CC Goal 1: Walla Walla's historic character is a primary source of its civic identity and attracts visitors wanting to experience an authentic and vibrant community.

- CC 1.1: Establish preservation districts, and compile inventories of buildings that are potentially significant on their own or possess contributing status to preservation districts.
- CC 1.2: Promote the City's street grid in new development as an important community design characteristic.

CC Goal 2: All of Walla Walla's residential communities are livable and attractive.

- CC 2.1: Recognize and celebrate the distinct and unique character of Walla Walla's neighborhoods.
- CC 2.2: Enhance residential neighborhoods with streetscape improvements and home improvement programs such as tool loan programs, self-help assistance, and homeowner loans.

CC Goal 3: The City should consider appropriately zoned land uses in areas approximate to the surrounding rural region.

- CC 3.1: Work with regional partners to respect residential areas and the surrounding agricultural lands and open space.

CC Goal 4: Downtown is the heart of Walla Walla, making all people feel welcome, accommodating a wide variety of civic and commercial functions, and reflecting the city's history.

- CC 4.1: Carefully protect and enhance Downtown's visual character, the most important single aspect of the city's identity, through historic preservation activities, complementary infill development, and sensitively designed public works.
- CC 4.2: Encourage infill mixed-use development near the Downtown farmer's market.
- CC 4.3: Foster mixed-use and live-work areas for artist housing/studios and live-work facilities Downtown.

CC Goal 5: Walla Walla incorporates open spaces and natural features as part of its attractions and regional identity.

- CC 5.1: Work with public and private partners to enhance the Mill Creek corridor with ecological restoration, habitat connectivity and trails to become a keystone asset in the city's physical identity.
- CC 5.2: Honor the city's name and character," place of many small waters," by protecting and revitalizing stream corridors and natural areas.
- CC 5.3: Support the implementation of the Urban Forestry Plan through preserving, restoring, and enhancing the tree canopy.
- CC 5.4: Improve and maintain public parks as community resources and an important part of Walla Walla's visual character.
- CC 5.5: Create new parks in communities without adequate open space.

CC Goal 6: Walla Walla continues to add new and attractive features to its historic qualities as it grows.

- CC 6.1: Assure adequate code enforcement to protect the safety and attractiveness of the City.
- CC 6.2: Incorporate Walla Walla's diverse cultures and artistic resources into public projects.

CC Goal 7: Walla Walla has a sense of place and prioritizes the everyday experiences that residents value, including access to nature, design, neighborhood livability, and a human-scaled environment.

- CC 7.1: Evaluate development and public investment decisions based on their ability to enhance daily quality of life while incorporating inclusive public engagement and equity considerations to ensure redevelopment benefits the broader community.
- CC 7.2: Enrich the cultural experiences of residents and visitors in the City through the creation of public murals and permanent and temporary art installations in public spaces, with support from the Arts Commission.
- CC 7.3: Encourage public art events and the organizations that produce them, including ArtSquared, First Friday Art Tours, Walla Walla Guitar Festival, the Balloon Stampede, and similar community arts initiatives.

Policy Connections

- **The Environment and Natural Resources Element** recognizes the importance of healthy mature trees, identifies restoration of Mill Creek as an urban amenity, and incorporates community character objectives into efforts to increase sustainability.
- **The Land Use Element** addresses community character objectives, policies to provide for a more equitable physical environment, measures to reduce land use conflicts, and design guidelines.
- **The Transportation Element** addresses streetscape and non-motorized improvements that provide greater mobility for all residents.
- **The Parks and Recreation Element** addresses arts and cultural elements in parks planning and projects.

Translating Policy into Action

Table 1. Community Character Implementation Action

Implementation Action	Timeline	Responsibility
Home improvement assistance programs	2-3 years	Community Development
Creating new parks	10 years	Parks and Recreation
Establish preservation districts and compile inventories of buildings that are potentially significant.	Ongoing	Community Development
Foster areas for artist housing/ studios and live/ work facilities Downtown.	5 years	Community Development
Develop standards for the processing and installation of murals.	3-5 years	Community Development



Land Use

Introduction

This Element identifies the land uses necessary for Walla Walla to accommodate projected growth over the 20-year planning horizon. Land use in a community influences many aspects of community health and vitality. It is the basis for establishing zoning, which determines where people can live, work, shop, or recreate.

Today and Tomorrow

Conditions Today

Walla Walla's population as of April 2025 was estimated at 34,850 by the Washington State Office of Financial Management. The City of Walla Walla's planning area includes the incorporated city limits and the land within the Urban Growth Area (UGA), which totals approximately 13,041 acres. Agricultural uses within the planning area are typically designated for future development on the Future Land Use Map and in the zoning code. Over time, these areas are expected to transition to urban uses, helping preserve agricultural areas outside the UGA.

The City of Walla Walla's population growth has generally been slow and steady. While the City averaged about 0.86% annually between 1970 and 2010, more recent growth has been slower, including two years of decline during the COVID-19 pandemic, from 2024 to 2025, when the City grew by 0.78%.

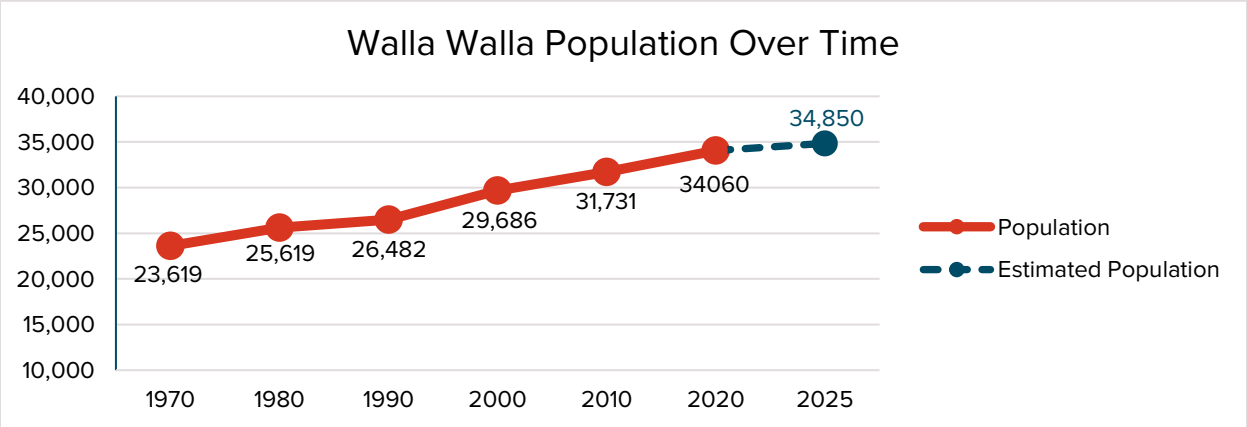


Figure 4. Walla Walla Population Over Time

Source: Washington State OFM Official Census Data

Land Capacity Analysis



In 2025, the City of Walla Walla analyzed vacant lands that could be redeveloped within city limits and the UGA using GIS analysis. The analysis identified available land for development by looking at existing development patterns, site utilization, permitted projects, and non-buildable areas due to the presence of critical areas. Capacity was estimated by assessing zoning capacity, examining permit records to identify actual built densities by zone, and applying a market factor to account for property owners who are unlikely to sell or redevelop. Full details about the methodology and calculations can be found in Appendix II. Land Capacity Analysis: Housing by Income Band.

Future Projections

The population of the City of Walla Walla is expected to be 39,884 people in 2046, according to the population target assigned by Walla Walla County. To accommodate future growth, the City of Walla Walla created the Future Land Use Map shown in this Element. The acreage of land designated for each purpose is shown below.

Table 2. Acreage of Land by Zone

Zone	Fully Developed Acres	Vacant / Underutilized Acres	Total Acres
Central Commercial	43	27	70
Heavy Industrial	96	189	285
Highway Commercial	279	302	581
Light Industrial/ Commercial	207	170	377
Mobile/Manufactured Home Park Community	75	3	78
Multi-Family Residential	147	63	210
Neighborhood Residential	2,128	529	2651
Public Reserve	51	2,887	2,938
Urban Planned Community	4	400	404
Total	**3,030**	**4,570**	**7,600**

Table 3. Acreage of Land Designated by Purpose

Land Use Designation	Acres in City	Acres in UGA	Total Acres
Residential	2,861	1,438	4299
Public	2,926	99	3025
Commercial	585	.9	586
Industrial	662	279	941
Airport	0	2,019	2019
Urban Planned Community	404	0	404
Downtown	86	0	86
TOTAL	**7729**	**3747**	**11,360**

Source: City of Walla Walla GIS



Challenges and Opportunities

Annexation Policy

The City's policy regarding the extension of water and sewer utility services in the UGA requires annexation for those who request to receive City services. Most of the City's growth will occur through annexation. For new housing developments to occur, large tracts of land will need to be annexed. Upon annexation, the City takes the lead role in administering the development process.

Critical Areas and Riparian Areas

Much of the developable land in the UGA, and some within the City, is constrained by proximity to one or more of Walla Walla's many riparian areas. Several designated floodplains limit development on the south side of the City. Additionally, each riparian area has a management zone that protects the riparian system. New development and the establishment of land uses in such areas should be carefully evaluated to ensure that critical areas are protected.

Commercial and Industrial Uses

Commercial and industrial land uses are concentrated in the north and west sides of the planning area, apart from the Eastgate commercial area. This may put pressure on transportation networks and other resources as people commute to employment or travel to obtain goods and services.

To alleviate this, Walla Walla could consider zoning that would allow:

- Small commercial areas in or near neighborhoods for people to obtain daily goods and services.
- Subarea planning that could encourage employment- related uses in other parts of the City's planning area.

New population and commercial growth are expected along the Myra Road corridor. The existing Valley Transit bus routes linking the Cities of Walla Walla and College Place could promote a compact urbanized area for future homes, jobs, and shopping.

Manufactured Home Communities

In early 2023, the City Council adopted Ordinances 2023-01 and 2023-02, adopting a new Manufactured Home Park Community zoning district and Comprehensive Plan Map Designation. The new zoning districts and comprehensive plan map designations were applied to land where manufactured home parks currently exist. The allowable uses for this new zoning district are primarily residential and closely related to manufactured homes, thereby limiting opportunities for redevelopment and displacement of park residents. These amendments were supported by the Walla Walla Regional Housing Action Plan, which includes recommendations related to increased opportunities for the siting of manufactured homes, the preservation of existing manufactured home parks, and strategies for mitigating the displacement of vulnerable residents.

Future UGA Study Areas

When the City's land capacity analysis and population projections indicate that additional land is needed within the Urban Growth Area (UGA), potential expansion areas should be evaluated with consideration for the City's ability to extend or provide urban infrastructure, while also respecting the County's goal of preserving prime agricultural land. UGA expansions should include sufficient land necessary to meet 20-year population, housing, and employment targets, plus a market factor, and should account for potential impacts on critical areas.

Walla Walla's Plan

Additional housing is to be built, additional employment opportunities, and new places to obtain goods and services. The City of Walla Walla seeks to retain its community character. This means planning for growth and its impacts so that Walla Walla is a great place to live for all residents. The City will offer opportunities and choices for housing, employment, and business, and continue to be a healthy, sustainable community.

Future Land Use Map

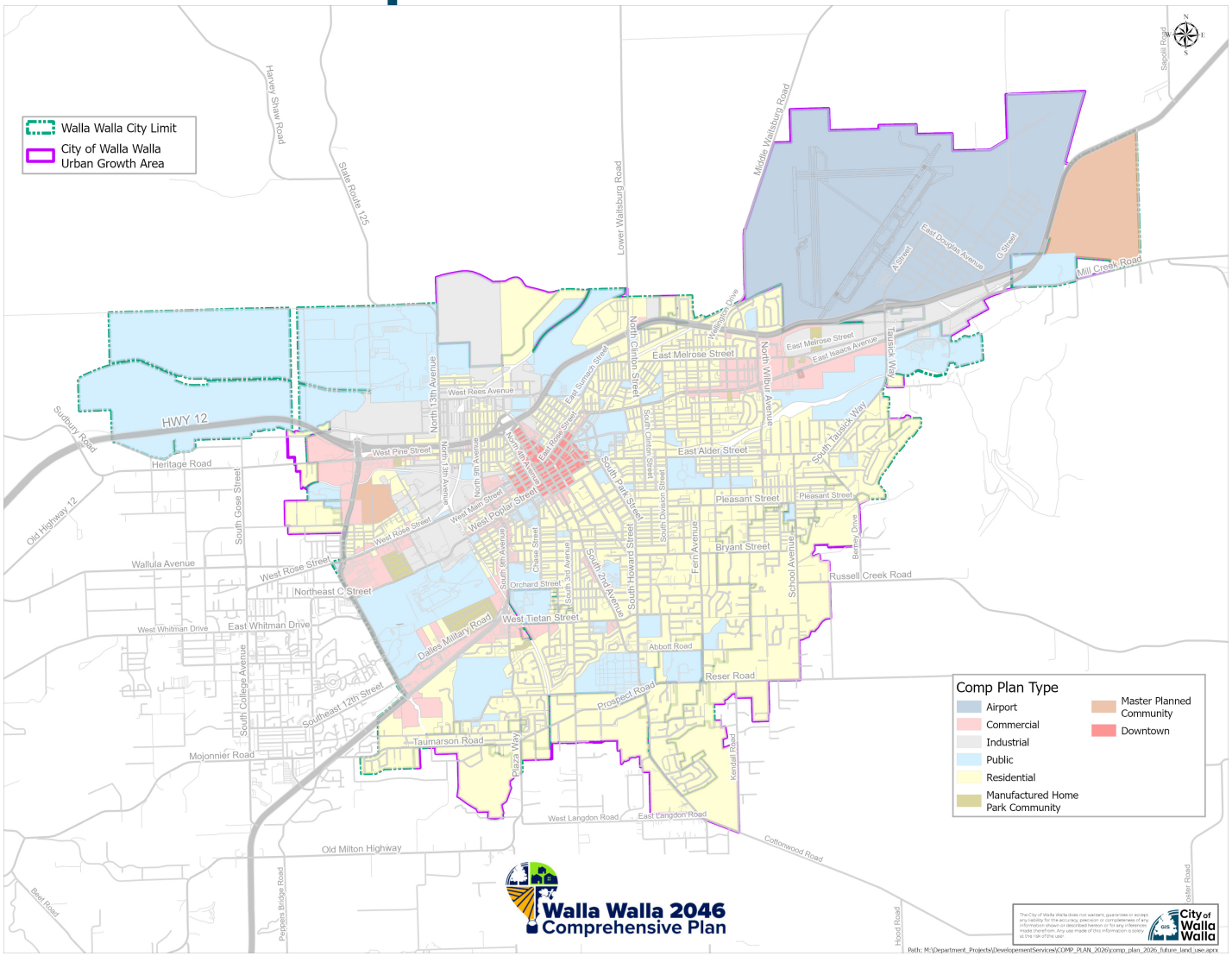


Figure 5. Future Land Use Map

Goals and Policies

LU Goal 1: Walla Walla grows in a responsible way that maintains or improves the quality of life for its residents.

- LU 1.1: Accommodate new residential and commercial development in areas with available infrastructure and services.
- LU 1.2: Land use will be developed in consideration of the Walla Walla Countywide Planning Policies.
- LU 1.3: Where appropriate, the City will consider Interlocal Agreements (ILA) with Walla Walla County to facilitate planning for growth in the Urban Growth Area.
- LU 1.4: The City will coordinate with Walla Walla County to plan for the delivery of urban services within unincorporated UGAs prior to annexation.
- LU 1.5: The City supports Walla Walla County's goal that, where feasible, all land within unincorporated Urban Growth Areas will be annexed to the City or incorporated within the 20-year planning horizon.
- LU 1.6: Encourage infill development that provides additional housing within the city.
- LU 1.7: Establish land use and zoning standards that prevent incompatible development, reduce conflicts between adjacent uses, and ensure orderly, balanced growth.
- LU 1.8: Develop Walla Walla's downtown in a way that encourages sustainability and supports community vitality.
- LU 1.9: Analyze proposed industrial uses for potential impacts on adjacent lands and ensure adequate public services can be provided at proposed or alternative locations.
- LU 1.10: Encourage commercial growth in areas of the Urban Growth Area where services can be provided.
- LU 1.11: To the extent possible, advance equitable access to healthy, safe, and sustainable environments through planning efforts that support overall community well-being.
- LU 1.12: Inform land use decisions to prevent the worsening of environmental health disparities, ensuring that new developments don't disproportionately impact vulnerable or underserved communities.
- LU 1.13: Strive to remedy existing environmental health disparities by prioritizing improvements, investments, and mitigation measures in communities that have historically experienced disproportionate environmental burdens.

LU Goal 2: Walla Walla coordinates with neighboring communities and state agencies for the improvement of the region.

- LU 2.1: Coordinate City plans with the Countywide Planning Policies and regional policies of the Walla Walla Valley Metropolitan Planning Organization.
- LU 2.2: Coordinate planning in the Urban Growth Area with Walla Walla County to ensure orderly, sustainable development consistent with City standards, and discourage development of subdivisions using septic systems and private water systems.
- LU 2.3: Cooperate with neighboring communities' appropriate agencies, and area Tribes to ensure the protection and revitalization of the region's natural resources.
- LU 2.4: Identify opportunities to link the City's roads, trails, parks, and open spaces with others in the region.
- LU 2.5: Cooperate regionally on the development and siting of essential public facilities to ensure that the burden, impact, and benefit is equitably distributed among neighboring communities.
- LU 2.6: Continue coordination with the Confederated Tribes of the Umatilla Indian Reservation, the Army Corps of Engineers, and Walla Walla County Flood Control District to restore Mill Creek.

LU Goal 3: There are a variety of uses allowed throughout Walla Walla that encourage options for housing and business.

- LU 3.1: Encourage mixed-use development and new housing Downtown.
- LU 3.2: Allow live/workspaces and mixed uses to encourage entrepreneurial opportunities for residents.
- LU 3.3: Allow master planned development to include mixed-use that is compatible with adjacent land uses.
- LU 3.4: Discourage strip-style commercial development by encouraging buildings to be developed close to the street frontage with parking lots to the rear.
- LU 3.5: Locate new commercial areas near, or mixed with, higher density residential development and at the intersection of major transportation corridors.
- LU 3.6: Allow commercial development that provides daily goods and services to adjacent residential neighborhoods.
- LU 3.7: Support a variety of housing types such as tiny homes, duplexes, multi-family development, cottage housing, and single-family residential.

LU Goal 4: Land use is sustainable and conserves natural resources.

- LU 4.1: Balance commercial, industrial, and residential development with the conservation of natural resources and open space by directing growth to areas already served by infrastructure.
- LU 4.2: Establish water-permeable greenway corridors and/or open space where feasible to ensure conservation and connectivity of natural areas, water infiltration and the protection of environmentally sensitive areas.
- LU 4.3: Protect natural features and critical areas, including topography and native vegetation such as riparian woody vegetation to minimize impacts to the surrounding ecosystem.
- LU 4.4: Ensure that landowners are educated regarding responsibilities of properties abutting or surrounding surface waters such as wetlands and other water bodies.

LU Goal 5: Walla Walla is a healthy city that is designed to provide opportunities for physical activity with multimodal transportation and access to parks and recreation.

- LU 5.1: Consider physical activity and health when adopting land use policies and regulations and in the siting of community facilities.
- LU 5.2: Ensure physical activity opportunities exist in new subdivisions and housing with safe pedestrian and bicycle access to nearby community facilities and amenities.
- LU 5.3: A network of open spaces and recreation facilities should be located in proximity to residential neighborhoods.
- LU 5.4: Maximize opportunities for green space and common areas to allow for health and recreation.

LU Goal 6: Provide inclusive public engagement practices.

- LU 6.1: Consider targeted outreach methods to include lower-income households and historically marginalized communities in local legislation related to planning and development.
- LU 6.2: Consider all community input received during planning and land use projects to help inform decisions.

Policy Connections

- **The Housing Element** includes policies on ensuring a sufficient variety of housing types and affordability to meet the community's needs within areas designated for residential uses.
- **The Environment and Natural Resources, Shoreline, and Climate Resilience Elements** address land use related to the protection of critical areas and the preservation of natural resources.
- **The Capital Facilities and Utilities Element** and the **Parks and Recreation Element** demonstrate how future land uses will be served by public services and infrastructure.
- **The Transportation Element** identifies options for motorized and non-motorized transportation of people and goods between the future land uses in the City.
- **The Historic Preservation Element** identifies policies for the preservation of historic buildings and neighborhoods. **The Community Character Element** offers other policies that address neighborhood character.

Translating Policy into Action

This section makes connections between other city plans, programs, and actions and the policy direction of this element.

Table 4. Land Use Implementation Action

Implementation Action	Timeline	Responsibility
Downtown Master Plan: Originally produced in 2004, this plan aims to direct high-quality infill and redevelopment to the core of the City. An update to this plan is recommended.	5 years	Community Development and Downtown Walla Walla Foundation
Allow live/workspaces and mixed uses to encourage entrepreneurial opportunities for residents.	5 years	Community Development
Discourage strip-style commercial development by encouraging buildings to be developed close to street frontage with parking lots to the rear.	5 years	Community Development
Allow commercial development that provides daily goods and services to adjacent residential neighborhoods.	5 years	Community Development
Ensure that landowners are educated regarding the responsibilities of properties abutting or surrounding surface waters, such as wetlands and other water bodies.	Ongoing	Public Works



Housing

The City of Walla Walla must ensure it has enough housing for all its residents. As the City grows, it also plays a role in providing everyone who lives here with access to a decent home that they can afford. There are many ways to do this, but increasing the different types of housing is an important factor in meeting community needs. This element describes the City of Walla Walla's current housing conditions, assesses its housing needs, and outlines how the city can ensure there are enough homes for everyone in the future.

Conditions Today

Population

The City of Walla Walla is growing slightly faster than Walla Walla County as a whole. Growth has been slower than the statewide average, with growth in the city slowing between 2020 and 2025. The percentage increase from 2010 to 2020, a ten-year period, was 7.3 percent, a faster rate of growth than over the previous decade. The percentage increase from 2020 to 2025, a five-year period, was 2.3 percent.

Table 5. Population Over Time, 2000-2025

	2000	2010	2020	2025	2010-2025 % Change	2020-2025 % Change
The City of Walla Walla	29,686	31,731	34,060	34,850	9.8%	2.3%
Walla Walla County	55,180	58,781	62,584	63,800	8.5%	1.9%
Washington State	5,894,121	6,724,540	7,706,310	8,115,100	20.7%	5.3%

Source: Washington State Office of Financial Management (OFM), 2025.

According to data from the U.S. Census, 46 percent of the City of Walla Walla's population is under 34 years old. The presence of higher educational institutions, such as Whitman College and Walla Walla Community College, increases the proportion of young adults in the community. In the City, around 5 percent of the population is between 18 and 19 years old. The Washington State Office of Financial Management (OFM) estimates that roughly 11 percent of the City population, or nearly 3,700 people, live in group quarters such as college residence halls, the state penitentiary, or nursing facilities, while the remainder reside in households.

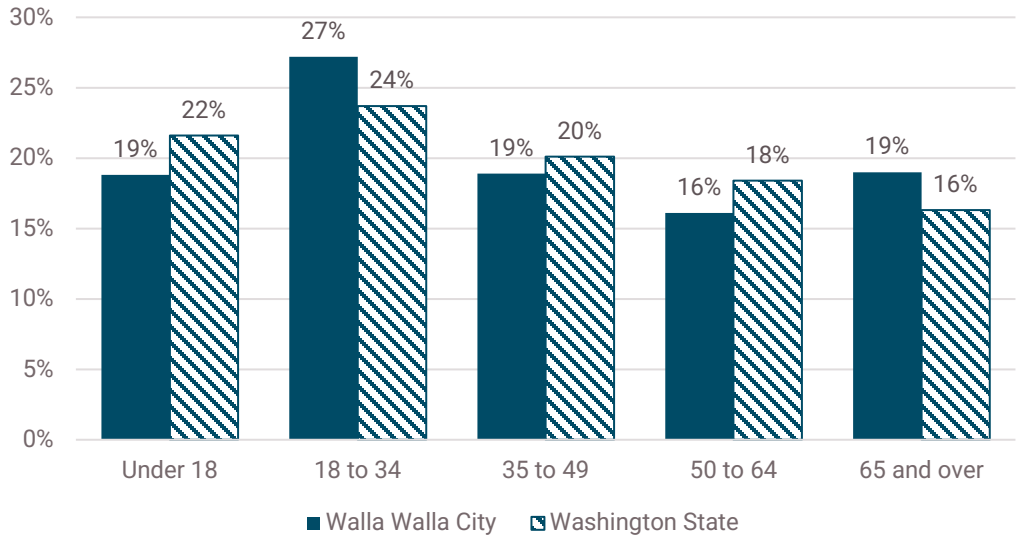


Figure 6. Age Distribution in the City of Walla Walla and Washington

Source: US Census Bureau 2023 Five-Year ACS (Table S0101)

Although the percentage of people in the City of Walla Walla aged 65 and over is about 19 percent, nearly one-third of households have a senior householder. About one-third of those households are rentals. These households may be particularly vulnerable to increases in rents, especially those on fixed incomes. The population is also more likely to have a disability, since the American Community Survey (ACS) reports that nearly 41 percent of the population over age 65 in the City of Walla Walla has a physical, visual, auditory, or cognitive impairment.

Table 6. Households with a Senior Householder in the City of Walla Walla

	Households
Total Households with a Senior Householder	**4,203**
Renter-Occupied	1,429
Owner-Occupied	2,774

Source: US Census Bureau 2023 Five-Year ACS (Table B25007)

In the City of Walla Walla, 91 percent of the me population identifies as white alone, with almost 25 percent of the population identifying as Hispanic or Latino.

Table 7. Gender, Race, and Ethnicity

	The City of Walla Walla	Walla Walla County	Washington State
Male	52.0%	50.8%	50.4%
Female	48.0%	49.2%	49.6%
White	73.0%	75.3%	67.8%
Black or African American	2.7%	1.8%	4.0%
American Indian or Alaska Native	2.0%	1.2%	1.2%
Asian	2.4%	1.9%	9.4%
Native Hawaiian or Other Pacific Islander	0.4%	0.2%	0.7%
Some other race	9.7%	9.9%	5.6%
Two or more races	9.9%	9.6%	11.4%
Hispanic or Latino origin (of any race)	24.3%	23.4%	14.1%

Note: Hispanic or Latino origin is considered an ethnicity and not a race.
Source: US Census Bureau 2023 Five-Year ACS (Table DP05)

Household Characteristics and Income

As of 2025, OFM estimates there are 13,089 total households in the City of Walla Walla. The average household size is 2.28 people per household. Sixty percent of all households in the City of Walla Walla are renter-occupied. Single-person households are the largest market for rental housing. However, it is notable that 26 percent of renter households have three or more members. Given that apartments are generally smaller in size, many of these households likely reside in single-family detached housing throughout the city and could possibly be candidates for future multifamily housing units. Over half (52 percent) of rental households have one person.

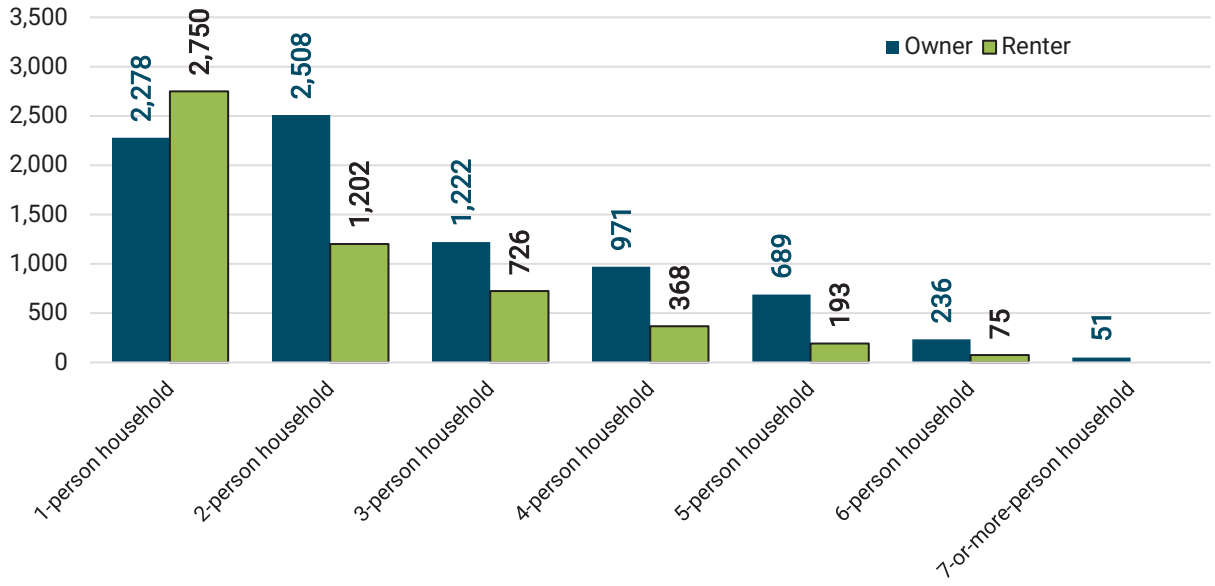


Figure 7. Renter and Owner-Occupied Households by Size

Source: US Census Bureau 2023 Five-Year ACS (Table B25009)

As of 2023, the American Community Survey lists median household income for households residing within the City of Walla Walla as $65,493, compared with a slightly higher median household income of $72,212 in Walla Walla County, and $94,952 statewide (ACS Five-Year Estimates, 2019-2023).

United States Department of Housing and Urban Development (HUD) calculations and groupings are based on the HUD Area Median Family Income (AMI), a calculation that takes into account household size. AMI is based on the median income for a four-person family household. In 2025, HUD's AMI for Walla Walla County is $97,900.1

HUD provides data on household income breakdowns relative to the Walla Walla County AMI. Therefore, this Housing Element groups households based on income categories relative to the County AMI. Note that HUD accounts for household size when grouping households into these income categories.

- Very Low Income—Under 30% of AMI (<$32,150).
- Low Income—30-50% of AMI ($32,150 - $48,950).
- Moderate Income—50-80% of AMI ($48,950 - $78,300).
- Lower Middle Income—80-100% of AMI ($78,300 - $97,900).
- Above Median Income—Above 100% of AMI (>$97,900).

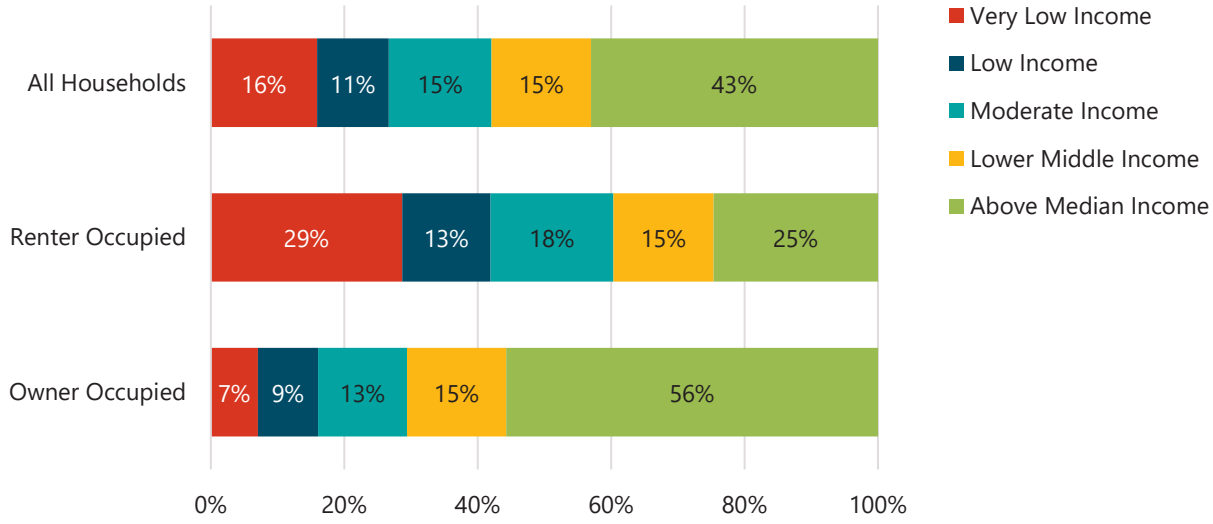


Figure 8. Household Income Categories - The City of Walla Walla

Source: US Department of Housing and Urban Development (HUD) Consolidated Housing Affordability Strategy (CHAS), 2017-2021

Owner-occupied households are more likely to be in a higher income category, with 56 percent earning more than AMI, whereas only 25 percent of renter households earn more than AMI. Around 42 percent of renter households have income levels classified as low or very low income, earning less than 50 percent AMI. This suggests a need for affordable rental housing options in the City of Walla Walla.

The Washington State Department of Commerce, in coordination with Walla Walla County, performs a yearly point-in-time count of homeless persons and households. The numbers that the Department of Commerce publishes use the HUD definition of homelessness, which excludes those who reported staying with family or friends. Walla Walla County includes those individuals and households in its published data, as it helps to depict both those who are chronically homeless as well as those with intermittent struggles with sustainable housing.

In 2024, there were 218 individuals who identified as homeless during the point-in-time (PIT) count. This number represents an increase over the 2023 count, in which 183 homeless individuals were identified. Since 2011, there has been an upward trend in homelessness, when the survey began tracking chronically homeless households. However, in 2025, PIT shows a decrease in homelessness from 218 to 197. This slight decrease still indicates a need to address long-term solutions to homelessness in the County.

Housing Conditions

The City of Walla Walla has an aging housing stock. Nearly 36 percent of homes in the City of Walla Walla were built prior to 1950. This suggests that investments will be needed in the coming decades to update the housing supply. Since 2010, over 1,200 homes have been built in the City.

Table 8. Housing Structures by Decade Built

	Percent of Housing Structures
Built 2020 to 2023	0.4%
Built 2010 to 2019	8.0%
Built 2000 to 2009	11.0%
Built 1990 to 1999	7.6%
Built 1980 to 1989	6.5%
Built 1970 to 1979	12.7%
Built 1960 to 1969	7.1%
Built 1950 to 1959	11.1%
Built 1940 to 1949	8.6%
Built 1939 or earlier	27.0%

Source: U.S. Census Bureau 2023 Five-Year ACS (Table DP04).

As of 2025, there were 14,274 housing units in the City of Walla Walla. 67 percent of all housing units in the City of Walla Walla are single-family residences.

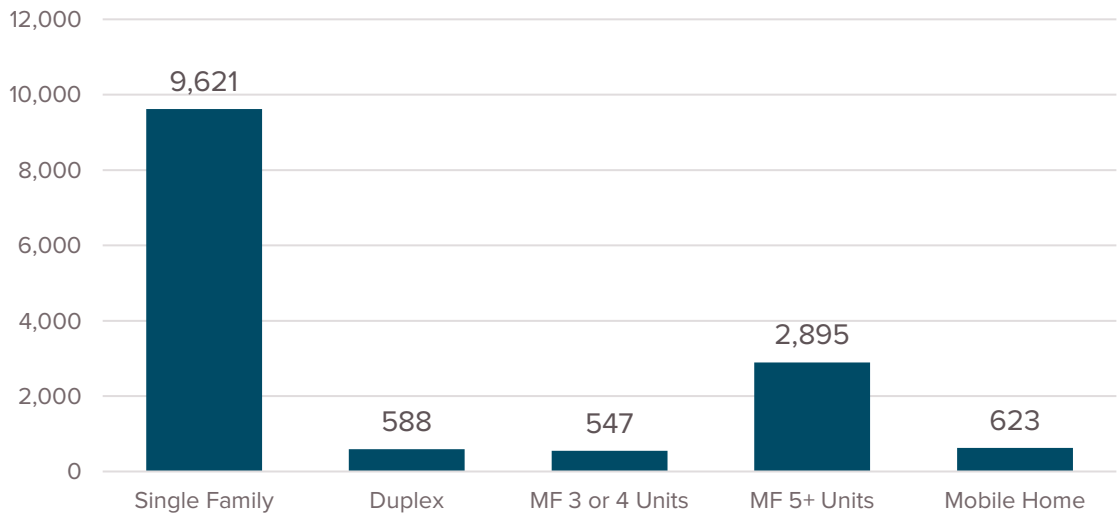


Figure 9. Housing Units by Type

Source: Washington Office of Financial Management (OFM, 2025)

When comparing household sizes (see Household Characteristics and Income above) with housing units by type, some potential housing gaps may be evident. For example, there are over 5,000 households with only one member, yet there are fewer than 2,300 studio and one-bedroom housing units combined. This is a difference of about 2,700 units. While not all one-person households are looking for a studio or one-bedroom unit, it is also likely that there are people living in larger shared houses that would prefer to live in a studio or one-bedroom unit, if there were enough units available. The presence of Whitman College is likely impacting the number of one-person households, yet with roughly 1,500 students, the data would still indicate a need for studios or one-bedroom units.

On the other hand, nearly 57 percent of housing units in the City of Walla Walla have three or more bedrooms, while only 34 percent of households have three or more members. There is potential that the number of households with three or more members is higher than actual demand, assuming people seeking small apartment units are instead sharing larger units due to the lack of appropriate supply in the apartment market.

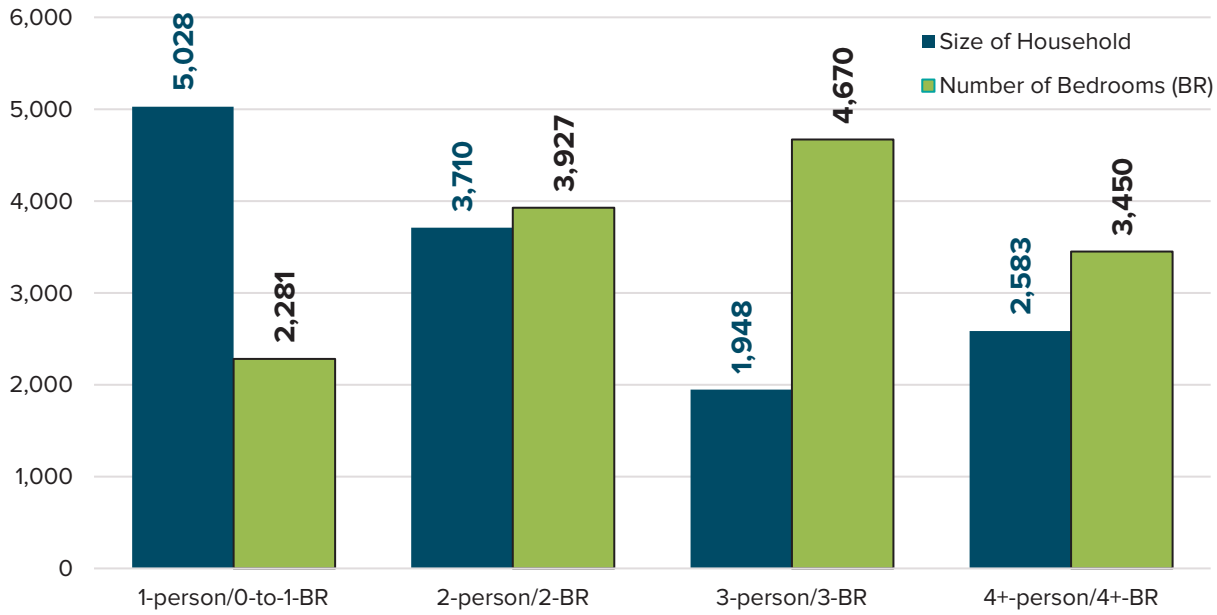


Figure 10. Alignment Between Household Sizes and Size of Units in the City of Walla Walla

Source: U.S. Census Bureau 2023 Five-Year ACS (Tables S2501 & DP04).

While data suggests that the housing stock generally supplies units that are too large for the kinds of households that exist in the City of Walla Walla, overcrowding still exists and is primarily among renter households. HUD defines overcrowding as greater than one occupant per room. Based on this definition, 158 owner-occupied housing units and 48 renter-occupied housing units are overcrowded, representing 1.6 percent of all occupied housing units.

The City of Walla Walla's vacancy rate hovers near the state average at about 7.4 percent. The American Community Survey estimates that of the total vacant units in the City of Walla Walla, 35 percent of those are for rent, 16 percent are for seasonal, recreational, or occasional use, and 47 percent are listed as "other vacant." This category includes properties that the owner does not intend to rent or sell but are currently in use, those being used for storage, those undergoing repair or renovation, and those in foreclosure

Housing Affordability

A housing cost burden, as identified by HUD, occurs when a household spends more than 30 percent of its income on housing costs. Households spending more than 50 percent of their income towards housing costs are considered severely cost-burdened. In the City of Walla Walla, 32 percent of all households were estimated to be either cost-burdened or severely cost-burdened as of 2021. A greater percentage of renter households were cost-burdened (51 percent) than owner-occupied households (19 percent).

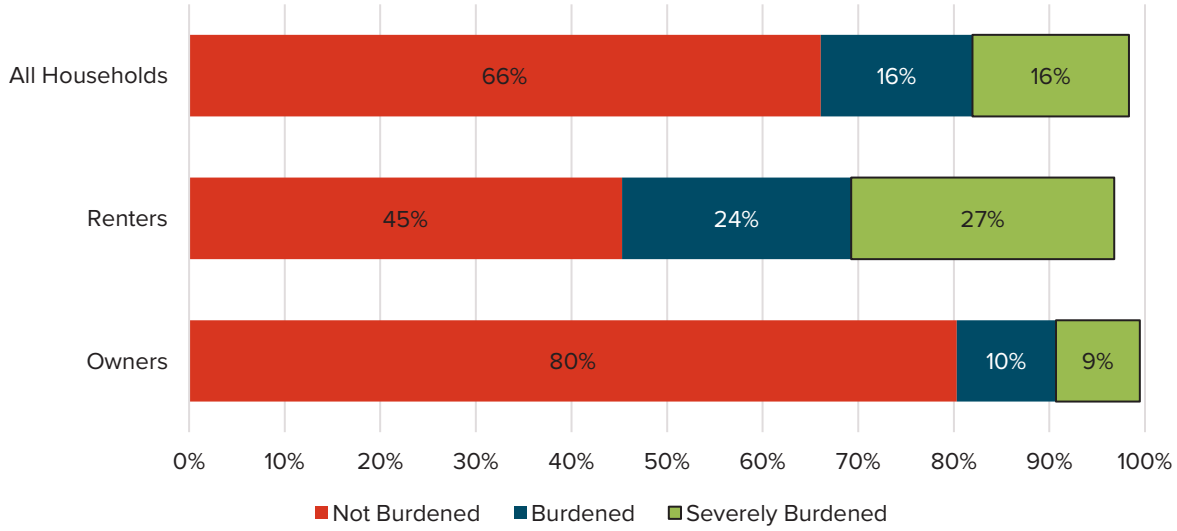


Figure 11. Cost Burden by Housing Tenure, the City of Walla Walla

Source: US Department of Housing and Urban Development (HUD) Consolidated Housing Affordability Strategy (CHAS), 2017-2021

The chart below shows the market asking rents for multifamily apartments. Between 2016 and 2025, rents increased by approximately 35 percent. However, rent growth has been relatively stable since 2023, decreasing by 0.7 percent over two years.

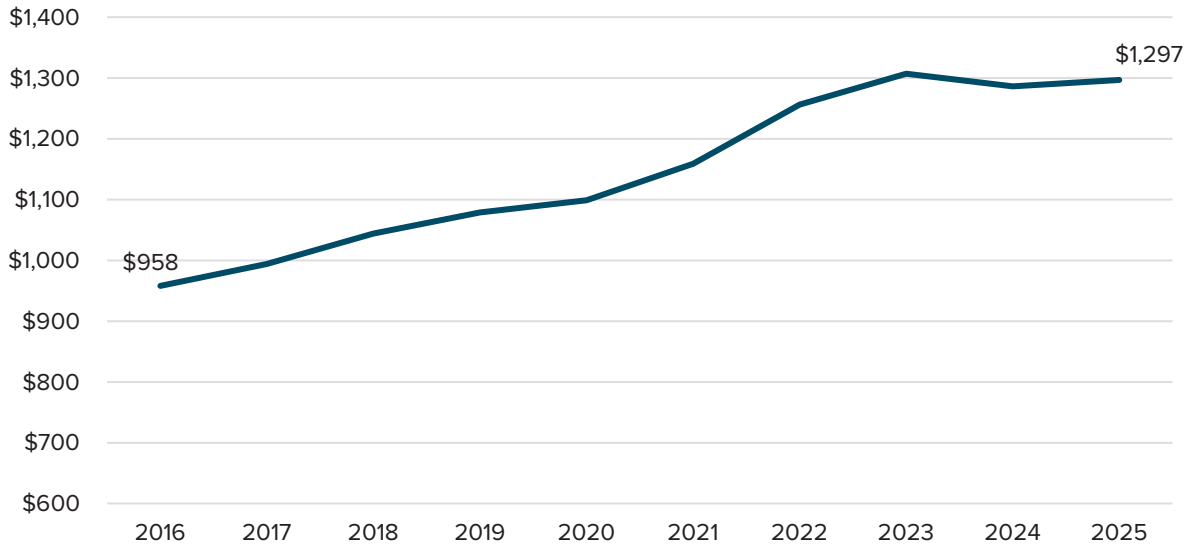


Figure 12. Market Asking Rent for Multifamily Apartments

Source: CoStar

To afford the median rent for a single-family home, a four-person household would need to earn at least $50,080 annually. To afford the median rent for a multifamily unit (as reported by the

Census Bureau Five-Year ACS), a household would need to earn at least $47,040 annually. The estimated number of renter households that earn enough to afford the median rent for a single or multifamily rental housing unit is shown below.

Table 9. Renter Households Affording Median Rent

Household Income to Afford Median Rent	Renter Households Number	Renter Households (Percent)
$47,040	3,039	57%

Source: US Census Bureau 2023 Five-Year ACS (Table S2503).
Households affording rent are those making less than $50,000 annually.

Among all renter households, 45 percent were estimated to be cost burdened, and 24 percent were estimated to be severely cost burdened. Few households with low or very low incomes can find housing they can afford.

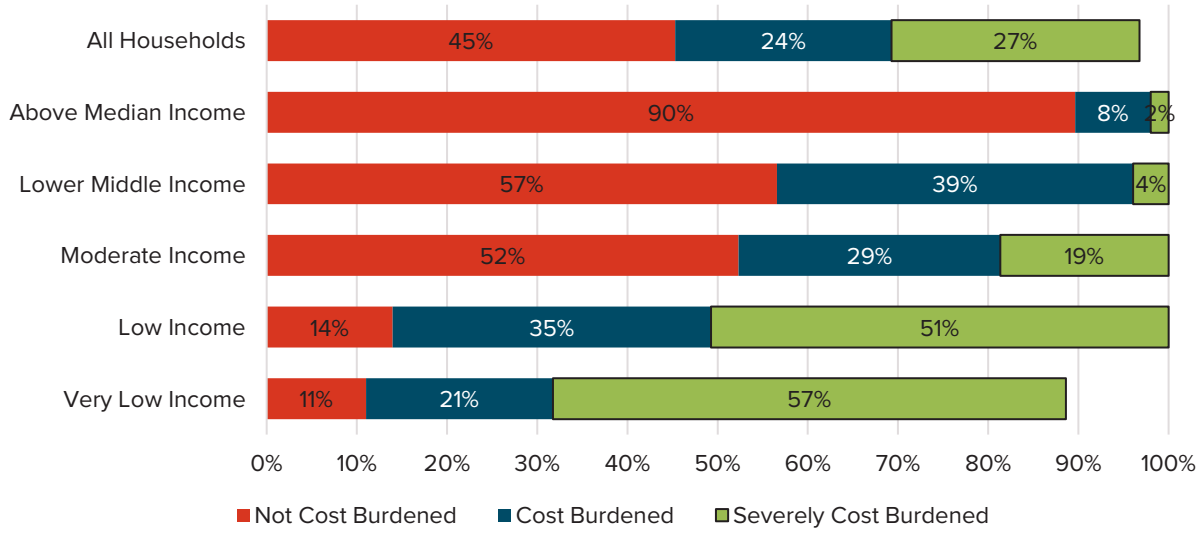


Figure 13. Renter Cost Burden by Income Category

Source: US Department of Housing and Urban Development (HUD) Consolidated Housing Affordability Strategy (CHAS), 2017-2021

The cost of owner-occupied housing more than doubled between November 2015 and November 2025. Most of this growth took place between 2015 and 2022. Since April 2022, median home prices have increased by 6.2 percent, reaching $405,623 in late 2025.

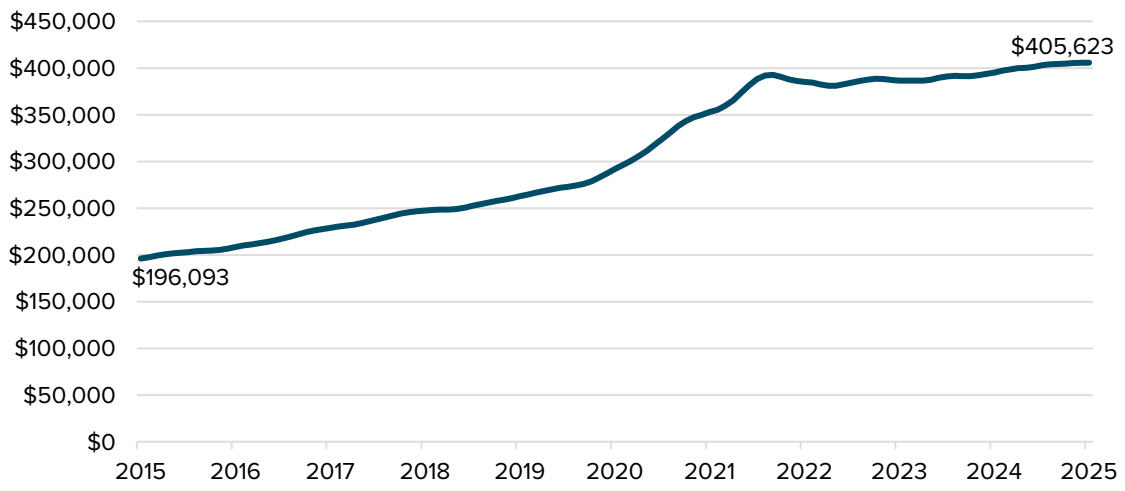


Figure 14. The City of Walla Walla Median Home Price, 2015-2025

Source: Zillow Home Value Index

While homeowners are generally less cost burdened than renters, low- and very low-income households are most likely to be cost burdened.

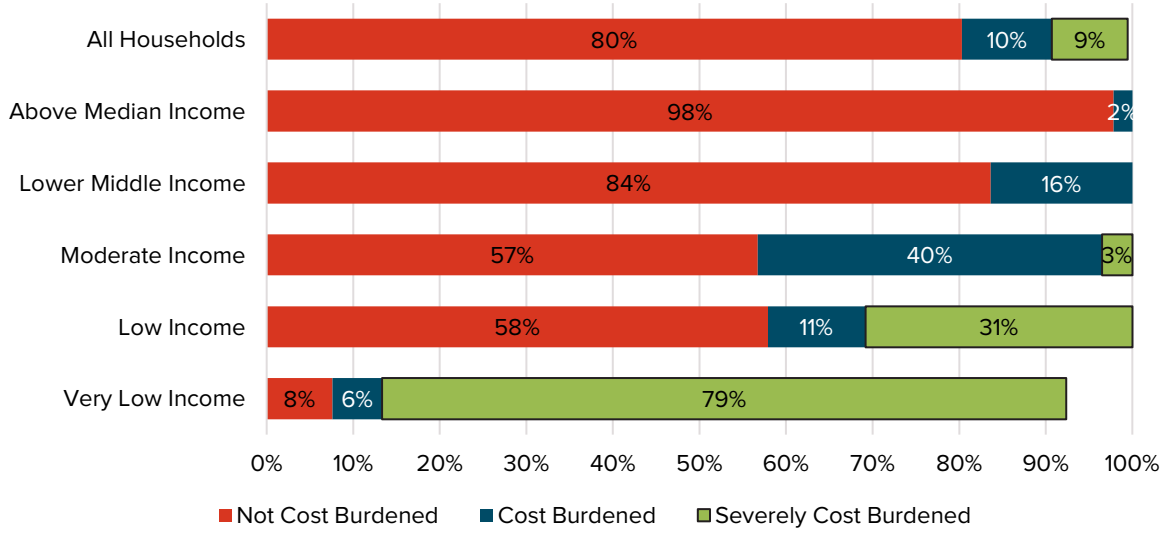


Figure 15. Owner Cost Burden by Income Category

Source: US Department of Housing and Urban Development (HUD) Consolidated Housing Affordability Strategy (CHAS), 2017-2021

The City of Walla Walla has a substantial inventory of subsidized housing, primarily owned and operated by the Walla Walla Housing Authority (WWHA). The Housing Authority owns and manages 613 units and provides rental assistance to another 1,174. An additional 50 units at the Meadow Grove Apartments were completed in 2025. The Walla Walla Housing Authority reports that approximately 1,900 households are on its waitlists, which have consistently remained above 1,500 households. Their target income for qualifying for their programs is below 60 percent AMI.

Of the 613 units owned and managed by the WWHA, 128 units are targeted at agricultural workers. Additionally, there is one transitional program targeting homeless veterans, which has nine units totaling 34 beds. The WWHA indicated that since the early 1990s, their programs have grown from 84 owned units with 20 rental assistance slots, to the numbers reported above. This equates to approximately 15 new subsidized units per year, on average.

In addition to WWHA, the Blue Mountain Action Council (BMAC) provides a variety of services to low-income Walla Walla residents, including housing serving seniors, developmentally disabled residents, chronically mentally ill residents, and shelters serving homeless families. Further details on the City of Walla Walla's subsidized housing inventory can be found in Appendix III. Adequate Provisions Analysis.

Future Projections

Population. As noted above, the OFM prepares low, intermediate, and high range growth management population projections for the counties within the State. The City of Walla Walla needs to plan for a total population of 39,884 by 2046 – an increase of 5,824 residents over the population reported in the 2020 Census and 5,034 over the population reported by the OFM in 2025.

Housing Capacity. Amendments to the GMA resulting from Washington State House Bill 1220 (2021) require jurisdictions to plan for housing unit targets by income band in addition to overall population growth targets. Walla Walla must plan for 2,348 net new housing units for the 2020-2046 planning horizon, broken down by what income band (as a percentage of Countywide Area Median Income) the new units can serve, as shown below in Table 10, under "Housing Needs."

A Land Capacity by Income Band analysis was performed, and the full report can be found in Appendix III. Adequate Provisions Analysis. The analysis identifies the capacity potential for approximately 2,370 new housing units within the city limits on vacant or redevelopable lands for the 2020 – 2046 planning period. The report identifies 2,198 pending housing units in the development pipeline, which also count towards meeting the city's growth targets. The housing unit land capacity and pending units were categorized by what income band they can serve, expressed as a percentage of Countywide Area Median Income (AMI), following the Department of Commerce guidance and supplemented by an analysis of housing costs for single-family, duplexes, condos, and rents by unit size in the City of Walla Walla. The analysis concluded that the City has sufficient capacity to meet its housing needs at all income levels under the current zoning.

Table 10. The City of Walla Walla Housing Capacity by Income Band, 2020-2046

Income Band (as % of County AMI)	Housing Needs
0-30 PSH*	428
0-30 Non PSH	714
30-50	517
50-80	157
80-100	93
100-120	116
120+	323
Total	**2,348**

*Permanent Supportive Housing

Table 11. The City of Walla Walla Housing Capacity by Income Band Detail, 2020-2046

Income Band (as % of County AMI)	Aggregated Housing Needs	Pending Units	Remaining Needs	Total Capacity	Surplus/ Deficit
0-30 PSH, 0-30 Non PSH, 30-80	1,816	639	1,177	1,304	**127**
80-120	209	384	-175	570	**745**
120+	323	1,175	-852	948	**1,800**
Total:	**2,348**	**2,198**	**150**	**2,588**	**2,672**

Challenges and Opportunities

As the City grows, there is an opportunity to encourage housing that best meets the needs of the City of Walla Walla residents.

A Variety of Housing Types

People have different housing needs throughout their lives. The City of Walla Walla's housing inventory indicates that there may be some gaps in housing stock. A greater stock of smaller unit rental housing may be needed to serve single-person households. This type of housing might support young adults who are just starting out, or seniors who wish to age in place. Building smaller-unit rental housing may free up larger units and increase the number of rentals available to serve families. The Land Capacity Analysis indicates that there is sufficient capacity for

multifamily housing. However, capacity alone does not determine whether adequate housing to meet the needs of the community will be built over the planning horizon. Addressing barriers to housing development, as shown in the Adequate Provisions Checklist, will help the City meet the needs of a wide variety of households.

Housing Affordability

The housing inventory shows that more than a third of the households in the City of Walla Walla are burdened by their housing costs. This includes people with moderate incomes as well as people with low and very low incomes, although people with lower incomes are more likely to be burdened by their housing costs. The City could consider a housing affordability plan to address this issue. Such a plan could address the needs for affordable rental and homeownership opportunities for families of all income levels, but particularly for households that make less than 50 percent of the area median income. Subsidized housing is also needed for seniors, people with disabilities, and people with very low incomes. Such housing may be developed and managed by non-profits or public agencies, but the City could consider ways that it can support its development.

Maintenance of Existing Housing Stock

The City of Walla Walla has a decent but aging housing stock. This can be an asset for a community as it grows if the existing housing is well-maintained. The City has a variety of ways to keep current housing in good condition. Such programs could include code compliance programs, minimum property maintenance standards, or home repair assistance programs.

Table 12. Existing Housing Stock

Zone	Description	Net Developable Vacant Acres	Net Developable Underutilized Acres	Total Net Developable Acres
CC	Central Commercial	1.7	7.7	9.4
CH	Highway Commercial	95.2	36.7	131.9
IH	Heavy Industrial	40.4	52.9	93.2
IL	Light Industrial / Commercial	29.1	24.1	53.2
PR	Public Reserve	33.4	2.5	35.9
RN	Neighborhood Residential	193.4	15.1	208.6
RM	Multi-Family Residential	12.9	1.1	14.1
UPC	Urban Planned Community	26.3	2.9	29.2

Goals and Policies

H Goal 1: A broad range of housing choices is available to meet the needs of people of diverse socioeconomic status, race/ ethnicity, household type, ability, and age.

- H 1.1: Provide an array of housing choices such as apartments, small lot single-family housing, accessory dwelling units, townhomes, manufactured homes, and cottages to meet the needs of people of all incomes throughout their lifespan.
- H 1.2: Ensure growth complies with Walla Walla County's adopted countywide housing growth targets.
- H 1.3: Address the needs of the unhoused population by working with local agencies and non-profits that provide services to this community.
- H 1.4: Encourage the use of existing housing stock to provide affordable housing for households with middle and lower incomes.
- H 1.5: Coordinate and collaborate with private agencies to ensure housing for people with special needs including seniors, people with physical and developmental limitations, victims of domestic violence, and homeless individuals and families.
- H 1.6: Work with educational institutions to ensure the provision of adequate housing for students and faculty.
- H 1.7: Support a housing land trust model that provides permanently affordable housing.
- H 1.8: Promote fair and equitable access to housing for all residents, with an emphasis on reducing racial disparities and preventing displacement.

H Goal 2: Attractive and functional neighborhoods are welcoming to all types of households.

- H 2.1: Integrate housing for extremely low, low, and moderate income households and those with special needs into a variety of geographical locations throughout the city, including near transit and services.
- H 2.2: Develop minimum property maintenance standards to ensure the safety and suitability of existing housing stock, while ensuring that enforcement does not jeopardize housing stability for residents.
- H 2.3: Promote energy-efficient housing that is designed to maximize the use of renewable resources such as solar and wind power.

- H 2.4: Locate new senior housing near transportation and community facilities to allow seniors to age in place.
- H 2.5: Develop a housing assistance program that helps homeowners with low incomes with small remodeling projects to improve weatherization, increase sustainability, and provide accommodations for disabilities.
- H 2.6: When siting new development, take into consideration accessibility to community facilities and services, including schools, transit, recreational facilities and areas, and parks, particularly for lower- and moderate-income families and individuals.

H Goal 3: Walla Walla supports all forms of affordable housing in a variety of types and sizes.

- H 3.1: Develop incentives for the construction of housing affordable to extremely low, low, and moderate-income households, such as density bonuses, waived fees, multi-family property tax exemption, or other such incentives.
- H 3.2: Periodically review and update permit processes to ensure they are timely, transparent, and fair for all applicants.
- H 3.3: Apply for state and federal funding to help provide housing for extremely low-, low-, and moderate-income households and those with special needs.
- H 3.4: Work with regional jurisdictions, non-profit agencies, and partners to support development, maintenance, and preservation of housing for extremely low, low, and moderate income households.

Policy Connections

- **The Environment and Natural Resources Element** includes policies to direct the location, site planning, and construction of housing to ensure the least impact to natural resources and the greatest benefits for the environment.
- **The Land Use Element** establishes a plan for where housing should be located in the community.
- **The Transportation Element and Capital Facilities and Utilities Element** plan for infrastructure, utilities, and public facilities to serve housing in Walla Walla.
- **The Community Character Element** provides guidance for community character and historic preservation to ensure the creation of attractive, functional neighborhoods.

Translating Policy into Action

Table 13. Housing Implementation Actions

Implementation Action	Timeline	Responsibility
Housing affordability program: Support the implementation of the regional Housing Action Plan for affordable housing in Walla Walla.	2 years	Community Development
Assistance program: This program would provide renovation assistance to homeowners with low incomes.	5 years	Community Development
Housing types demonstration projects: Work with the development community to create demonstration projects that showcase diverse housing types.	5 years	Community Development



Economic Development

Introduction

Walla Walla's economy is strongest when it builds from its existing assets while also broadening the range of business sectors that can grow here. Agriculture, wine, tourism, arts, education, healthcare, and downtown commerce remain foundational to the city's identity and economic vitality. At the same time, long-term resilience requires continued support for less seasonal and less volatile sectors, including light manufacturing, technology, professional services, skilled trades, creative industries, film and media production, value-added agriculture, and small to mid-sized employers that provide year-round, living-wage employment.

Today and Tomorrow

This section contains an overview of current economic conditions and activities in the City of Walla Walla as well as its role in the County and region. It also considers recent trends in employment and wages and anticipates the potential opportunities and challenges posed by those trends over the 20-year planning horizon.

Conditions Today

The City of Walla Walla is the economic hub of the Walla Walla Valley, with the largest population and the greatest areas of economic activity. The major areas of economic activity are shown below, and include:

- **Downtown**, the cultural, financial, and historical center of the City of Walla Walla, anchored by the Walawála Plaza, located at 1st Avenue and Main Street.
- **Eastgate**, centered on Isaacs Ave and North Wilbur Avenue, is anchored by the Eastgate Marketplace, a shopping center in the northeast of the City. Significant opportunities exist for revitalization in this auto-oriented area.
- **Southgate**, focused along South 2nd Avenue between East Chestnut Street and West Tietan Street, is an employment center anchored by the Southgate Medical Park. As with Eastgate, there are significant redevelopment opportunities in this auto-oriented corridor.
- **9th Avenue and Plaza Way**, located along South 9th Avenue and Plaza Way between West Rose Street and Village Way, and is anchored by Safeway, Bi-Mart, and Rosauers Supermarket.
- **Myra Road,** centered along Myra Road, from Highway 12 to Taumarson Road and anchored by the Walla Walla Town Center, Twin Creek Plaza, and WinCo, with surrounding areas for future development.

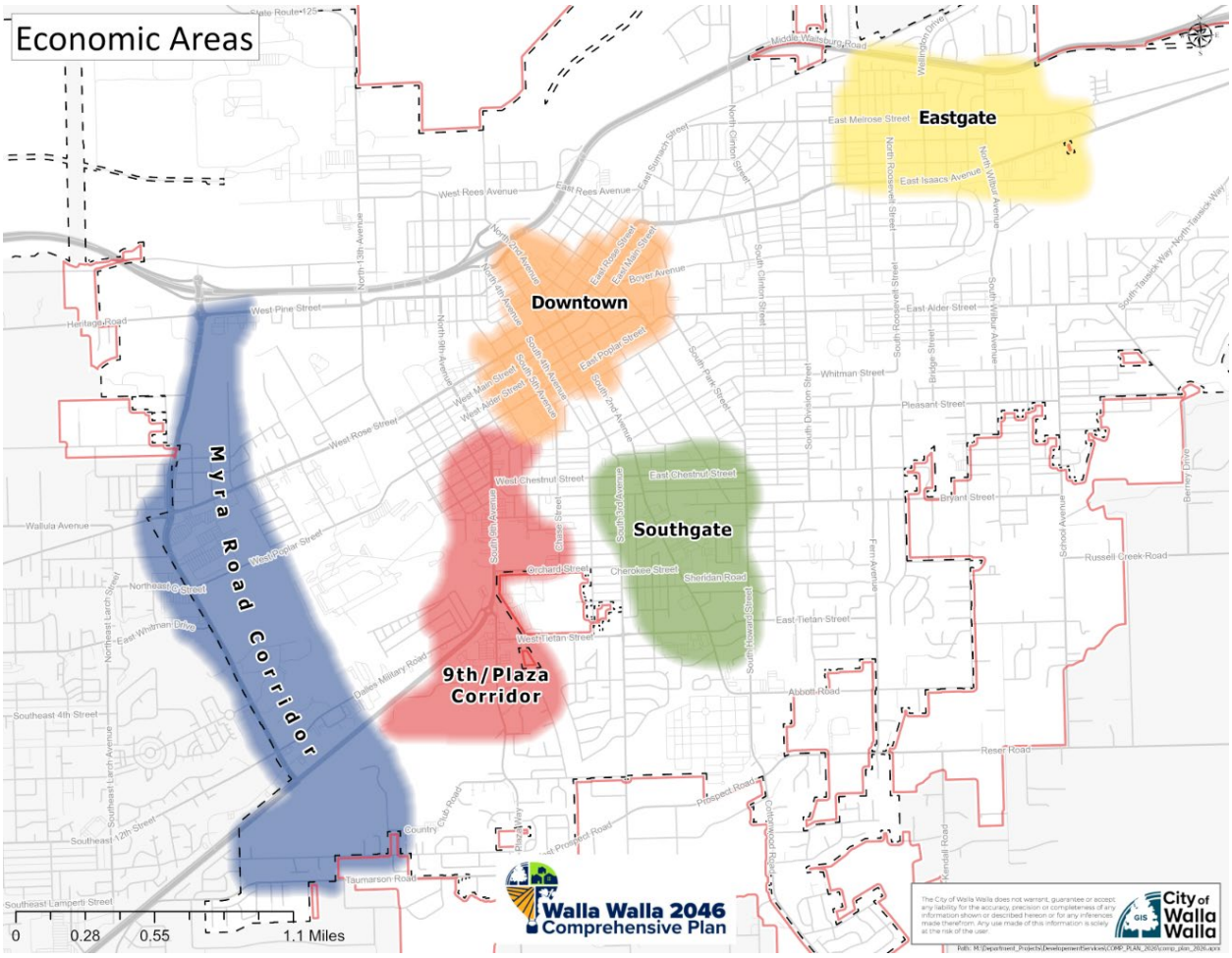


Figure 16. Areas of Economic Activity in the City of Walla Walla

As of 2022, the City of Walla Walla was home to 15,754 jobs, up from 13,944 in 2012 (an increase of 13 percent). The largest employment sectors in the City of Walla Walla include health care and social assistance, public administration, educational services, and accommodation and food services.

	2012	2022	Change	% Change
Educational Services	1,105	1,902	797	72%
Accommodation and Food Services	1,385	1,815	430	31%
Health Care and Social Assistance	3,664	4,050	386	11%
Public Administration	1,547	1,926	379	24%
Construction	352	551	199	57%
Arts, Entertainment, and Recreation	197	355	158	80%
Administration & Support, Waste Management	279	397	118	42%
Wholesale Trade	278	393	115	41%
Agriculture, Forestry, Fishing and Hunting	76	153	77	101%
Manufacturing	839	881	42	5%
Professional, Scientific, and Technical Services	339	371	32	9%
Utilities	68	86	18	26%
Transportation and Warehousing	133	148	15	11%
Management of Companies and Enterprises	27	41	14	52%
Mining, Quarrying, and Oil and Gas Extraction	1	4	3	300%
Real Estate and Rental and Leasing	181	180	(1)	-1%
Information	263	247	(16)	-6%
Retail Trade	1,620	1,470	(150)	-9%
Finance and Insurance	640	460	(180)	-28%
Other Services (excluding Public Administration)	950	324	(626)	-66%
	13,944	**15,754**	**1,810**	

Figure 17. The City of Walla Walla Jobs by Sector, 2012-2022

Source: US Census Bureau via LEHD OntheMap

Between 2012 and 2022, the sectors that added the most jobs in the City of Walla Walla were educational services, accommodation and food services, health care and social assistance, and public administration. Together, these sectors added nearly 2,000 jobs to the city's economy. Over the same period, the retail trade, finance and insurance, and other services sectors saw the most job losses.

Ten of the top 15 employers in Walla Walla County are located in the City of Walla Walla. The largest of these include Providence Saint Mary Medical Center, the Washington State Penitentiary, and the Walla Walla School District.

The City's economic goals focus on fostering a diverse, sustainable, and well-balanced mix of activities that serve both residents and visitors. Its approach supports continued community development by emphasizing the place (environment and land use), the people (culture, services, and applied expertise), and a shared commitment to shaping the future together.

The Port of Walla Walla (the Port) is the leading agency for economic development for both the City of Walla Walla and the County. The Port's 2025 Economic Development Plan focuses on the creation and maintenance of family-wage jobs and fosters private sector capital investment to enhance the economic health of families in Walla Walla County, including families living below the poverty line. The Port's Plan is action-oriented and identifies benchmarks within the following six core elements:

- Small Business Development
- Existing Business Retention/Expansion
- Business Recruitment, Marketing, and Advertising
- Site and Infrastructure Development
- Economic Profiling
- Economic Development Advocacy

The Port's 2025 plan includes roles and actions for several economic, educational, and planning partners, including Walla Walla Community College, Whitman College, WorkSource Walla Walla, the Downtown Walla Walla Foundation, Visit Walla Walla, the Walla Walla Valley Chamber of Commerce, the Walla Walla Valley Wine Alliance, school districts, the Walla Walla Valley Metropolitan Planning Organization, and others. In this plan, the City of Walla Walla's role is identified as follows:

- Formulate and adopt economic policy and guide public investment.
- Provide guidance concerning the Port's implementation of the Economic Development Plan.
- Invest in specific economic development infrastructure projects within its jurisdiction.
- Work complimentary together on-site visitations, retention efforts, and targeted economic development initiatives.
- Provide technical assistance (GMA planning support).
- Support public policy decisions that promote economic development.
- Elected official and administrative staff participation in the bi-monthly economic development informational meetings.

Future Projections

The City of Walla Walla Employment Targets

As part of the Comprehensive Planning process, Walla Walla County assigned population, housing, and employment growth targets to jurisdictions based on the expected countywide growth forecast by the Washington State Office of Financial Management (OFM). Based on historic trends and expected growth, the County assigned employment growth based on a 1:1 ratio of housing units to jobs. Therefore, the City of Walla Walla's target for the 2026-2046 period is 2,348 net new jobs. The City's housing target is also 2,348 new housing units.

Eastern Washington Employment Forecasts by Sector

The Washington State Employment Security Department produces job forecasts by industry for the major workforce development areas in the state. For the Eastern Washington Partnership, which includes Walla Walla County as well as other Eastern Washington counties all the way to the Canadian border (excluding Spokane, as shown below), the sectors with the highest expected job growth are professional and business services, education and health services, government, and leisure and hospitality.

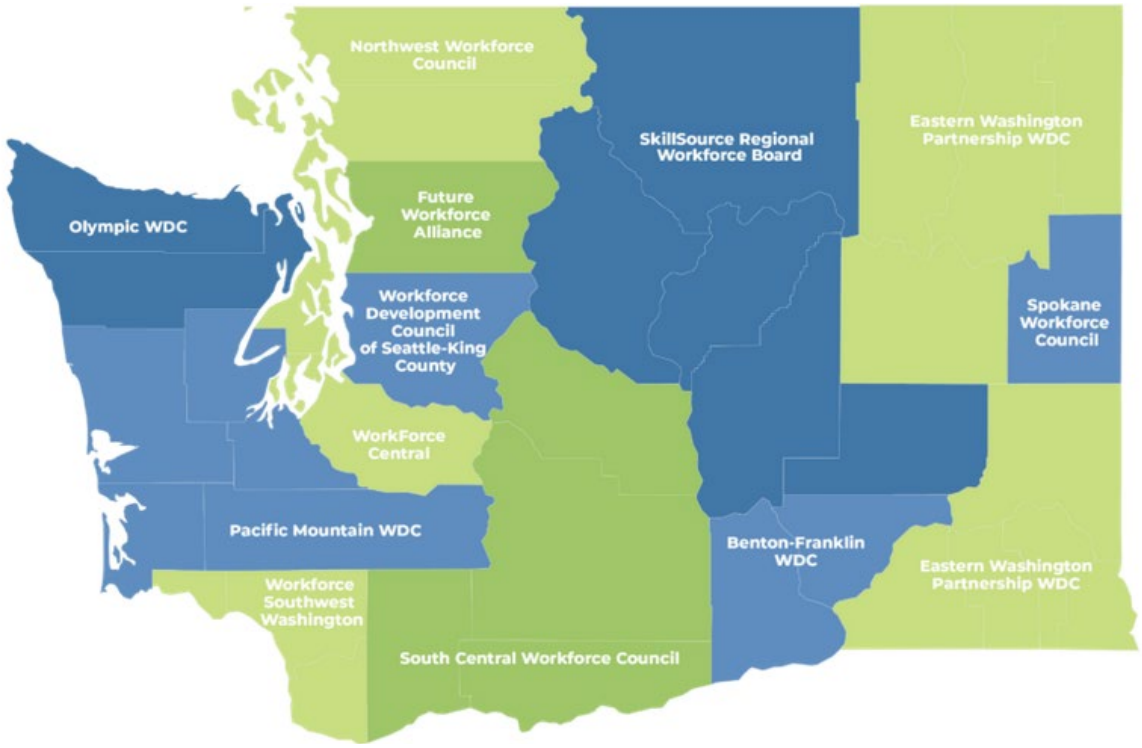


Figure 18. Washington State Workforce Development Areas

Source: Washington Workforce Association

Table 14. Employment Forecasts by Sector, Eastern Washington Workforce Development Area, 2023-2033

Title	Estimated employment 2023	Net New Jobs 2023-2033	Estimated employment 2033	Average annual growth rate 2023-2033
Total Nonfarm	**79,100**	**6,100**	**85,200**	**0.75%**
Natural Resources and Mining	400	0	400	0.00%
Construction	3,700	200	3,900	0.53%
Manufacturing	9,000	100	9,100	0.11%
Food and Beverages Manufacturing	2,600	200	2,800	0.74%
Wholesale Trade	2,100	0	2,100	0.00%
Retail Trade	6,900	200	7,100	0.29%
Food and Beverage Stores	1,800	0	1,800	0.00%
Transportation, Warehousing, and Utilities	1,900	100	2,000	0.51%
Information	500	0	500	0.00%
Financial Activities	2,100	100	2,200	0.47%
Professional and Business Services	3,500	500	4,000	1.34%
Education and Health Services	13,300	1,900	15,200	1.34%
Leisure and Hospitality	7,000	500	7,500	0.69%
Arts, Entertainment and Recreation	1,000	100	1,100	0.96%
Accommodation and Food Services	6,000	400	6,400	0.65%
Other Services	1,600	200	1,800	1.18%
Government	27,100	2,300	29,400	0.82%



Employment Land Capacity

As part of the Comprehensive Plan Update, the City conducted a Land Capacity Analysis (LCA), identifying vacant and redevelopable parcels in the City for both housing and employment uses. The full methodology and results of the LCA can be found in Appendix II. Land Capacity Analysis: Housing by Income Band of this plan. As noted above, the City has an employment target of 2,348 net new jobs for the 2026-2046 planning period. Using density assumptions based on recent commercial development by zone, and standard assumptions for square feet per employee, the LCA found a capacity for 4,405 new jobs on vacant and underutilized parcels in commercial and mixed-use zones. Additionally, the LCA found 1,183 pending jobs in development that have occurred since 2020 (planned or proposed). These pending jobs are not located on vacant or underutilized parcels. Since pending jobs and land capacity for employment on vacant and underutilized parcels both count towards meeting the City's job target, this results in a total of 5,588 new jobs over the planning horizon. This number includes pending jobs. In total, this is a surplus of 3,240 above the target, showing that the City of Walla Walla has sufficient capacity to meet its job targets for the 2026-2046 planning horizon. Table 15 on the following page shows the job capacity and the assumed commercial share of land by zone.

Table 15. Employment Land Capacity in the City of Walla Walla, 2026-2046

Zone	Description	Category	% Commercial	Net Commercial Developable Acres	Assumed Density (Jobs/Ac)	Gross Job Capacity	Net Job Capacity
CC	Central Commercial	Mixed-Use	75%	7.1	36.3	256	**256**
CH	Highway Commercial	Mixed-Use	75%	98.9	29.0	2,873	**2,873**
IH	Heavy Industrial	Industrial	100%	93.2	8.7	812	**812**
IL	Light Industrial / Commercial	Industrial	100%	53.2	8.7	464	**464**
PR	Public Reserve	Public	95%	34.1	0.0	0	**0**
RN	Neighborhood Residential	Residential	0%	0.0	0.0	0	**0**
RM	Multi-Family Residential	Residential	0%	0.0	0.0	0	**0**
UPC	Urban Planned Community	Residential	100%	29.2	0.0	0	**0**
		Total		**315.8**		**Total Land Capacity**	**4,405**
						Pending Jobs	1,183
						Grand Total	**5,588**
						Target	2,348
						Surplus	**3,240**

Challenges and Opportunities

The City of Walla Walla will likely face important economic challenges over the next twenty years. The City's remote location, distance from major transportation hubs, lack of easy access to the Interstate Highway System, and major railroad lines may limit the attractiveness of the City of Walla Walla for the recruitment of large businesses and for business and employee retention.

Additionally, as discussed in greater detail in the Housing Element, housing affordability is a challenge in the City, particularly for renters. A lack of available and affordable housing can have significant negative impacts on the city's economy, particularly in sectors with lower-wage jobs, such as the tourism and service industries, which are important sectors in the City. Among all renter households, 45 percent are estimated to be cost burdened, spending more than 30 percent of their income on housing costs, and 24 percent are estimated to be severely cost burdened, spending more than half their income on housing costs. Few households with low or very low incomes can find housing they can afford.

Wages pose both a challenge and an opportunity for the City: while wages for common jobs in the City's top sectors vary widely, jobs in the healthcare and education sectors are among the highest paying in the local economy. As these higher-paying sectors continue to grow, household incomes should rise. However, jobs in the accommodation and food services industry, which are important in the City's central business district and wine industry, are much lower paying. These jobs are essential to a healthy economy, but workers are susceptible to displacement as the cost-of-living rises.

The wine industry is a major driver of tourism and has contributed to significant growth in the accommodation sector. The City recently completed a Tourism Master Plan that highlighted the continued importance of tourism and the wine industry in the local economy. In 2022, winemakers in Walla Walla County produced nearly 3.5 million gallons of wine (55.8 gallons per capita). This is the highest production level since at least 2009, indicating strong growth in the sector and a rebound from the height of the COVID-19 pandemic. However, there are indications that the alcoholic beverage industry, and wine in particular, could face significant headwinds in the coming years. Nationwide, the demand for wine has been declining since 2020. A report by Silicon Valley Bank0F0F0F1 shows that across the US, the total wine volume consumed has declined in 2021, 2022, 2023, and 2024. These trends indicate that the City may need to diversify its economic and tourism base beyond wine to achieve sustainable growth in the near term.

Educational institutions in the City, including Walla Walla Public Schools and private schools, Whitman College, and Walla Walla Community College, offer unique opportunities for workforce development and business attraction, especially for students and employers in the health care, food services, and viticulture sectors. higher education is facing significant demographic challenges and a continued decline in enrollment. To remain sustainable, institutions are adopting new strategies. Many are shifting their focus to attract adult learners, expanding online and hybrid education options, and developing innovative pathways to strengthen enrollment. Building on this opportunity will be key to economic growth.

[1] Silicon Valley Bank. State of the US Wine Industry 2025. https://www.svb.com/globalassets/library/uploadedfiles/wine/svb-state-of-the-us-wine-industry-report-2025.pdf

Downtown Walla Walla is a significant commercial center for the region as well as a high-quality amenity for residents, visitors, and businesses. Public investments in Downtown, such as the recent completion of Walawála Plaza and Heritage Square, will help attract new workers and businesses to the city.

The key commercial corridors of Eastgate, Southgate, 9th Avenue, and Plaza Way are experiencing challenges such as persistent vacancies, limited pedestrian amenities, and auto-oriented layouts dominated by large parking lots. Looking ahead, these areas have strong potential to be revitalized through improved pedestrian facilities, upgraded streetscapes, and the introduction of public attractions that create a more inviting and connected environment. A focused analysis of each corridor should identify strategies to strengthen economic vitality and support long-term economic health and sustainability.

The City's other opportunities include replacing and maintaining the built environment and infrastructure, which include the streetscapes and sidewalks; preserving established neighborhoods with historic buildings and homes; and supporting the Parks and Recreation programs and facilities.

Leveraging the City's Identity for Economic Vitality

Many local businesses benefit from the City's attractive physical identity, and the business community is actively promoting the City's attractions. Because businesses and developers benefit from these attractions, it is appropriate that developers and businesses invest in the community's attractiveness and amenities.

Accommodating Growth While Maintaining Attractiveness and Walla Walla's Unique Character

The City should balance attracting higher-paying jobs while taking deliberate steps to preserve its historic, physical, and social character. To achieve this, the City should promote its development incentives and financial tools. The City can also continue the use of special tax valuation to help activate and rehabilitate underutilized historic buildings, strengthening both economic vitality and preservation efforts.

Goals and Policies

ED Goal 1: Walla Walla continues to build a diversified, skilled, and well-educated workforce.

- ED 1.1: Work with the City's higher education partners to expand opportunities for residents seeking higher education and technical skills for job advancement and greater economic opportunity.
- ED 1.2: Coordinate with Whitman College, Walla Walla University, Walla Walla Community College, and Walla Walla Public Schools to support their substantial contributions to the economic vitality of the City.
- ED 1.3: Promote and support the Opportunity Zones.
- ED 1.4: Collaborate with the Port of Walla Walla, the State, neighboring jurisdictions, tribal governments, and special districts to promote economic growth.
- ED 1.5: Prioritize employer recruitment efforts to ensure the City's growth aligns with Walla Walla County's adopted countywide employment growth targets.

ED Goal 2: Walla Walla has an array of sustainable employment choices for all income and age levels, particularly jobs that pay a living wage.

- ED 2.1: Seek to diversify Walla Walla's economy with a variety of businesses to weather economic cycles.
- ED 2.2: Address regulatory, policy, and other barriers to business retention, expansion, and recruitment in Walla Walla.
- ED 2.3: Encourage business stakeholders in the community to develop more employment opportunities.

ED Goal 3: Walla Walla has a supportive environment for entrepreneurial opportunities and startup businesses.

- ED 3.1: Support home-based businesses and occupations by reviewing and implementing policies and regulations that are current and adaptive to new technologies.
- ED 3.2: Work with the Port of Walla Walla and private commercial owners to provide low-cost incubation space for startup businesses, including office-based and industrial.
- ED 3.3: Evaluate the impact of development standards on businesses and amend as needed.
- ED 3.4: Ensure there is adequate land and infrastructure for businesses and industries including utilities and transportation connections.

ED Goal 4: Walla Walla offers a high quality of life for entrepreneurs, their families, and employees.

- ED 4.1: Accommodate housing at all income levels for future employees through appropriate land use and development regulations.
- ED 4.2: Support and encourage the creation and retention of quality, accessible, and affordable childcare.
- ED 4.3: Strive to connect the community with affordable and quality broadband.

ED Goal 5: Downtown Walla Walla is full of thriving businesses and is recognized and celebrated as the center of the community.

- ED 5.1: Retain and recruit businesses in the Central Business District.
- ED 5.2: Encourage continued revitalization of Downtown through appropriate development, redevelopment, and rehabilitation.
- ED 5.3: Incentivize redevelopment of vacated commercial spaces and upper story levels in the Downtown.
- ED 5.4: Continue the support and encouragement of tourism-based commerce within the Downtown while balancing the needs of residents.

ED Goal 6: Walla Walla has a thriving retail economy with ample shopping opportunities, and local residents choose to shop in the city.

- ED 6.1: Analyze conditions in the Eastgate Corridor to determine strategies for strengthening economic vitality.
- ED 6.2: Promote the long-term economic health and sustainability of commercial corridors, including Eastgate, Southgate, 9th Avenue/ Plaza Way, and Myra Road.
- ED 6.3: Work with property owners to develop the Myra Road corridor as a mixed-use urban village that supports both commercial and residential development.

ED Goal 7: Tourism continues to be an important part of Walla Walla's economy, including heritage and enology and viticulture.

- ED 7.1: Maintain and improve the built environment of sidewalks, parks, paths and other public amenities that visitors will enjoy and utilize.
- ED 7.2: Support the region's tourism agencies in promoting the City and region as a welcoming place to live and a destination for entertainment, commerce, recreation, and tourism.

ED Goal 8: Walla Walla provides a resilient, year-round local economy that honors Walla Walla's heritage, agriculture, wine, tourism, and cultural identity while expanding business-sector diversity, living-wage employment, and opportunities for entrepreneurship.

- ED 8.1: Support the retention, expansion, and modernization of existing businesses across Walla Walla's established and emerging sectors.
- ED 8.2: Encourage land use, infrastructure, and permitting approaches that support flexible, multi-use business environments, and preserve and enhance areas suitable for light industrial, maker, production, studio, warehouse, office, and other mixed-use employment activities.
- ED 8.3: Strengthen Walla Walla's ability to attract and grow small to mid-sized businesses that provide year-round employment and reduce reliance on any single season, industry, or visitor-driven revenue stream.
- ED 8.4: Recognize creative industries, film, media, and related production sectors as well as associated support services as emerging economic opportunities that diversify the local economy, increase off-season activity, support local vendors, and build on Walla Walla's quality of place.
- ED 8.5: Coordinate economic development planning with workforce training and education, housing, transportation, broadband, utilities, land-use planning, and commercial space needs to support long-term business growth, retention, and recruitment.
- ED 8.6: Support economic diversification by encouraging growth, retention, and recruitment of small to mid-sized employers in sectors that provide year-round, living-wage jobs and are not solely dependent on seasonal visitor activity.
- ED 8.7: Support entrepreneurship, incubators, co-working, maker spaces, and adaptive-reuse opportunities that allow local businesses and emerging sectors to start, scale, and remain in Walla Walla.
- ED 8.8: Support Walla Walla's Creative District as both a cultural and economic development asset by encouraging arts, design, film, media, culinary, heritage, music and production-related businesses that contribute to downtown vitality, local entrepreneurship, visitor experience, and year-round employment.

Policy Connections

- **The Land Use Element** includes policies to accommodate projected growth and ensure sufficient land capacity is available for new jobs and residents.
- **The Capital Facilities and Utilities Element** and the **Transportation Element** demonstrate how future land uses will be served by public services and infrastructure.

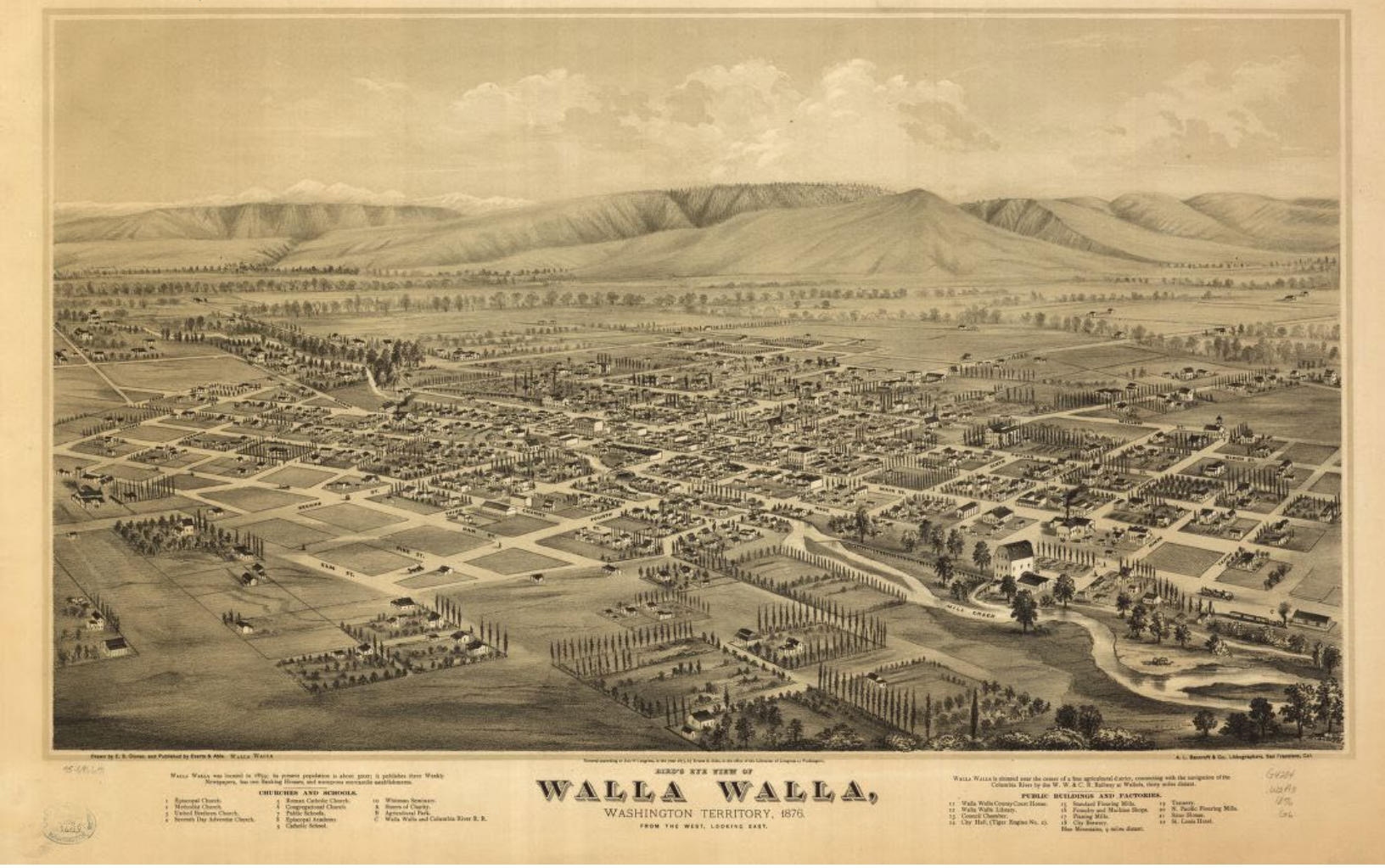
- Policies for the preservation of historic buildings and neighborhoods are included in the **Historic Preservation Element**. Other policies that address neighborhood character can be found in the **Community Character Element**.

Translating Policy into Action

Table 16. Economic Development Implementation Actions

Implementation Action	Timeline	Responsibility
Invest in public infrastructure	Ongoing	Public Works
Participate in regional economic development meetings and activities	Ongoing	Community Development
Enhance the economic health of the City of Walla Walla through the development and execution of the Port of Walla Walla Economic Development plan	Ongoing	Port of Walla Walla and the City of Walla Walla
Monitor and adjust development standards to meet the needs of employers, while maintaining community values.	Ongoing	Community Development
Encourage redevelopment in vacant commercial spaces Downtown and highway commercial zones	Ongoing	Community Development
Work with the Port of Walla Walla and private commercial owners to provide low-cost incubation space for startup businesses, including office-based and industrial.	Ongoing	Community Development and Port of Walla Walla
Initiate commercial corridor studies to assess infrastructure needs and support the sustainability and resilience of key corridors	5-10 years	Community Development and Public Works
Support the redevelopment and strengthen the economic vitality of the Eastgate commercial corridor.	5 years	Community Development
Create and launch a dedicated webpage that clearly presents the City's available economic incentive tools	1-5 Years	Community Development
Support the implementation of the Tourism Master Plan	Ongoing	Community Development

Historic Preservation



Bird's eye view of Walla Walla, Washington Territory

Source: Walla Walla, Everts & Able 1876 via the Library of Congress

Introduction

The City of Walla Walla is a vibrant community with a rich history—some of the oldest built-environment resources in the state are present in the City. The history of the Walla Walla Valley begins with early stewardship of the land by the ancestors of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Walla Walla's historic resources help define the character of the city and its inhabitants, create a strong sense of place, enhance the quality of life for residents, and connect those residents to the city's heritage.

The City of Walla Walla has valued the preservation of its historic buildings and sites for many years and formalized that commitment by establishing the Historic Preservation Commission in 2002. In 2003, the City became a Certified Local Government (CLG) and created a Historic Preservation Plan (HPP) in 2022. The HPP provides a roadmap for the program, ensuring that the heritage and historic places that enrich the community remain for future generations. As a Certified Local Government (CLG), Walla Walla's commitment to historic preservation recognizes the value of maintaining the rich history of the community and the economic benefits of preserving structures, particularly in downtown Walla Walla and its historic neighborhoods.

CLG status is given by the National Park Service (NPS) and serves as a means for local governments to strengthen their historic preservation efforts. CLGs are eligible for technical assistance and matching grants from their State Historic Preservation Offices (SHPO), which are sponsored by the NPS and state governments. The City has successfully collaborated with residents, private investors, and organizations such as the Downtown Walla Walla Foundation to adaptively reuse and redevelop several historic structures in the City's core to preserve Walla Walla's historic architecture. Significant preservation and revitalization efforts include:

- Establishment of the Downtown Walla Walla Foundation in 1984.
- Rehabilitation and renovation of the Die Brücke Building.
- Rehabilitation and renovation of the Whitehouse-Crawford Building.
- Creation of a public-facing interactive GIS (geographic information system) map of the Walla Walla Register of Historic Places.
- Generation of historic property inventory reports for homes and buildings to provide the information required for listing on historic registers.
- Designation of the Downtown Walla Walla National Historic Register District in 2021.
- Creation and City Council adoption of a city-wide Historic Preservation Plan in 2023.

Walla Walla has embraced historic preservation as an effective tool for economic vigor and stability. For the past 40 years, historic preservation has been used to transform the downtown core, Fort Walla Walla Historic District, and neighborhoods throughout the City. Walla Walla's cultural stewardship has helped the City remain an attractive and vibrant place to live, work, and play.

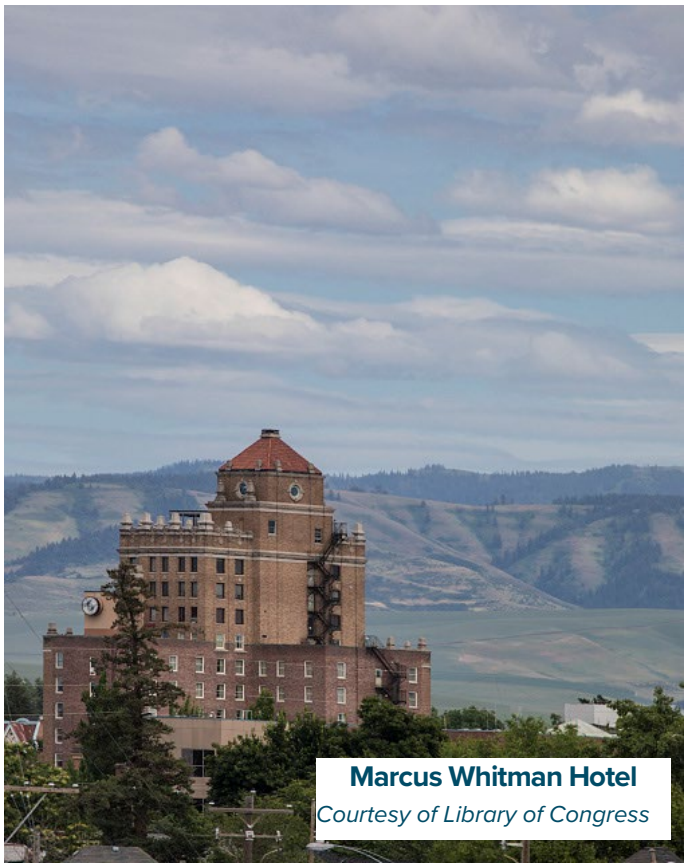


For the purposes of this plan, historic preservation is defined as follows:

Historic preservation is an activity that preserves historic resources and their ability to communicate their intended meaning and significance. Historic preservation includes the identification, evaluation, designation, protection, and retention of significant architectural, historic, and cultural resources in the built and natural environments. Resources can include everything from small objects and individual buildings to sites and districts, as well as landscapes, streetscapes, and viewsheds. The benefits of historic preservation are increased sustainability and green building, and it can create a strong and unique sense of place through the retention of older buildings. Overall, historic preservation efforts enhance a community's quality of life.

There are numerous benefits of historic preservation. Four key areas where historic preservation can benefit a community are social, cultural, environmental, and economic.

1. **Social:** Historic resources are recognized and known entities within their community, whether that is land associated with traditional cultural practices, a park that generations have visited with family and friends, or a commercial building that has housed a highly regarded legacy small business.
2. **Cultural:** Within Walla Walla, historic buildings represent a window to the past and what the City used to look like, providing opportunities for cultural tourism and for still-standing historical buildings to be in use today.
3. **Environmental:** Historic preservation can support the efforts of environmental sustainability. Reusing historic buildings and structures preserves the embodied energy inherent to these resources and reduces what is taken to the landfill.
4. **Economic:** The labor intensiveness of reusing historic buildings creates local jobs. Cultural resources provide a rich setting for businesses and events that draw residents and tourists, encouraging investment in local economies. Historic properties tend to have stable property values, allowing them to weather economic crises.



Marcus Whitman Hotel
Courtesy of Library of Congress

Several laws at the federal, state, and local levels serve as the legal basis for the City's historic preservation activities. At the federal level are the National Historic Preservation Act of 1966 (NHPA), as amended; the National Environmental

Policy Act of 1969 (NEPA), as amended; the Archaeological and Historic Preservation Act of 1978 (AHPA), as amended; the Archaeological Resources Protection Act of 1979 (ARPA), as amended; and the Native American Graves Protection and Repatriation Act of 1990 (NAGPRA), as amended, and others.

Washington state laws on historic preservation include the State Environmental Policy Act (SEPA) of 1971; the Shoreline Management Act (SMA) of 1971; the Abandoned and Historic Cemeteries and Historic Graves Act (RCW 68.60); the Archaeological Sites and Resources Act; the Washington State Historic Building Code; the Governor's Executive Order 21-02; Chapter 25-12 of the Washington Administrative Code (WAC): Advisory Council on Historic Preservation; and Chapter 19.27.120 of the Revised Code of Washington (RCW): Building Code Exception.

The City of Walla Walla Municipal Code Chapter 2.27 establishes the Historic Preservation Commission (HPC), commonly called the Historic Preservation Ordinance. This ordinance defined the HPC responsibilities and established the City of Walla Walla Register of Historic Places (WWRHP), often referred to as the Local Register, and authorized the special valuation program (ten-year period of revised assessment valuation). The purpose of the ordinance is to provide for the identification, evaluation, designation, and protection of the City's historic and prehistoric resources. It also seeks to preserve and rehabilitate eligible historic properties for future generations through the use of special valuation, a property tax incentive, and other means. As a Certified Local Government (CLG), the City is responsible for administering the HPC; continuing to survey local historic properties; maintaining the WWRHP; and providing the public with opportunities to participate in other preservation activities.

Funding

CLG status is given by the National Park Service (NPS) and is a means for local governments to strengthen their historic preservation efforts. There are many benefits to being a CLG, such as eligibility for public and private funding through technical assistance and matching grants, typically administered by State Historic Preservation Offices (SHPO) and supported by the NPS and state governments.

Annual CLG grant funding is available from the NPS through the Department of Archaeology and Historic Preservation (DAHP). CLG grants can be used to support a variety of preservation planning activities, including historic surveys, developing design guidelines, educational materials, and others.

The City of Walla Walla and the Historic Preservation Commission have been active in seeking grants through the DAHP to complete inventories of neighborhoods. Reconnaissance-level surveys have been completed of the following neighborhoods:

- Downtown Walla Walla
- Green Park Neighborhood
- Germantown

The City does not have a grant program specific to designated historic properties.

Today and Tomorrow

Historic Context

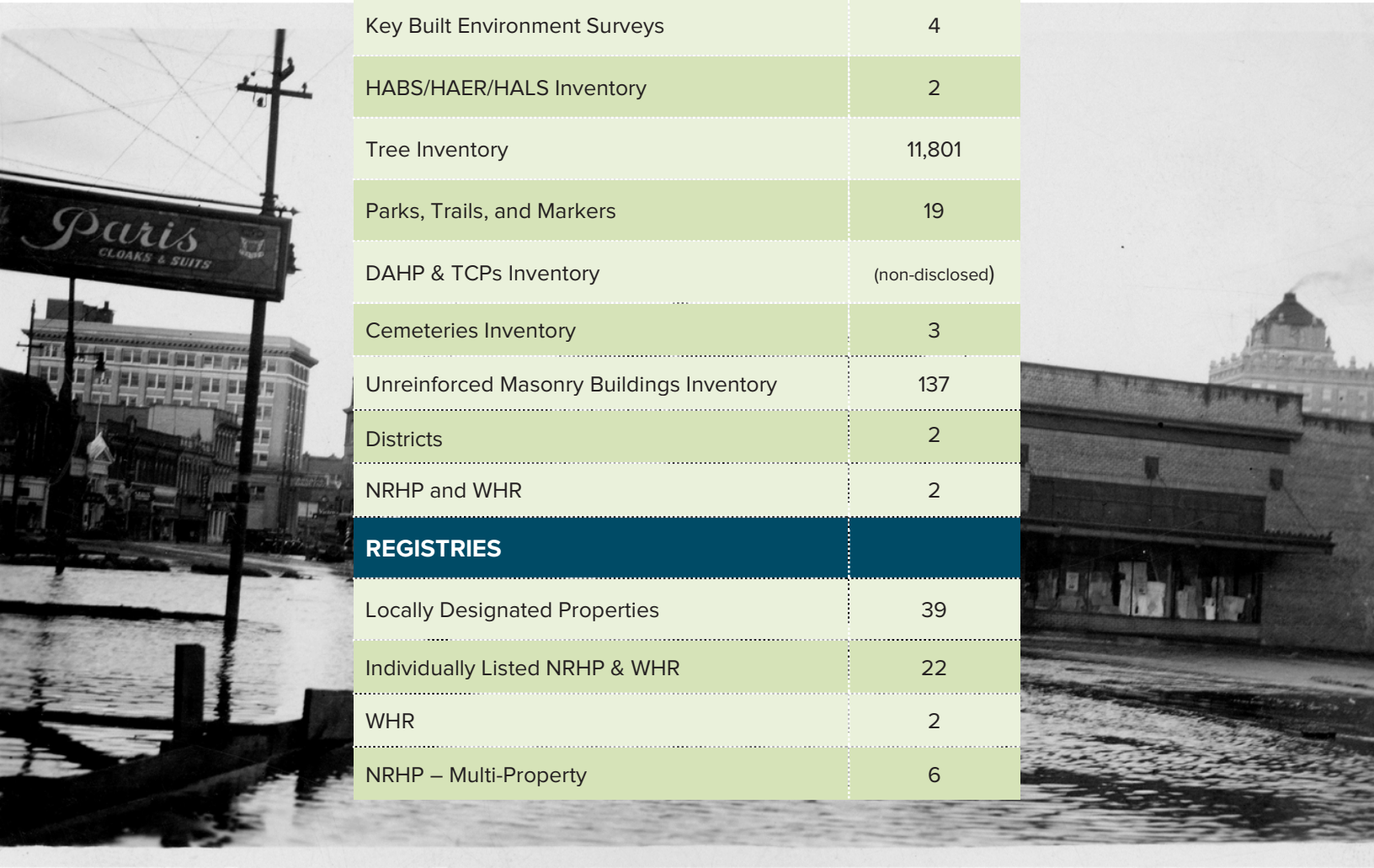
Historic context is not a complete history of Walla Walla, but it provides a summary of the City's founding and development in the context of the built environment. To provide context for the City's history, staff completed surveys and inventories of historic features. There are multiple inventories that relate to historic resources and are maintained by different entities and accessed in different ways.

The Historic Preservation Plan is a reference in the Comprehensive Plan, and it provides full lists and more detailed information on built-environment surveys and historic inventories completed to date.

Cultural resource surveys conducted within the city limits resulted in over 1,300 inventoried resources in the City of Walla Walla historic inventory via WISAARD.

Table 17. Inventoried and Registered Resources

INVENTORIES	Qty
Key Built Environment Surveys	4
HABS/HAER/HALS Inventory	2
Tree Inventory	11,801
Parks, Trails, and Markers	19
DAHP & TCPs Inventory	(non-disclosed)
Cemeteries Inventory	3
Unreinforced Masonry Buildings Inventory	137
Districts	2
NRHP and WHR	2
REGISTRIES	
Locally Designated Properties	39
Individually Listed NRHP & WHR	22
WHR	2
NRHP – Multi-Property	6



View of Main Street, looking west, after 1931 flood — from the Washington State Archives

Conditions Today

Sixty-four properties and structures within the City are either listed on the National Register of Historic Places, the Washington Heritage Register, or the City's Local Register of Historic Places. The Historic Preservation Plan, a reference to this Comprehensive Plan, includes a complete list of the properties and structures on the various historic registers.

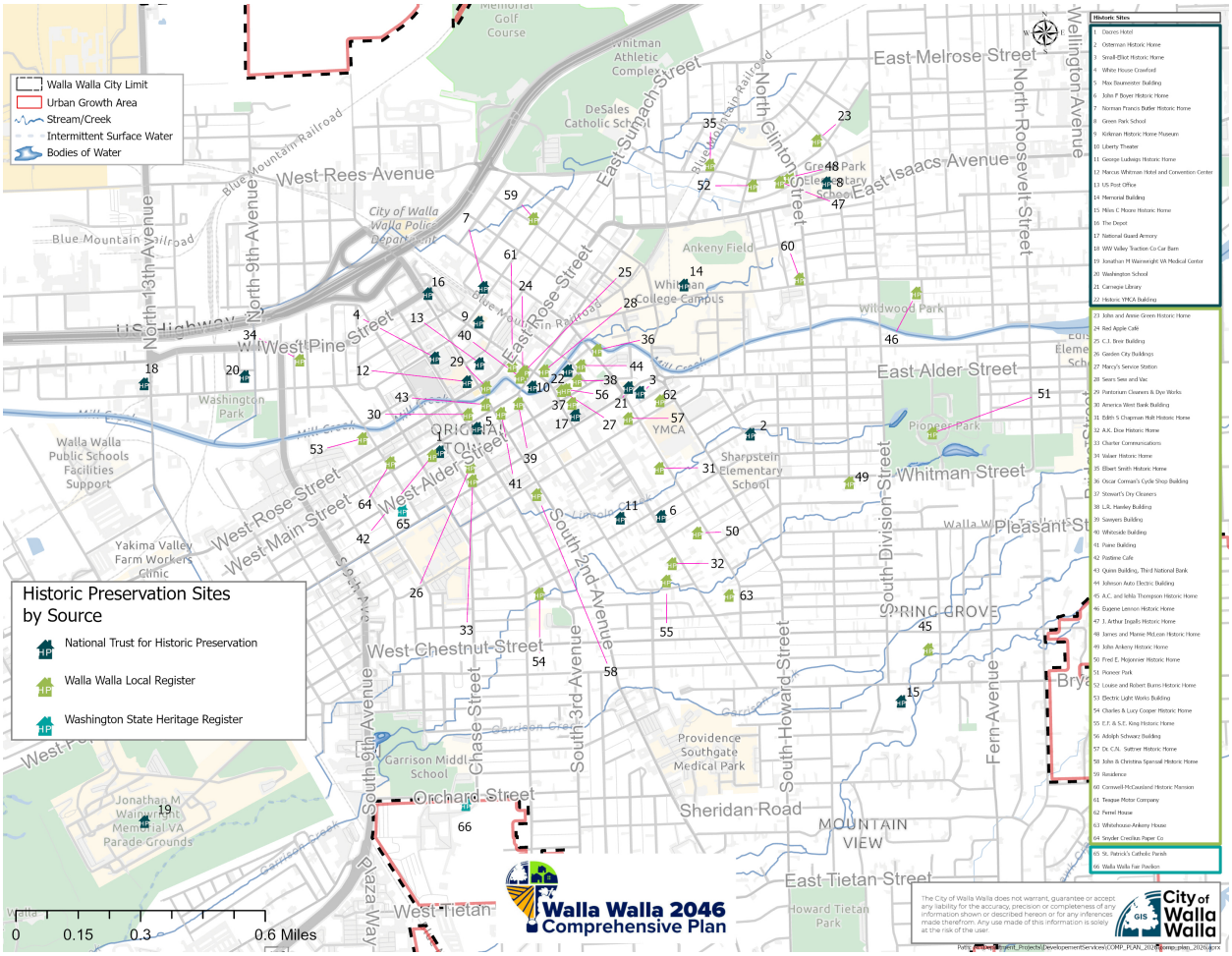


Figure 19. Historic Preservation Sites

The current state of historic preservation in the City of Walla Walla is robust, with more initiatives to preserve the city's architectural and cultural heritage sites. The Downtown Walla Walla Historic District was listed on the National Register of Historic Places in September 2021, covering roughly 100 properties.

The community has made progress in a number of preservation and restoration projects. For example, the exterior of the Walla Walla County Courthouse, including terracotta and sandstone elements, is being restored thanks to a sizable state grant, with efforts underway to extend work to other facades. The City completed and adopted a long-term Historic Preservation

Plan in 2023, developed with public input, to guide preservation efforts over the next decade. Lastly, newer tools for public engagement and transparency are being implemented—for example, the development of an interactive map to display the city's historic register properties, making it easier for residents and visitors to understand and appreciate what is historic in Walla Walla. More information about the City's historic preservation may be found in the Historic Preservation Plan.

Challenges and Opportunities

Historic preservation can face many challenges, such as buildings that have been altered over time in ways that diminish their historic integrity, or properties that are under pressure for demolition to make way for redevelopment opportunities. Deterioration and the high cost of rehabilitation hinder preservation efforts, and declining state and local grant funding for surveys and inventories further intensifies these challenges.

One goal of this Plan is to increase awareness of historic preservation and its benefits. Currently, inadequate incentives, regulatory frameworks, and lack of education pose challenges. There is a need for an easily accessible method to share information and engage stakeholders and the general public in the preservation process.

The Walla Walla community sees the benefits of historic preservation through a vibrant downtown, increased tourism, and pride in the community. Maintaining that momentum in strategic ways, such as identifying the community's priorities for preservation and promoting rehabilitation of structures, is key to an effective preservation program. A lack of education of historic preservation processes and programs among the public continues to pose challenges. Enhancing the community's knowledge of preservation incentives and tools is an important opportunity. Other opportunities include economic development through historic rehabilitation, which generates direct economic impacts through purchases of goods and services and indirect impacts through related spending at local businesses.



Sharpstein Elementary School
Courtesy of the Library of Congress

Walla Walla's Plan

The purpose of the Historic Preservation Element is to provide guidance for residents, developers, and organizations regarding preservation issues within the City of Walla Walla. This document formalizes City policy, guides public and private investment to advance the City's preservation goals, supports the work of the Historic Preservation. More information about the city's historic preservation may be found in the Historic Preservation Plan.

Commission, and promotes historic preservation throughout the community in order to:

- Safeguard the history of Walla Walla as represented by the buildings, districts, objects, sites, structures, and landscapes which reflect significant elements of the City's history;
- Foster civic and neighborhood pride in the beauty and accomplishments of the past, and a sense of identity based on Walla Walla's history;
- Stabilize or improve the aesthetic and economic vitality and values of historic sites, improvements and objects;
- Assist, encourage, and provide incentives to property and business owners for preservation, restoration, rehabilitation, redevelopment and use of outstanding historic buildings, districts, objects, sites, and structures;
- Conserve valuable material and energy resources by ongoing use and maintenance of the existing built environment.

Goals and Policies

The following goals support the vision and mission of Walla Walla's historic preservation program and will guide ongoing work.

HP Goal 1: Walla Walla values its rich history and strives to protect and memorialize it.

- HP 1.1: Broaden and clarify the role of historic preservation within the city's decision making.
- HP 1.2: Work with residents and property owners to establish preservation districts with design guidelines.
- HP 1.3: Encourage designation to the Walla Walla Register of Historic Places.

HP Goal 2: Walla Walla values its unique cultural resources.

- HP 2.1: Protect archaeological resources and traditional cultural properties, including those significant to area Tribes.
- HP 2.2: Continue seeking grant opportunities to conduct cultural resource surveys.
- HP 2.3: Encourage alternatives to demolishing cultural resources and prohibit demolition of those eligible for a historic register when the purpose is to build parking.
- HP 2.4: Reuse existing public buildings in such a way that civic and historic design elements are preserved, and encourage school districts, Whitman College, and Walla Walla County to reuse structures rather than tear down.

HP Goal 3: Walla Walla is committed to making historic preservation information available to its citizens.

- HP 3.1: Expand the community's understanding of cultural resources in collaboration with the Confederated Tribes of the Umatilla Indian Reservation and broaden the range of historic properties and stories that are documented.
- HP 3.2: Provide educational materials in a variety of formats that outline the benefits of historic preservation and encourage appropriate renovation, restoration, and infill construction throughout the City.

HP Goal 4: Historic preservation supports Walla Walla's economic vitality.

- HP 4.1: Provide assistance and education to developers, landowners, and interested citizens in obtaining grants and tax incentives for the reuse and rehabilitation of designated cultural resources.

- HP 4.2: Publicize historic preservation projects and highlight the economic benefits.
- HP 4.3: Encourage adaptive reuse of historic structures through incentives such as local register designation and accessing special valuation property tax benefits.

HP Goal 5: Ensure authenticity guides heritage tourism in Walla Walla.

- HP 5.1: Actively encourage and promote Walla Walla as a heritage tourism destination, including attractions such as historic barns/farms, historic wineries, historic downtown, charming historic neighborhoods, local history sites, Fort Walla Walla Museum, Frenchtown Historic Site, Whitman Mission, Kirkman House Museum, walking tours, and biking tours.
- HP 5.2: Utilize heritage tourism materials to engage with Walla Walla residents.
- HP 5.3: Continue to honor local historic sites not designated on the City's local register.
- HP 5.4: Support and encourage adaptive reuse of historic buildings in downtown Walla Walla.

Policy Connections

- **The Housing Element** includes policies to revitalize neighborhoods and preserve the housing stock.
- **The Economic Development Element** includes policies for promoting heritage tourism.
- **The Community Character Element** includes policies that address the community's physical qualities and how we experience them.

Translating Policy into Action

This section makes connections between other city plans, programs, and actions and the policy direction of this element.

Table 18. Historic Preservation Implementation Action

Implementation Action	Timeline	Responsibility
Establish preservation districts for neighborhoods, work with residents and property owners, and explore opportunities with DAHP grant funds in the future.	Ongoing	Community Development and Historic Preservation Commission
Refine education materials that outline the benefits of historic preservation	3-5 years	Community Development and Historic Preservation Commission
Develop a program/ process that highlights historic preservation projects	5 years	Community Development and Historic Preservation Commission
Expand visitor awareness of Walla Walla's heritage and its historic resources online and promote WW as a destination for cultural heritage tourists	Ongoing	Visit Walla Walla Fort Walla Walla Museum Communications
Implement the recommendations of the Historic Preservation Plan	Ongoing	Community Development



Parks and Recreation

Introduction

Parks and recreation facilities are key components in developing and maintaining a vibrant and attractive community. The City of Walla Walla contains numerous city parks, which include a pool, cemetery, sports complex, and golf course to meet community needs. Recreation programs bring people together, improve the quality of life, and promote a healthy community. Parks and recreation facilities also play an important role in the City's economy by attracting and retaining workforce, instilling community pride, and encouraging tourism. Additionally, a balanced and engaging community park system is a strong selling point for employers who want to invest in the community and attract talent.

This Element provides a summary and overall assessment of the parks and recreation resources in the City of Walla Walla along with goals and policies. The City's Parks and Recreation Comprehensive Plan, as adopted by reference, provides a much more detailed inventory and analysis of the City's parks and recreation facilities as well as a more expansive review of future capital projects.





Today and Tomorrow

Conditions Today

The City of Walla Walla has a rich and distinctive history of park development that reflects the community's early commitment to civic beauty and recreation. This legacy began in 1901, when the City Council proposed retaining city-owned property for a "City Park." That vision became reality in 1908, with the opening of Walla Walla's first park, named City Park. In 1931, the park was renamed Pioneer Park.

The transformation of this land into a vibrant public space was driven by the Women's Park Club of Walla Walla, led by Grace Isaacs in the early 1900s. This dedicated group of local women championed the creation and funding of the park, turning a dusty tract into a beautiful civic landmark. They built essential infrastructure, including the iconic gazebo and fountains, which left a lasting imprint on Walla Walla's cultural and physical landscape.

Their efforts did not stop there. With the support of Park Commission President John Langdon, the Park Club continued raising funds for park improvements and city beautification. Their advocacy led to the hiring of the renowned Olmsted Brothers, one of America's most influential landscape architecture firms. John C. Olmsted provided detailed recommendations for Pioneer Park and proposed a comprehensive vision for additional parks throughout the City.

In the decades that followed, the Club remained instrumental in expanding and enhancing Walla Walla's park system. They donated land, planted trees and shrubs, installed play equipment, and added amenities that enriched the community's quality of life. Their foresight and dedication established a tradition of green space preservation that continues today, reflected in the wealth of parks that make Walla Walla a uniquely livable and beautiful city.

The City's park system has grown to include 17 parks encompassing approximately 600 acres of parkland. This includes Veterans Memorial Golf Course, an 18-hole municipal golf course, Mountain View Cemetery, an 89-acre cemetery established in the 1860s, and Veterans Memorial Pool, an Olympic-sized lap pool with slides and splash features. The park system offers a wide range of recreation programs, youth and adult sports, educational opportunities, and community events. Mountain View Cemetery also serves as a space for passive recreation activities such as walking and cycling. Residents and visitors alike enjoy amenities such as the downtown Walawála Plaza, the fully rebuilt Heritage Square, eight pickleball courts and expanded parking at the Mill Creek Sportsplex, and six pickleball courts at Pioneer Park.

Future Projections

Population growth in the City has historically been slow and steady, averaging approximately 0.49% per year from 2016 to 2025, with two years of negative growth during the coronavirus pandemic. Between 2024 and 2025, the City experienced a growth rate of 0.78%. While the current inventory provides sufficient parkland by acreage per capita, anticipated growth in the southern region of the City will require the development of additional park spaces to meet future demand.

According to the American Community Survey (ACS) 5-year 2023 data, approximately 46% of Walla Walla's population is younger than 35, with another 19% of the population over the age of 65. These age groups typically have a higher demand for parks and recreation activities, as younger adults are engaged in sporting activities and older adults are engaged in recreation programs and other social activities. A variety of recreation activities that meet the needs of all age groups should be provided, with the intent to engage all sectors of the community and to develop an inclusive recreation program.

Tournament Based Tourism

There is also a growing demand for recreational sports that promote tourism. Interest in tournament-based sporting activities such as volleyball, baseball, softball, soccer, and swimming continues to expand, and there is a need to provide high-quality recreation facilities and amenities to support this growth. Expansion of parkland by adding fields, parking, and basic infrastructure will be needed to accommodate this growth. As recreational tourism and the population increase, existing open spaces will be programmed to promote outdoor events.

Indoor Recreation Space

Indoor recreation facilities owned by the City are limited, and future opportunities to provide flexible gym space for a variety of uses should be evaluated. In the short-term, finding opportunities to either expand existing recreation centers or shared-use facilities within the school system should be a priority.



Challenges and Opportunities

Funding

The Parks and Recreation Department faces a significant backlog of deferred maintenance projects due to limited funding. Historically, capital for the Department has come from the City's general fund, grants, and private donations.

Updating the Parks and Recreation Comprehensive Plan will keep the City strategically aligned to plan and budget for park improvements, while also strengthening its ability to secure state grant funding.

While an assessed value levy will help build a sustainable funding source for future park improvements, immediate needs remain until sufficient funds have been collected. In the short term, expanding partnerships with outside organizations, collaborating with facility providers, and leveraging cooperative agreements will be essential to address critical gaps, particularly the lack of indoor recreation space. These partnerships can help meet community needs now, while longer-term funding strategies are implemented.

While these funding sources have been valuable, there is an opportunity to expand partnerships with external organizations, strengthen collaboration with facility providers, and explore additional funding mechanisms to support system-wide improvements and targeted facility upgrades. Addressing the Department's substantial backlog of deferred maintenance projects will require a more diversified and sustainable funding strategy.

Community Outreach and Stewardship

As the community grows, so should the communication tools for public outreach. Keeping the public informed of planned improvements, facility closures, upcoming recreational programs, and volunteer opportunities will increase stewardship and reduce costs. User-friendly enhancements to the City website, the use of social media, and public announcements are effective ways to disseminate information to the public with minimal effort and cost. Volunteer stewardship opportunities, such as tree planting, fundraising, and maintenance build partnerships with community organizations and advance park developments, improvements, or conservation efforts.

Preservation of the Urban Forest

The existing urban forest is a great asset to the City and contributes to the high quality of life. However, many of the trees are over 100 years old and are reaching the end of their expected lifespans. Replacement of this canopy is an important part of maintaining the quality of life, and will require public education, volunteerism, and adequate funding, including full implementation of the existing Urban Forestry Management Plan.

Public Safety

Public safety is a cornerstone of the City's successful park system and plays a vital role in encouraging park usage and supporting tourism. Active, well-maintained parks naturally promote a sense of security and community pride. To achieve this, City efforts will focus on public education and collaboration with community policing initiatives, keeping parks vibrant through events and programming, and ensuring that equipment and facilities remain clean, safe, and in excellent condition throughout the system.

Attracting New Park Users

There are many opportunities to schedule events such as concerts, cultural activities, and sporting events to attract park users and recreational tourism. This may mean that additional sports fields are needed in the existing sports complexes to attract larger tournaments, or facilities upgraded to support larger crowds. These types of events generate revenue for the City's general fund through increased hotel and sales tax revenue and for the park system through user fees and on-site vending.



Walla Walla's Plan

To meet the community's parks, recreation, and open space needs, the City is dedicated to providing proper funding and mechanisms to maintain existing parks and to develop new parklands.

- Collaboration with agencies, the public, and the private development community to provide more recreational programs, opportunities, and volunteerism.
- Preservation and enhancement of the City's urban forest.
- Offering services and programs to all ages and segments of society in order to build healthy and productive lives.
- Proactively supporting the Parks and Recreation Comprehensive Plan and assisting in educating the public on what the park system has to offer.

The goals and policies outlined in the Comprehensive Plan have been developed to reflect the values and future of the community. The intent of these policies is to provide the Parks Department with the flexibility they will need to achieve these goals.

Parks and Recreation Inventory Map

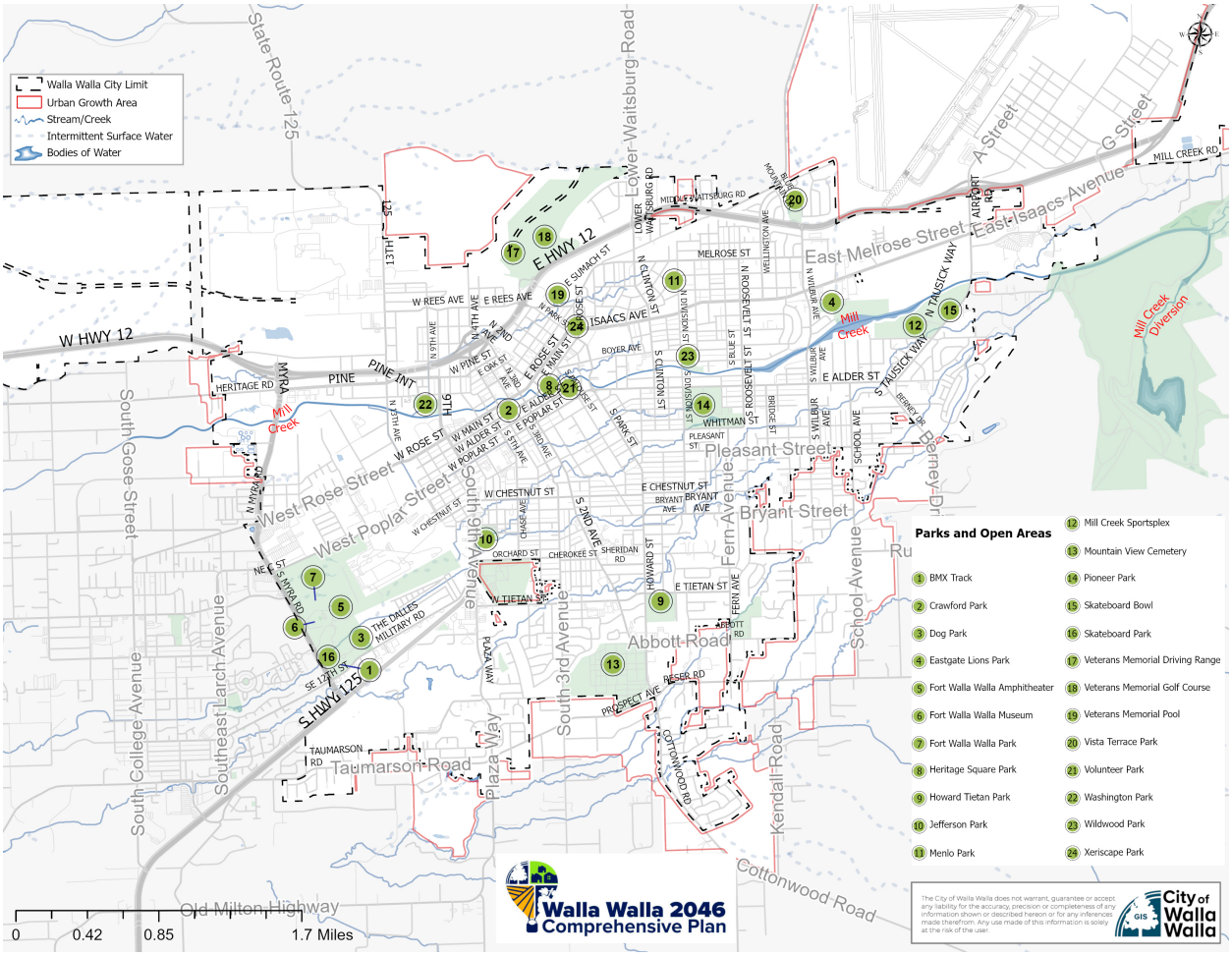


Figure 20. City Parks and Recreation Areas

Goals and Policies

PR Goal 1: Walla Walla provides high levels of parks and recreation services.

- PR 1.1: All parks and facilities shall achieve a Level of Service score of B or higher in resident satisfaction surveys.
- PR 1.2: All parks and facilities shall be maintained at a high level, with an emphasis on safety and security.
- PR 1.3: Continue to regularly survey residents at the conclusion of recreation programs to ensure programs are meeting the needs of the community.
- PR 1.4: Acquire sufficient land for a neighborhood park in the south portion of the city or Urban Growth Area in order to develop a park to meet the needs of residents in this developing area of the city.
- PR 1.5: Maintain and expand funding in order to maintain parks at high levels of service.
- PR 1.6: Explore options to provide parks and recreation facilities within a 1/2-mile walk of 80 percent of Walla Walla's population.
- PR 1.7: Explore the feasibility of the city using a dedicated grant researcher and writer across multiple departments to raise funds and coordinate matching opportunities.
- PR 1.8: Explore the feasibility of establishing a Metropolitan Parks District for the purpose of creating dedicated funding for the Parks and Recreation Department.
- PR 1.9: Research and initiate the conversation of selecting natural grass fields to artificial turf.

PR Goal 2: Parks and recreation services are designed to meet the needs of a diverse population.

- PR 2.1: Maintain and expand partnerships with local organizations to assist with facility and program development.
- PR 2.2: Programs should have participation that mirrors the diversity of the community as a whole.
- PR 2.3: Maintain and expand scholarships for program registration to assist low-income families and participants.

- PR 2.4: Ensure that the advisory committee, Parks Recreation and Urban Forestry Advisory Board, is representative of the diversity of the community to guide the development of facilities and programs.
- PR 2.5: Survey and involve residents and stakeholders in outreach regarding their parks and recreation preferences, needs, and visions at least every six years.
- PR 2.6: Evaluate existing facilities for ADA compliance and schedule upgrades to increase accessibility as necessary.
- PR 2.7: Ensure that all future facilities are ADA compliant.
- PR 2.8: Provide all interpretive and regulatory signage in both English and Spanish.
- PR 2.9: To create and maintain a welcoming and inclusive environment for all members of our community, regardless of their race, ethnicity, gender identity, sexual orientation, ability, socioeconomic status, age, language, religion, to access and enjoy the benefits of parks and recreation facilities.

PR Goal 3: Parks and recreation services enhance the quality of life for residents.

- PR 3.1: Identify opportunities to attract visitors to Walla Walla for parks and recreation facilities.
- PR 3.2: Ensure facility capacity is available to meet the needs of both residents and visitors.
- PR 3.3: Conduct a feasibility study for the development of a community center.
- PR 3.4: Continue to provide and expand recreation programs that improve health and wellness.
- PR 3.5: Conduct a feasibility study about future park acquisition, including development impact fees and other possible funding methods.
- PR 3.6: Create a trails master plan for the city that is developed in coordination with the City's Transportation Plan and the Blue Mountain Regional Trails Plan.
- PR 3.7: Protect wildlife and natural habitat and minimize user conflicts.
- PR 3.8: Maintain and expand partnerships throughout the community.
- PR 3.9: Link parks via a coordinated wayfinding system using existing sidewalk and trail corridors.
- PR 3.10: Native plants should be used where appropriate in parks and recreation facilities.
- PR 3.11: Pest management strategies should be targeted and scaled appropriately.
- PR 3.12: Explore the feasibility of a seasonal ice rink facility.



Policy Connections

- **The Capital Facilities and Utilities Element** support the City's efforts to maintain parks and facilities while identifying funding for new parklands.
- **The Transportation Element** identifies the necessary connections for pedestrians and cyclists between parks, homes, and businesses.
- **The Community Character** Element supports the continued strength of the parklands and recreation facilities.
- **The Environment and Natural Resources Element** focuses on the preservation of open space and protection of air and water quality.
- **The Economic Development Element** recognizes the importance that parks and recreation facilities play in promoting opportunities through sports tourism and improving the general quality of life, leading to business relocation.

Translating Policy into Action

This section makes connections between other city plans, programs, and actions and the policy direction of this element.

Table 19. Parks and Recreation Implementation Action

Implementation Action	Timeline	Responsibility
Parks and Recreation Comprehensive Plan	Updated every 6 years	Parks and Recreation
Explore impact fees for park development	3 years	Community Development
Further developing partnerships with the public school system	3 years	Parks and Recreation
Make necessary upgrades to facilities to draw recreation tourism	5 years	City Council
Explore public/ private partnerships	5 years	Parks and Recreation
Plan for the acquisition of lands adjacent to Mill Creek for a trail corridor	10+ years	Parks and Recreation and Community Development





Environment and Natural Resources

Introduction

This Element provides an overview of the physical and environmental characteristics of the City and its unincorporated Urban Growth Area. The landscape is shaped by numerous small streams and by Mill Creek, the area's primary waterway, which flows through the City before joining the Walla Walla River. Within the urban area, Mill Creek is channeled through the Mill Creek Flood Control District, a major engineering project designed to reduce flood risk.

The City's broader physical character is defined by rolling hills, a fertile valley, and many waterbodies, situated at an elevation of approximately 965 feet. The region is also distinguished by its unique geographic soils, which contribute to moderate liquification risk and are addressed through appropriate geotechnical evaluation and development standards.

Today and Tomorrow

Geology and Topography

Walla Walla is located between the Cascade and Rocky Mountains in the Columbia Basin. This area is underlain by a series of lava flows, which are part of the basaltic materials known as the Columbia River Basalt. Lava was issued from vents and fissures during the Miocene Epoch, approximately 15 million years ago. From that time to the present, basalt in the western portion of the Columbia Basin has been folded and faulted into a series of east-west-trending anticlines and synclines called the Yakima Fold Belt. During the Pleistocene Epoch, violent floods from glacial Lake Missoula cut channels into the basalt. The resulting landscape is known as the Channelized Scablands and consists of a jumble of coulees, buttes, mesas, dry waterfalls, hanging valleys, and giant ripples.

Within the Columbia Basin, southeast of the basin's center, is the Walla Walla River Basin. This roughly triangular area of about 1,750 square miles extends 45 miles westward from the crest of the Blue Mountains in southeast Washington and northeast Oregon to the Columbia River. The Walla Walla River is a distributary system. The river and its tributaries drain an area nearly 40 miles wide, spanning the border between Washington and Oregon. Underlying the Walla Walla River basin is the Columbia River Basalt, over which layers of alluvial sedimentary deposits (from Mill Creek, the Walla Walla River, and its tributaries), loess (wind-blown sedimentary deposits), and depositional materials from the Missoula floods. This basin area is formed by anticlines of four folds in the basalt bedrock. See the figures of the Walla Walla River Basin that follow.

- To the east and south, the largest fold is the broadly arched anticline of the Blue Mountains.
- To the west and south is Horse Heaven Ridge, which extends eastward from the Cascades to the Blue Mountains to the north, and is a low arch formed by a monoclinal dip of the basalt, north of the Touchet River.
- To the west, the Divide anticline closes the lower part of the valley and forms a rock divide between the Walla Walla Valley and the Pasco Basin to the west.

The highest point in the Walla Walla Basin is 6,250 feet at Table Rock. The average elevation of the Blue Mountains is 5,000 feet. Lowland elevations range from 2,500 feet at the base of the Blue Mountains to less than 270 feet at the confluence with the Columbia River.

The Walla Walla River Basin and the Mill Creek Basin, as described above, should not be confused with the boundaries of the Walla Walla Basin Watershed (WRIA 32) and its five watershed implementation areas, including the Walla Walla Subbasin and Mill Creek Subbasin. These latter watersheds and subbasin geographic areas have been defined for watershed planning purposes by the Walla Walla Basin Watershed Council and are referred to in the Walla Walla Subbasin Plan and its related documents/plans. WRIA 32 includes only the portion of the Walla Walla River Basin within Washington State.

Mill Creek is a major tributary of the Walla Walla River. It originates in Washington in the Blue Mountains at an elevation of 5,500 feet. The creek flows through 15 miles of mountainous terrain (entering Oregon and returning again to Washington) before it enters the Walla Walla Valley about two miles east of the City of Walla Walla. From there, it heads west, through the City of Walla Walla, to the Walla Walla River. The Mill Creek elevations range from 5,500 feet (at the headwaters) to 590 feet (at the mouth of Mill Creek, where it enters the Walla Walla River). The incorporated City of Walla Walla and the unincorporated portion of the UGA are within the Mill Creek Basin. The topography is relatively flat and slopes from the northeast (elevation 1,260 feet) to the southwest (elevation 850 feet), an overall grade change of approximately four percent.

Air Quality

Poor air quality can adversely affect human health and the environment. The US Environmental Protection Agency (EPA) and the State of Washington Department of Ecology (Ecology) track air pollution in the State of Washington.

Ecology identifies the main sources of air pollution in the state as vehicle emissions and smoke from outdoor burning and wood stoves. In winter, temperature inversions can result in stagnant air conditions in the Walla Walla region, trapping pollutants and contributing to poor air quality.

With respect to air toxics, the EPA has identified multiple toxic air pollutants in Walla Walla County. The purpose of the EPA's toxic air pollutants assessment is to identify and prioritize air toxins, emission source types, and locations that are of greatest potential concern in terms of contributing to population risk.

The EPA's Air Quality Index (AQI) provides an indicator of overall air quality in the City of Walla Walla. For 2024, the most recent year for which complete data are available, the AQI indicates

that of the 365 days for which data were reported, 84% had air quality categorized as “good,” while 16% had air quality categorized as “moderate.”[2]

Smoke, which is measured as particulate matter, can contribute to the actual and/or perceived air quality of a region and can cause irritation for individuals with asthma or other respiratory problems. Sources of smoke can include outdoor burning, wood stoves and wildfires. Within Washington State, outdoor burning of household yard waste is prohibited in all UGAs. Ecology allows agricultural burning under certain conditions.

Soils

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) classifies soils throughout the United States, and this information is compiled in Soil Surveys. The Walla Walla Urban Growth Area (UGA) is included in the Soil Survey of Walla Walla County, Washington, which identifies 26 mapped soil types within the UGA.

Of these soil types, several are classified as prime farmland under USDA criteria, and others are designated as farmland of statewide importance. (See map of Prime and Important Farmland.)

The Soil Survey rates many of the UGA’s soil types as “very limited” for the construction of residential dwellings and small commercial structures. These limitations are typically associated with one or more factors, including flooding, depth to saturated zone, depth to a thin cemented pan, slope, shrink-swell potential, and depth to soft bedrock.

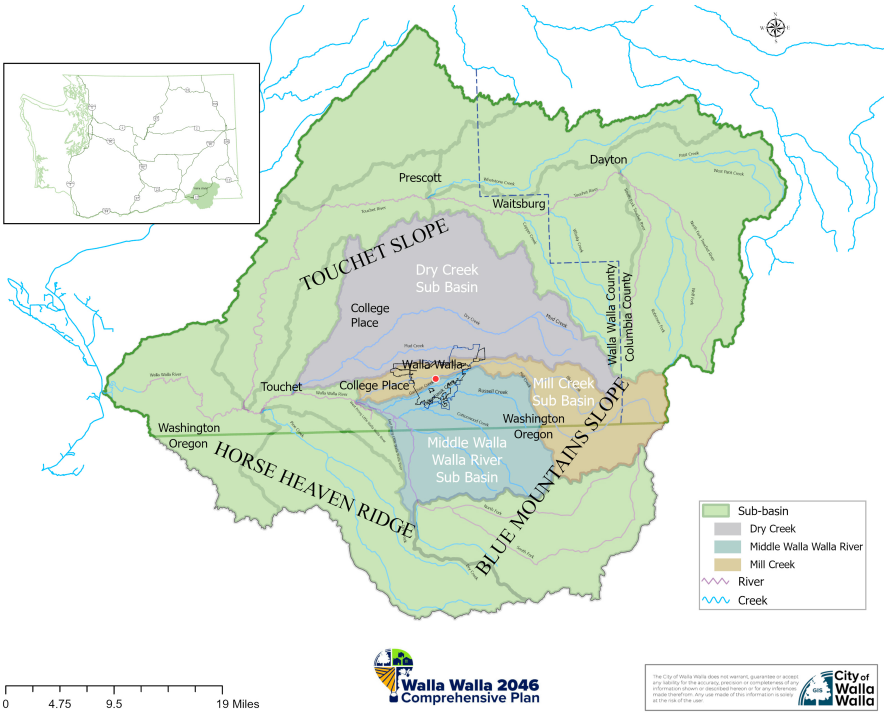
Despite the identified soil limitations, development occurs on several of these soil types, including those rated as limited due to shallow saturated zones, the presence of a thin cemented pan, and flooding concerns.



[2] EPA Air Quality Index Report from https://www.epa.gov/outdoor-air-quality-data/air-quality-index-report

Hydrology and Water Resources

Within the Walla Walla Basin, surface water and the shallow aquifer exhibit a high degree of hydraulic connection. Precipitation and river flow serve as the primary sources of water in the Walla Walla River valley, with water stored in mountain snowpack, groundwater aquifers, and surface water bodies. The river both recharges and sustains the aquifer system. Water availability in the basin depends on the relationship between precipitation, surface water runoff, and aquifer recharge and discharge. Within the Walla Walla Urban Growth Area (UGA), drinking water and irrigation rely on a combination of shallow gravel aquifer groundwater, deep basalt aquifer groundwater, and surface water. Because of the strong hydraulic connection among these sources, they are considered conjunctive—meaning withdrawals from one source can directly affect the availability of another.



Groundwater and surface water use have increased dramatically over the past century. As a result, the region is experiencing declining shallow aquifer levels, reduced spring and base flows, diminished river flows, and rising water temperatures in the Walla Walla River and its tributaries, including Mill Creek and Yellowhawk Creek.

Surface Water

Surface waters within the UGA include creeks, intermittent streams, springs, and ponds. The named creeks and springs include:

- Barber Creek
- Bryant Creek
- Butcher Creek
- Caldwell Creek
- College Creek
- Garrison Creek
- Gose Spring
- Greco Irrigation
- Kathy Creek
- Lincoln Creek
- Mill Creek
- Mudd Creek
- Owen Spring
- Peter Spring
- Reser Creek
- Stone Creek
- Titus Creek
- Yellowhawk Creek

There are 41 ponds within the UGA, ranging from one-eighth of an acre to almost six acres. Eleven of the ponds, including Pioneer Park, Jefferson, and Lincoln Ponds, are within city parks. The named ponds within the UGA are:

- Old General Hospital Duck Pond
- Jefferson Pond
- Lakum Duckum Pond
- Lincoln Pond
- Klicker Pond
- Pioneer Park Pond

Bennington Lake, at 50 acres, is located just outside the limits of the UGA and accepts diversion water from Mill Creek for recreational and flood control purposes.

Groundwater

Groundwater resources beneath the Walla Walla Basin are found in two distinct aquifers: a deep basalt aquifer that underlies the entire basin and a shallower gravel aquifer that underlies the lower central basin. In the eastern part of the Walla Walla Basin, groundwater movement, like the topography, is generally from east to west.

Several studies have contributed to the current understanding of the geology and hydrogeology of the basalt and gravel aquifers. The studies have been performed by the Department of Ecology Division of Water Resources, in cooperation with the US Geological Survey (USGS), and by consultants to the City of Walla Walla, Walla Walla County, the Walla Walla Watershed Planning Unit, and the Walla Walla Basin Watershed Council. [3]

The recharge process of the basalt aquifer is described in the State Department of Conservation Division of Water Resources publication, Water Supply Bulletin No.7, as follows:

> "The Blue Mountains slope is dissected by steep-sided, narrow canyons as much as 1,500 feet deep. Mill Creek Canyon is one of the deepest of these. The gradient of the streams in general is less than the slope of the basalt beds; therefore, the outcrop pattern of each individual lava flow, as viewed from above, is V-shaped, pointing downstream. This outcrop geometry forms a favorable situation for natural recharge of groundwater into the permeable layers cropping out in the stream channels."
>
> As rainwater and snowmelt percolate down into the porous zones between the flows of basalt, the water moves by gravity down the dip of the basalt

[3] These include:

Piper, A.M., Robinson, T.W., Thomas, H.E., 1933, Groundwater in the Walla Walla Basin, Oregon-Washington-Part 2. Department of the Interior, US Geological Survey
Piper, A.M., Robinson, T.W., Thomas, H.E., 1933, Groundwater in the Walla Walla Basin, Oregon-Washington-Part 1. Department of the Interior, US Geological Survey
Price, C.E., 1960, Artificial Recharge of a Well Tapping Basalt Aquifers, Walla Walla Area, Washington: Washington Department of Conservation Division of Water Resources Water Supply Bulletin No. 7
Newcomb, R.C., 1965, Geology and Ground-Water Resources of the Walla Walla River Basin, Washington-Oregon: Washington Department of Conservation Division of Water Resources Water Supply Bulletin No. 21
Mac Nish, R.D., Myers, D.A., and Barker, R.A., 1973, Appraisal of Ground-Water Availability and Management Projections, Walla Walla River Basin, Washington and Oregon: Washington Department of Ecology Water Supply Bulletin No. 37
Barker, R.A. and Mac Nish, R.D., 1976, Digital Model of the Gravel Aquifer, Walla Walla

> toward the center of the Walla Walla Basin, which is a few miles southwest of the City of Walla Walla. Discharge from the basalt aquifer varies from one part of the basin to another. In the highlands, discharge occurs directly to streams and is the major factor in maintaining summer flows of Mill Creek and the Walla Walla River. Within the central valley, discharge is limited to pumpage from wells and may also discharge vertically into the shallow gravel aquifer. Beyond the west and northwest margins of the basin, the aquifer discharges by underground flow to the Columbia and Snake Rivers." [4]

Within the basalt aquifer, there has been a long-term decline in water levels, indicating that there is more water pumped out locally than is replaced by natural recharge or movement of water from adjoining areas.[5] The decline has been greatest in areas along the northeastern margin of the Walla Walla Valley, including the cities of Walla Walla, College Place, and Milton-Freewater.[6]

The gravel aquifer is linked with the network of natural springs, streams, canals, and ditches that cross the surface of the basin. The aquifer's recharge sources include precipitation, stream and canal leakage, basalt aquifer inflows, and infiltration of excess irrigation water. Discharge from the gravel aquifer includes uptake of water by plants and surface discharges (springs and wells), as well as downward leakage into the basalt aquifer. Water levels within the gravel aquifer have also been decreasing.[7]

---

[4] Water Supply Bulletin 45, Walla River Basin, Washington and Oregon: Washington Department of Ecology
Mac Nish, R.D., and Barker, R.A., 1976, Digital Simulation of a Basalt Aquifer System, Walla Walla River Basin, Washington and Oregon: Washington Department of Ecology Water Supply Bulletin 44|YH
Pacific Groundwater Group, 1995, Initial Watershed Assessment, Water Resources Inventory Area 32, Walla Walla Watershed, Open File Technical Report 95-11
Lindsey, K., Kennedy Jenks Consultants, 2003, Candidate SASR Sites Hydrogeology, Walla Walla Basin Shallow Aquifer Recharge. Prepared for Economic and Engineering Services, Portland, OR.
Marti, P.B., 2005, Assessment of Surface Water and Groundwater Interchange in the Walla Walla River Watershed: Washington Department of Ecology Publication No. 05-03-020
Warinner PE, John, Fountainhead, 2006, Strategic Plan: Shallow Aquifer Recharge, Strategy for Restoring and Seasonally Recharging Shallow Gravel Aquifer(s) and Spring-Fed Streams of the Walla Walla Watershed, Walla Walla Watershed Alliance and NRCS|
Golder Associates, Inc., 2007 City of Walla Walla Extended Area Aquifer Storage and Recovery Groundwater Flow Model

[5] Price, C.E., 1960, Artificial Recharge of a Well Tapping Basalt Aquifers, Walla Walla Area, WA: WA Department of Conservation Division of Water Resources Water Supply Bulletin No. 7, p. 8-9
Pacific Groundwater Group, 1995, Initial Watershed Assessment, Water Resources Inventory Area 32, Walla Walla Watershed, Open File Technical Report 95-11, p. 34

[6] Mac Nish, R.D., Myers, D.A., and Barker, R.A., 1973, p. 13

[7] Lindsey, K., Kennedy Jenks Consultants, 2003, 4, p. 10-11
Warinner PE, John, Fountainhead, 2006, p. 2-4, p. 2-5, p. 4-2
Kennedy/Jenks Consultants, 2006, Results of the First Season of Shallow Aquifer Recharge Testing at the Hall-Wentland Site, Umatilla County, Oregon and Walla Walla County, Washington, 2, p. 11
Bower, Robert, Hydrologist, Walla Walla Basin Watershed Council, 2007, personal communication

Over the last century, increasing irrigation needs have placed a higher demand on water from the aquifer.[8] At the same time, changes in irrigation practices (e.g., ditch/channel lining, straightening of rivers for agricultural and flood control purposes, the active tilling of wetlands, and the reduction in the practice of flood irrigation) have reduced the amount of artificial recharge to the aquifer. Losses in natural function (e.g., flood control and channelization of the Walla Walla River, Mill Creek, and smaller streams) have also reduced the amount of natural recharge via infiltration from surface waters.

Decreases in water levels in the aquifers have negative economic and environmental impacts. Economically, as groundwater levels decrease, more energy is required to pump the water to the surface. Environmentally, lower water levels in the aquifer systems have resulted in degradation of water quality within the system, as well as reduced discharge to surface water streams. Reduced stream discharge, in turn, has negative impacts on aquatic function, water quality, habitat, and species.

Given these issues, management practices are necessary to maintain local groundwater within the aquifers at levels that will ensure groundwater use remains economical for current users and that will protect the environmental quality of surface water streams.

The City is coordinating at the watershed level to improve management of surface water, groundwater, aquatic habitat, and resilience. Several options are being considered or implemented to improve the utilization of existing groundwater resources. These include water rights transfer, water demand reduction, Shallow Aquifer Recharge (SAR), and Aquifer Storage and Recovery (ASR).[9] The City's Watershed Resiliency Plan includes more detail on the resiliency of the Mill Creek Watershed.

The City uses a deep basalt ASR program, which utilizes water from Mill Creek to recharge portions of the basalt aquifer for future municipal water supply use. The program, initiated in 1999, is designed to: reverse the historic decline of water levels in the basalt aquifer; meet peak water supply demands with groundwater, thereby reducing impacts to Mill Creek during periods of low instream flow; provide a secure, alternate source of drinking water should surface water supply be lost due to a wildfire within the watershed; and maximize the use of surface water rights during high draw periods. Recharge water, supplied from Mill Creek, is available for five to seven months each year. [10]

---

[8] Lindsey, K., Kennedy Jenks Consultants, 2003, 4, p. 11 Mac Nish, R.D., Myers, D.A., and Barker, R.A., 1973, p. 20 Pacific Groundwater Group, 1995, p. 14-15

[9] HDR-EES, et al., May 2005, WRIA 32 Walla Walla Watershed Plan, Walla Walla WRIA 32 Watershed Planning Unit, ES-p. 5-6

[10] The following documents describe the progress of the ASR program:
Golder Associates, Inc., 2007 City of Walla Walla Extended Area Aquifer Storage and Recovery Groundwater Flow Model
Golder Associates, Inc., 2006 City of Walla Walla Aquifer Storage and Recovery Reservoir Permit Application
Golder Associates, Inc., 2006 Technical Memorandum—Attachment A, Streamflow Evaluation, Walla Walla Extended Area ASR
Golder Associates, Inc., 2006 Technical Memorandum—Attachment A, Streamflow Evaluation, Walla Walla Extended Area ASR, March 24, 2006
Golder Associates, Inc., 2006, Report on City of Walla Walla Updated Hydroecological Conceptual Model for Extended Area Aquifer Storage and Recovery Evaluation, Submitted to the City of Walla Walla

The Walla Walla Oregon Basin Aquifer Recharge Strategic Plan (2024 Water Year) summarizes aquifer recharge goals, activities, and data for Walla Walla watershed stakeholders so that they may use it while making sustainable water resource decisions for ecological, agricultural, and economic benefit.

Watershed Management

There are many agencies involved in the planning and regulation of surface and groundwater resources within the Walla Walla Basin. These include: US Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers, Washington State Department of Ecology (ECY), Washington Department of Fish and Wildlife (WDFW), Oregon Water Resources Department (OWRD), Oregon Department of Fish and Wildlife (ODFW), National Oceanic and Atmospheric Administration (NOAA) Fisheries Service, Walla Walla Watershed Management Partnership, Walla Walla Basin Watershed Council, Snake River Salmon Recovery Board, Confederated Tribes of the Umatilla Indian Reservation (CTUIR), Walla Walla County, the City of Walla Walla and others.

Since 2000, planning efforts have been organized at the watershed level in order to integrate the various efforts (see the Table 20 on the following page) into a comprehensive planning framework. In 2019, the Washington Legislature and Ecology tasked the Walla Walla Management Partnership, the organization tasked with managing the watershed, to develop a 30-year strategic plan for water management in the Walla Walla Basin. This effort was a collaboration with the Confederated Tribes of the Umatilla Indian Reservation, the State of Oregon, and stakeholders on both sides of the state border. This effort has been named Walla Walla Water 2050. The group released a final strategic plan in June 2021 and is being implemented by the partners with the assistance of the Walla Walla Basin Advisory Committee.

Table 20. Water Resource Planning Efforts

Planning Efforts	Managing Organizations	Purpose
Walla Walla Watershed Plan (Water Resource Inventory Area 32)	WRIA 32 Planning Unit, Walla Walla County	Surface & groundwater quantity, aquatic habitat, and instream flow planning
Snake River Salmon Recovery Plan	Snake River Salmon Recovery Board	Protection and restoration of salmon habitat
Walla Walla Subbasin Plan	Walla Walla County	Basin-wide assessment, inventory, and management plans for aquatic and terrestrial species
Flow Enhancement Feasibility Study	U.S. Army Corps of Engineers, Confederated Tribes of the Umatilla Indian Reservation (CTUIR)	Assessment and feasibility of enhancement efforts for improvement of instream flows in the Walla Walla Basin
Walla Walla Water 2050 Initiative	Ecology, CTUIR, local agencies	Improve stream flows and water supplies in the Walla Walla River Basin.

Planning Efforts	Managing Organizations	Purpose
Walla Walla Water 2050 Strategic Plan	CTUIR, Walla Walla Basin Advisory Committee, Ecology, local agencies in WA and OR	30-year strategic plan for water management in the Walla Walla Basin.
Total Maximum Daily Load (TMDL) Studies	Ecology, Oregon Department of Environmental Quality, Walla Walla Basin Watershed Council, City of Walla Walla	Water cleanup plans—to restore water quality in 'impaired' water bodies as identified by the Clean Water Act
Mill Creek Report	City of Walla Walla, CTUIR, Washington Department of Fish and Wildlife	Report addressing improvements to the City's municipal water supply system and increasing flows of Mill Creek for salmonids and other native aquatic life.
Water System Plan	City of Walla Walla	Framework for the City's provision of water service
Stormwater Management Plan	City of Walla Walla	Identifies stormwater infrastructure needs and provides an overview of regulatory requirements for stormwater.
Watershed Resiliency Plan	City Walla Walla	Addresses potential risks to the municipal watershed, prepares for potential impacts of wildfire, and identifies opportunities to improve the resiliency of the Mill Creek Watershed.
Well System Plan	City of Walla Walla	Framework for the City's well system.
Coordinated Water System Plan	City of Walla Walla, Walla Walla County	Current or proposed measures to manage municipal water resources
Wellhead Protection Plan	DOH, City of Walla Walla	Groundwater source protection
Community Wildfire Protection Plan	Walla Walla County	Assess wildfire hazards for entire Mill Creek watershed and consider options for reducing risk and effects
Milton-Freewater Hydrological Simulation	Walla Walla Basin Watershed Council, Oregon State University	Model of surface water-groundwater interaction
Lower Mill Creek Habitat and Passage Assessment and Strategic Action Plan (Tetra Tech, 2016)	Confederated Tribes of the Umatilla Indian Reservation	To resolve fish passage issues and improve fish habitat while maintaining or improving flood control, recreation, and economic values

Water resource planning efforts specific to the Walla Walla UGA are identified in the Walla Walla Watershed Plan and related documents (including the Walla Walla Subbasin Plan and Snake River Salmon Recovery Plan). Some of these actions include:

- Surface and Groundwater Supplies—improvements to water conservation and efficiency, implementation of ASR and water storage, establishment of a water budget for a residential area not served by a public water supply, exploration and implementation of a turbidity reduction system for water diverted from Mill Creek.
- Surface Water Quality—rerouting stormwater runoff, implementation of stormwater Best Management Practices (BMPs), including sediment basins, wetland protection/restoration.
- Groundwater Quality—protection of wellheads and critical shallow gravel aquifer recharge areas, wetland protection/restoration.
- Habitat Management—removal of fish passage barriers, screening of diversions, riparian revegetation and buffers, habitat improvements.

Within the Walla Walla UGA, the Walla Walla Watershed Plan identifies both Mill Creek and Yellowhawk Creek as Priority Protection Areas with respect to aquatic habitat and protection of focal or local aquatic species. See Natural Resource Lands below.

In 2019, the Washington Legislature tasked the Walla Walla Management Partnership and the Department of Ecology to collaboratively develop a 30-year strategic plan for water management in the Walla Walla River Basin. This initiative, called the Walla Walla Water 2050, includes stakeholders in both Washington and Oregon. The final Walla Walla Water 2050 Strategic Plan was released in June 2021 and is currently being implemented by the Plan's partners and the Walla Walla Basin Advisory Committee.



Stormwater Runoff and Water Quality

During a rain event, rainwater either soaks into the ground or runs across it; the latter is termed stormwater runoff. As areas become more developed, a larger amount of stormwater runs off paved surfaces, roofs, and compacted soils and lawns, rather than soaking into the ground. As stormwater drains into local waterways, it carries with it sediment, as well as other pollutants, including fertilizers, pesticides, road salt, oil, and heavy metals. Large stormwater flows within streams and creeks cause erosion and degradation of riparian habitat. Stormwater management can help reduce these impacts.

Within the City of Walla Walla, stormwater runoff may be retained on site, directed to the municipal stormwater system, or may drain into ponds and creeks. Some existing stormwater infrastructure within the City of Walla Walla directs stormwater to streams and creeks without any treatment. Newer stormwater infrastructure within public streets and rights of way has been installed to collect and retain stormwater in catch basins. Catch basins then allow the water to infiltrate into the ground. New and modified private development projects are required to maintain stormwater runoff at pre-development rates. Excess stormwater runoff must be collected, retained, and infiltrated on site.

The Stormwater Management Manual for Eastern Washington, maintained by the Washington State Department of Ecology (Ecology), provides guidance on the measures necessary to control the quantity and quality of stormwater produced by new development and redevelopment. It also includes best management practices (BMPs) intended to reduce the negative impacts of stormwater.

Stormwater management techniques applied in accordance with the Manual are presumed to meet the technology-based treatment requirement of State law and can be utilized to meet State water quality standards. Ecology requires the City to either adopt this Manual or to develop its own stormwater regulations, certifying that they are consistent with the Manual. The City's Stormwater Management Program Plan describes applicable regulatory requirements, the status of current City activities, and a description of activities planned to be implemented.

The Federal Clean Water Act section 303(d) requires states to prepare a list of water bodies that do not meet water quality standards. All water bodies identified on the list must attain water quality standards within a reasonable period, either through a Total Maximum Daily Load (TMDL) study (Water Cleanup Plan) or other pollution control mechanisms. A TMDL establishes the maximum amount of pollutants allowed in a water body and serves as the starting point or planning tool for restoring water quality.

The current Washington State Department of Ecology Water Quality Assessment Tool for the State lists multiple waterbodies within the UGA as impaired waterways, violating water quality standards under the Clean Water Act. TMDL studies and BMPs are used to return water bodies to a healthy condition. TMDLs and BMPs are being implemented under the umbrella of the Walla Walla Watershed Resiliency Plan.

Table 21. Impaired Waterways

Waterway	How it is Impaired
Garrison Creek	Ammonia-N, Chloride, Chlorine, Dissolved Oxygen, Fecal Coliform, Temperature, 4,4'- (DDT, DDD, DDE), Hexachlorobenzene,
Lincoln Creek	Temperature
Mill Creek	Bacteria (Fecal Coliform), Dissolved Oxygen, Temperature
Titus Creek	Temperature
Yellowhawk Creek	Temperature
Stone Creek	Temperature

Wildfire

The main surface water supply for the City of Walla Walla is Mill Creek. The water supply is unfiltered and is therefore vulnerable to the effects of disturbances from watershed management activities and natural events such as landslides and wildfires. The impacts to surface water from wildfire includes immediate changes to water quality that will have significant consequences for water treatment. The Walla Walla County Community Wildfire Protection Plan (CWPP)/Wildfire Vulnerability Study/FIREWISE describes the physical and chemical changes that can be expected to affect the water quality of Mill Creek after a wildfire.

As explained in the CWPP, the changes to the City of Walla Walla's source surface water quality after a wildfire can be expected to persist for several years or decades following a catastrophic fire.[11] Impacts to water quality are expected to be most severe during the first runoff season following the fire. Typically, peak concentrations occur with rain events or with the spring snowmelt.

Impacts can include:

- Erosion rates are generally highest in the first year after a fire and generally do not return to normal for up to 10 years after a fire.
- Debris and ash can block streams and water supply intakes.
- Stormwater runoff rates and peak flows will increase. Stormwater runoff flows typically remain elevated for seven to ten years.
- Water quality changes include sediment and turbidity loadings and increases in pH, and in concentrations of cyanide (from fire retardants), total organic carbon, nitrate-nitrogen, ammonia-nitrogen, metals, and cations (ions with a positive charge). Levels of cations typically remain elevated for two to three years.

Watershed recovery can be expected to take five to 10 years, while the reestablishment of forest areas will take more than ten years. The worst-case scenario would be that the Mill Creek supply can only be used intermittently for up to 10 years or more following a catastrophic fire. When Mill

[11] Walla Walla County Community Wildfire Protection Plan, 2025

Creek water is not available for the municipal water supply, the groundwater supply wells become the sole source of water for the system.

The City of Walla Walla Comprehensive Water System Plan states that if the City encountered a temporary loss of Mill Creek as a source, the City could be supplied with enough water using all available well sources, pumping at a near 24-hour duration. However, if the City experienced a long-term loss of Mill Creek, the City would need to implement upgrades and additional sources in the short term.

This information underscores the importance of protecting the Mill Creek Municipal Watershed from wildfire threats. The CWPP is intended to cover the Mill Creek Watershed and the entirety of Walla Walla County. The mission of the Plan is to assess wildfire hazards in and around the Mill Creek Drainage and Walla Walla County, and to identify options for reducing the risk of wildfire within the planning area and mitigating the impacts if a fire does occur.

The Plan notes that fire history in and around the Mill Creek Watershed and Walla Walla County has shown that the area experiences frequent fires. Given the current fuel load levels, coupled with hotter and drier summer conditions and an extended fire season, fires can be expected to increase in size, frequency, and severity compared to those of the past. While wildfire suppression has been successful in containing wildfires that threaten the Mill Creek Watershed, without proper mitigation efforts, this trend will not be sustainable. The historic Blue Creek Fire demonstrated that wildfire within the boundaries of the Mill Creek Watershed is inevitable.



Mill Creek water intake during the Paradise Fire, week of Aug. 24, 2026. Photo by Jeff Schardt.

Natural Resource Lands

Forest

Historically, logging of both the upland and riparian tree species has occurred throughout much of the Walla Walla Basin, including the Mill Creek Basin. Forest management activities have been conducted by both private and public entities. More recently, logging has not occurred in the upper portion of the Mill Creek Basin in order to protect the quality of the water supply for the City of Walla Walla. This area is included within the Umatilla National Forest; public access is limited to the Mill Creek area of the forest. There are no designated forest resource lands within the Walla Walla UGA.



Critical Areas

The Growth Management Act (GMA) requires that all cities and counties identify, designate and regulate critical areas. Critical areas are identified as:

- Wetlands
- Frequently Flooded Areas
- Fish and Wildlife Conservation Areas
- Geologically Hazardous Areas
- Critical Aquifer Recharge Areas

Critical areas within the City are defined and protected by the City of Walla Walla Critical Areas Ordinance (CAO).

Five critical areas are discussed in the following sections.

Wetlands

The US Fish and Wildlife Service maintains the National Wetland Inventory (NWI), which maps the characteristics, extents, and status of wetlands within the US. According to the NWI, there are approximately 222 acres of wetlands within the UGA. These wetlands include Mill Creek from Roosevelt Street to the eastern boundary of the UGA and a portion of Mill Creek between Myra Road and 9th Avenue. Four of these wetlands, including two of the largest, are located within City parks. See the Surface Water and Wetlands map. Wetland buffers add protection for the wetlands and are enforced through the municipal code.

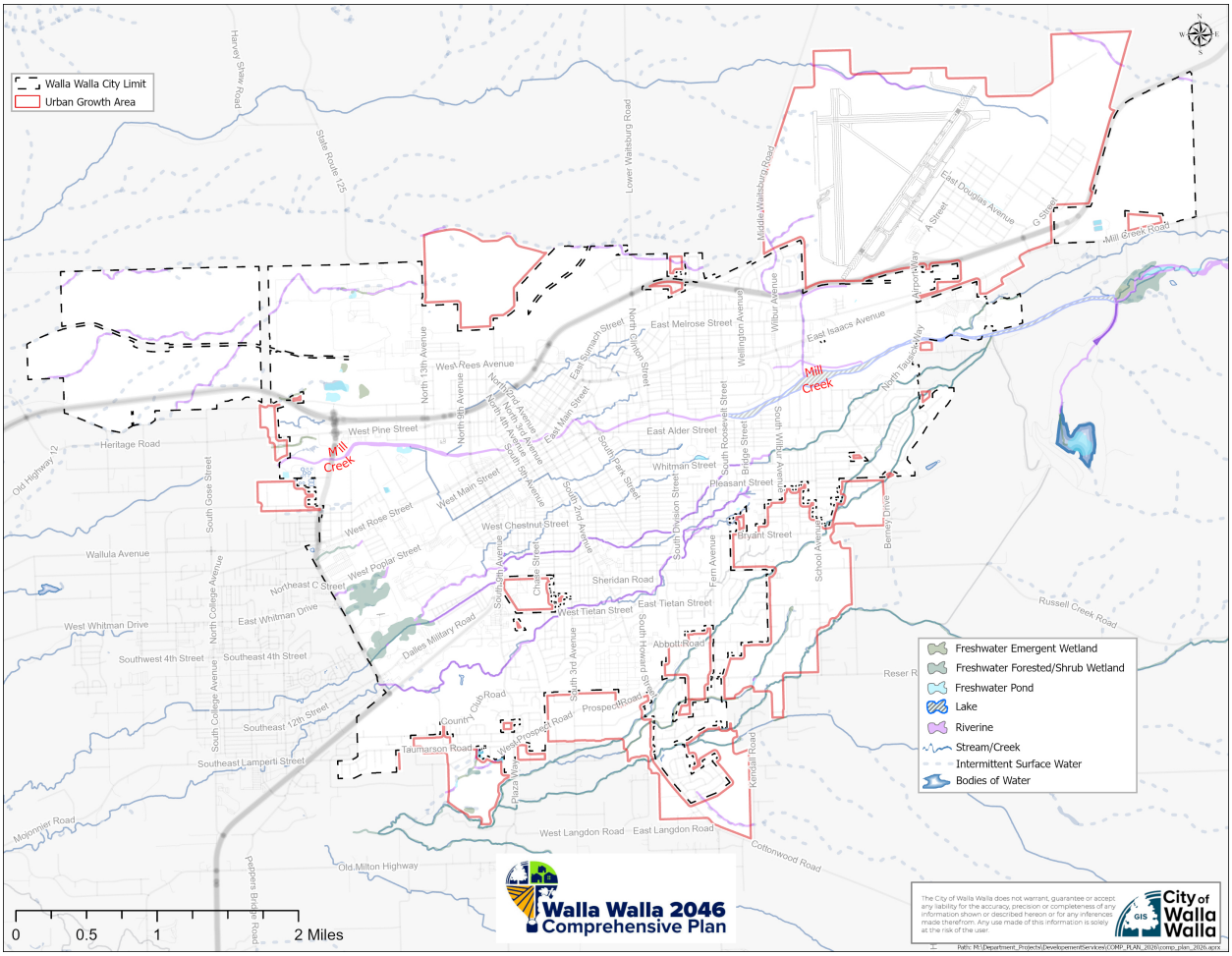


Figure 21. Wetlands and Surface Water Map

Frequently Flooded Areas



The Walla Walla area is prone to flooding from Mill Creek. In 1931, a devastating flood struck Walla Walla. As a result, the United States Army Corps of Engineers (USACE) completed two flood control projects along Mill Creek. Just northeast of the UGA at Rooks Park, a diversion was constructed to route water from the creek to the Bennington Lake reservoir. Another diversion was constructed to divert water from Mill Creek into Yellowhawk and Garrison creeks, directing the water south of the City. The second project channelized a section of Mill Creek within the UGA in a concrete channel with vertical sides. A portion of this channel flows beneath the buildings and streets in downtown Walla Walla. Other areas of the creek have been artificially widened with steep sides. The 1996 flood produced significant flows of 3,900 cubic feet per second (cfs). This flow exceeded the channel safety capacity of 3,500 cfs. Nonetheless, the flows were contained within the channel during this flood event.

These projects have been successful at protecting Walla Walla from floods, but have had negative impacts on aquatic species, on fishing and recreational opportunities, aesthetics, and on the quality of natural areas. Modified stream channels limit access for fishing, degrade stream habitat, and reduce water quality. Mill Creek flood control water diversions can redirect or harm fish. The USACE diverts water from Mill Creek into Bennington Lake when flows reach or exceed 1,400 cfs. This may occur about every three years. [12]

The diversions are a concern because Mill Creek is host to species listed as threatened under the Federal Endangered Species Act (see the following section, Fish and Wildlife Conservation Areas). The Mill Creek Work Group has recommended improvements to flood protection in the lower Mill Creek area (below 9th Avenue), which when implemented, would allow the USACE to raise the diversion threshold to 3,400 cfs. At 3,400 cfs, the USACE estimates that diversions could be reduced to approximately every 30+ years. [13] The Mill Creek Work Group is a group comprised of representatives from federal, state, and local agencies, tribal organizations, non-profits, and interested citizens with an interest in improving conditions in Mill Creek for fish, wildlife, and area residents.

According to the Federal Emergency Management Agency (FEMA) National Flood Insurance Program maps, there are approximately 169 acres within the UGA that are within the 100-year flood zone. These areas are along Middle Waitsburg Road, Russell Creek, and Reser Creek and are largely undeveloped (FEMA Panel Map 530194 0435 B).

The City's critical areas regulations briefly address frequently flooded areas. The regulations indicate that structures in designated flood areas are subject to other flood-related City codes.

[12] US Army Corps of Engineers Mill Creek Biological Assessment, March 2003
[13] US Army Corps of Engineers Mill Creek Biological Assessment, March 2003

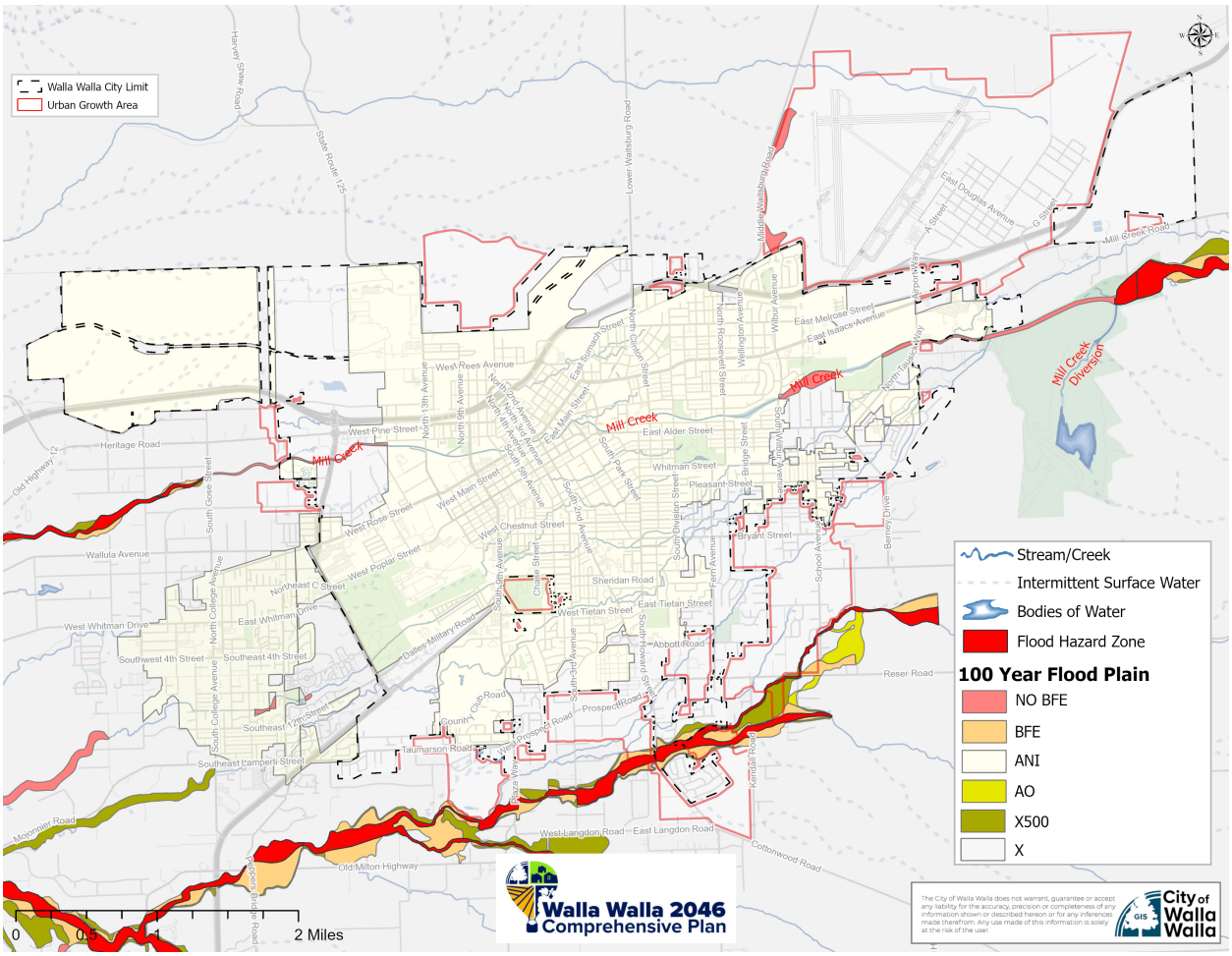


Figure 22. Frequently Flooded Areas Map

Fish and Wildlife Conservation Areas

Over the past 150 years, extensive water appropriation and inadequate fish-passage conditions have significantly harmed aquatic species. Although improvements in irrigation efficiency have reduced overall water demand, they have also diminished the seasonal recharge of the shallow groundwater aquifer. As groundwater levels decline, the natural discharge from springs into streams and creeks decreases as well.

In the Walla Walla Basin, including Mill Creek, heavy irrigation withdrawals combined with reduced groundwater levels have led to seasonal drying of creek channels. This dewatering poses serious risks for fish. It can strand fish and block their movement, cause direct mortality, increase vulnerability to predation and disease, and elevate downstream water temperatures, all of which further stress already impacted populations.

De-watering, expanding urban and agricultural development, and flood-control activities are reducing both the quality and quantity of aquatic habitat. The loss of riparian vegetation along

creeks within the UGA and the absence of vegetation along the channelized reach of Mill Creek leads to higher water temperatures, diminished fish cover, and reduced food availability. Sedimentation from stormwater runoff and unstable streambanks further degrades habitat by filling pools, widening and shallowing channels, and burying spawning gravel.

The Washington Department of Fish and Wildlife (WDFW) lists Chinook salmon, steelhead, and bull trout as candidate species. Additionally, within an area that includes the Walla Walla UGA, steelhead and bull trout are listed as threatened species under the Federal Endangered Species Act. Populations of these aquatic species within the Columbia Basin continue to decline due to the degradation of habitat. Chinook salmon and steelhead are anadromous (live in salt water and return to fresh water to spawn). Bull trout populations within the Walla Walla River and Mill Creek are fluvial (migrate between small tributaries and main rivers) and/or resident (remain non-migratory).

According to the Washington Department of Fish and Wildlife's SalmonScape and Priority Habitats and Species (PHS) database, creeks in the City support the following species that are listed under the Endangered Species Act (ESA):

- Garrison Creek—Summer Steelhead (presumed)
- Yellowhawk Creek—Spring Chinook (documented), Summer Steelhead (documented)
- Mill Creek—Spring Chinook (documented), Summer Steelhead (documented), Bull Trout (documented)

The Wetlands and Surface Water map shows the location of wetlands, streams, and creeks. Wetlands function to improve water quality. By acting as a natural filter, wetlands remove pollutants from stormwater runoff while slowing stormwater peak flows.

Open space is generally a more compatible land use next to critical areas because it introduces fewer impervious surfaces and provides more vegetation, shade, and natural cover that help protect water quality. These characteristics reduce runoff and lessen the potential for degradation compared with more intensive urban uses.

The degree of benefit, however, depends on how the open space functions. Uses such as golf courses or sports fields with parking lots can generate higher pollutant loads, while natural parks designed for passive recreation tend to have fewer impacts. Maintenance practices, such as turf fertilization, irrigation, or the application of de-icing materials on roads and parking areas, also influence how well the open space supports adjacent critical areas.

Protection and restoration of aquatic habitat within the Walla Walla Basin is occurring as a result of the Walla Walla Watershed Plan (WWWP). Under the plan, the foundation of basin-wide aquatic habitat management is contained in the Walla Walla Subbasin Plan. Within the Walla Walla UGA, both Mill Creek and Yellowhawk Creek have been identified by the WWWP as Priority Protection Areas with respect to aquatic habitat and protection of focal aquatic species. Priority Protection Areas are stream reaches that, if allowed to further degrade, represent a substantial decline in abundance, productivity, and life history diversity. The WWWP and related plans/documents include specific management strategies and actions to improve aquatic habitat within the UGA.

In addition to identifying species of concern, the WDFW also identifies priority habitat. Through the Priority Habitats and Species (PHS) Program, the WDFW identifies the habitats and species of

priority and maps their locations. PHS literature identifies the needs of fish and wildlife based on the "best available science" and can be used in land use decisions that may affect these habitats. The Priority Habitat map shows the location of priority habitats within the UGA; these include wetland, riparian, ring-necked pheasant, and waterfowl habitats.

The City's critical areas regulations address fish and wildlife habitat conservation areas, among other environmental elements. Wetland buffers add protection for wetlands and are enforced through the municipal code.

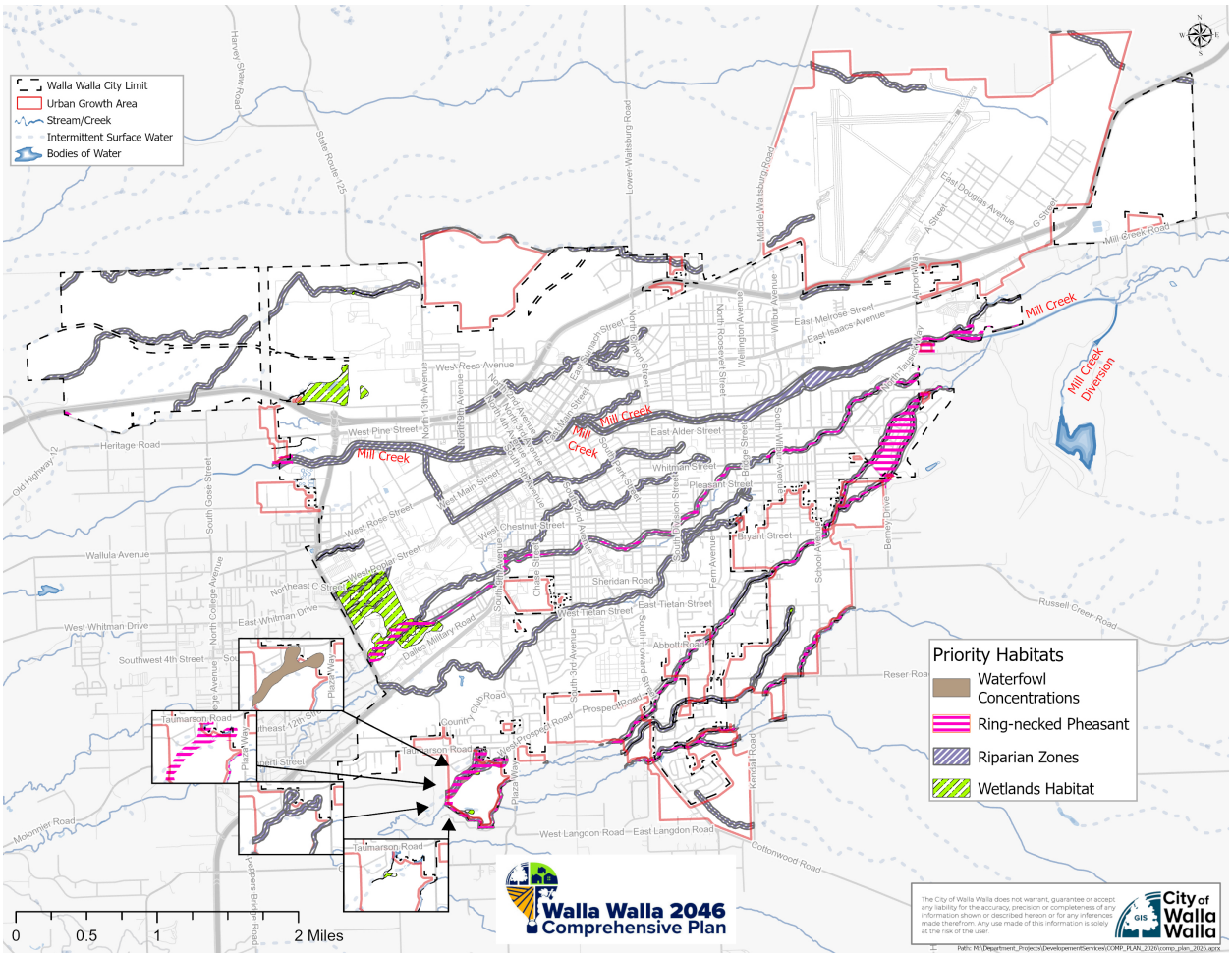


Figure 23. Fish and Wildlife Habitat Conservation Areas Map

Geologically Hazardous Areas

The City's critical areas regulations address geologically hazardous areas. Geologically hazardous areas are designated as those that are susceptible to one or more of the following types of hazards: erosion hazards; landslide hazards; seismic hazards; and other geological events, including mass wasting, debris flows, rock falls, and differential settlement.

The Washington State Hazard Mitigation Plan (2023) determines which counties within Washington are most vulnerable to future earthquakes, based on FEMA's HAZUS information. HAZUS is a computer-based system, available from FEMA, used to estimate potential losses from earthquakes, floods, and hurricanes. The counties considered most at risk are those with an Annualized Earthquake Loss of at least $1 million or with an Annualized Earthquake Loss Ratio equal to or greater than the state's ratio of 0.02. Twenty-three counties within Washington, including Walla Walla County, meet one of these two criteria. The City participates in the Walla Walla County Multi-Jurisdiction All-Hazard Mitigation Plan (HMP), which outlines mitigation strategies to reduce regional natural hazard risks.

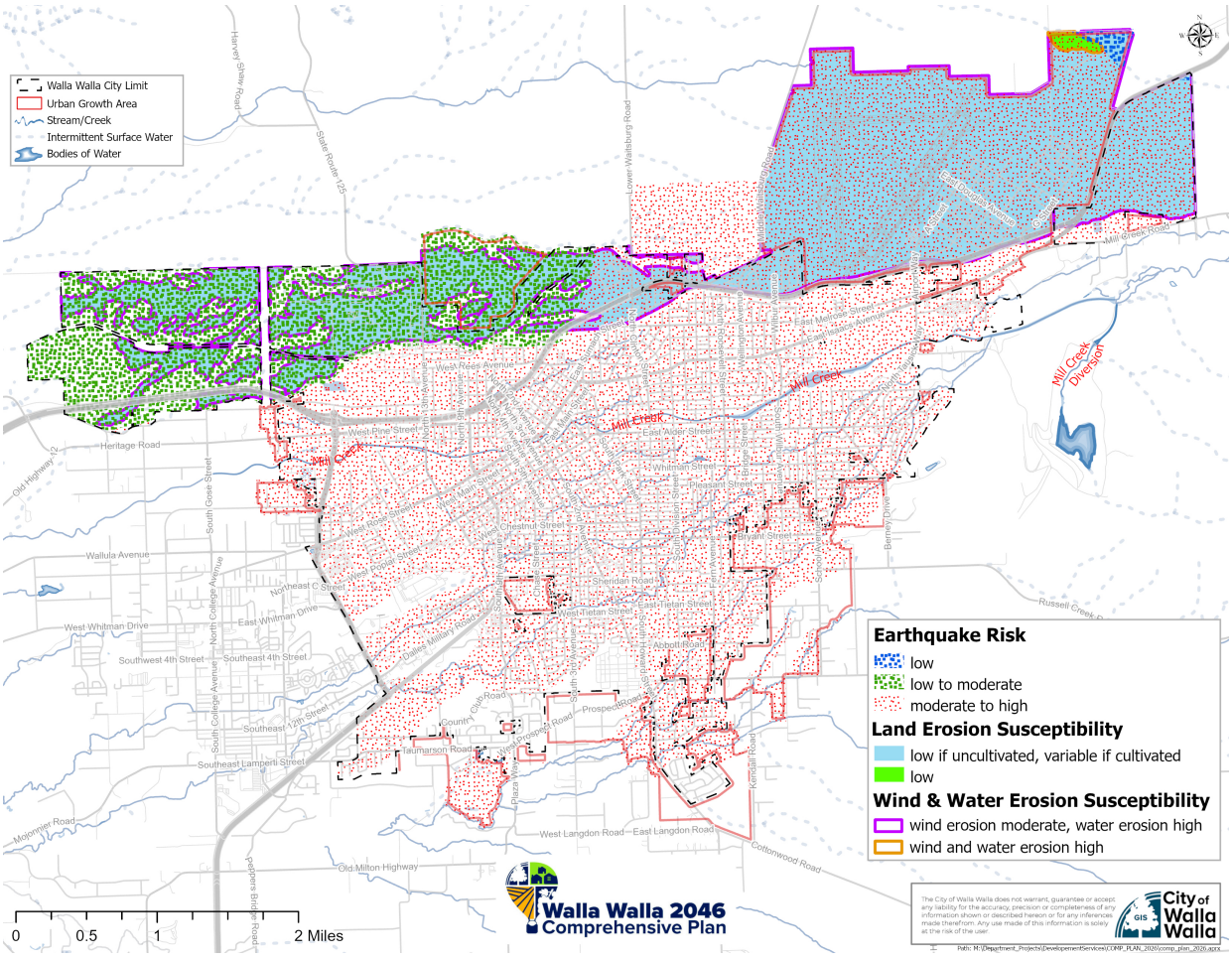


Figure 24. Geologically Hazardous Areas Map

Critical Aquifer Recharge Areas

Critical aquifer recharge areas (CARA) are those areas with a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030(2). CARA have prevailing geologic conditions associated with infiltration rates that create high potential for contamination of ground water resources or contribute significantly to the replenishment of ground water. CARA in the City of Walla Walla is designated as follows: sufficient to minimize the hazard.

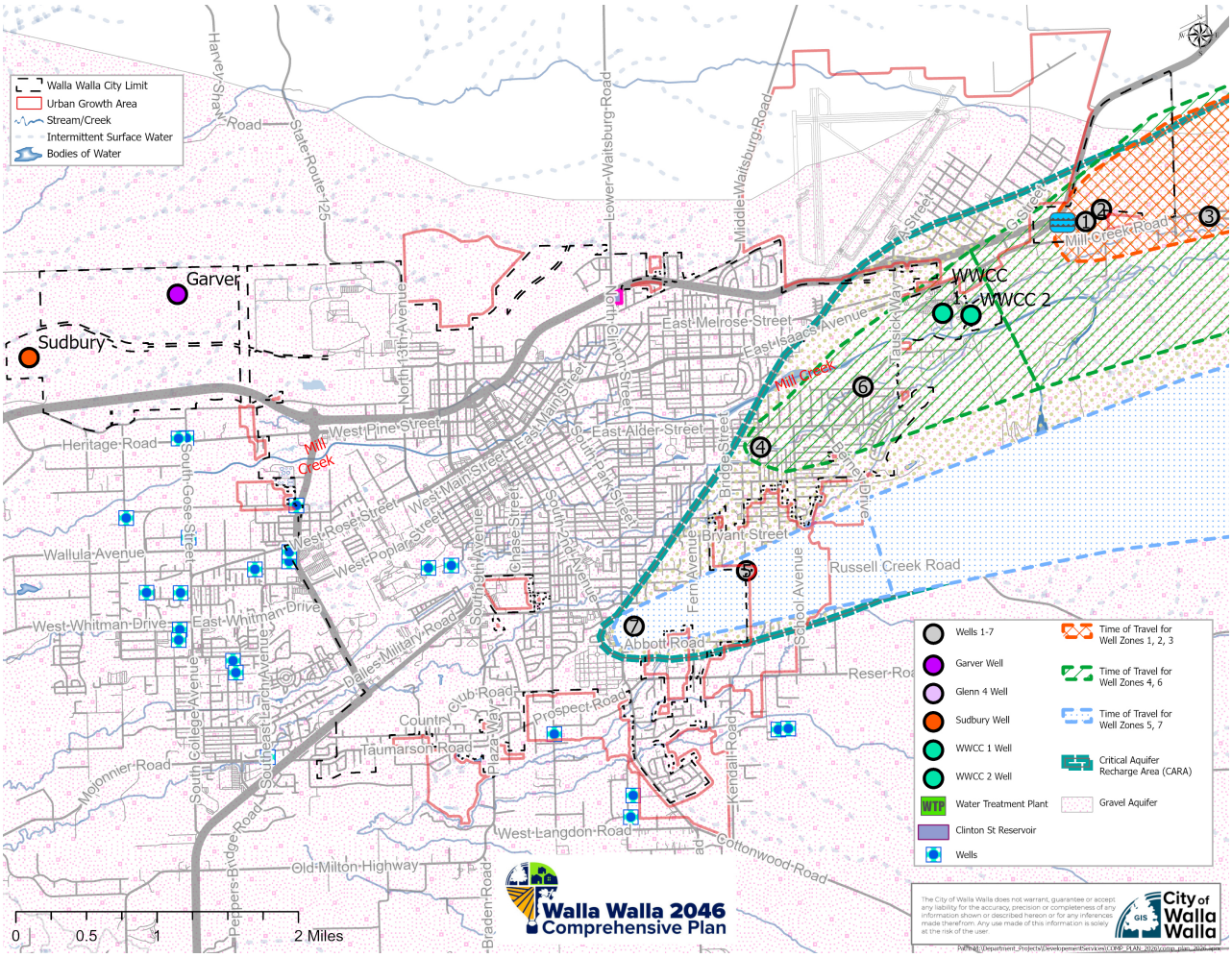


Figure 25. Critical Aquifer Recharge Areas Map

Urban Forestry

Trees have a special place in the City. Historically, local groups have sponsored annual tree planting activities. The first focused tree planting effort began in 1907 by local civic groups. Walla Walla 2020 championed tree-planting activities in the 1980s. Since then, tree planting has been the primary public service focus of the Rotary Club of Walla Walla.

There are over 50 state champion trees in Walla Walla. State champion trees are the largest of their species known in Washington State. Cuttings from several of these trees have been collected for cloning as part of the Champion Tree Project, the goal of which is to preserve, protect, propagate, and plant America's best and biggest trees. Over a third of the champion trees are located within Pioneer Park, and others are found on the Whitman College campus.

The City identifies, promotes, protects, and maintains Walla Walla's heritage trees. A heritage tree is defined as a tree or group of trees designated by the city because they meet the criteria of exceptional value. Exceptional value is determined by the urban forestry advisory commission based on association with historic figures or events, rare or unusual species, exceptional aesthetic quality, or large size.

Trees are valued for their beauty and large diameter and/or height. Trees also provide valuable environmental and economic benefits, such as shade. Trees that shade a building in the summer can help reduce energy consumption and cooling costs. In the winter, large evergreen trees can provide protection from cold winds, which may help reduce heating costs.

Trees in urban areas shade pavement and parking lots, helping to reduce the heat island effect. The heat island effect occurs when temperatures in urban and suburban areas can be elevated 2 to 10° above the surrounding rural area. Trees also intercept rainfall, which can help reduce peak stormwater flows. Trees reduce air pollution by absorbing carbon dioxide and air pollutants, such as ozone, carbon monoxide, and sulfur dioxide. The collection of trees in an urban area is often referred to as its urban forest.



The City of Walla Walla maintains an Urban Forestry Management Plan (UFMP). The UFMP includes management and maintenance recommendations; inventories of trees along city streets and within the city parks; and approved street tree lists. The Parks, Recreation, and Urban Forestry Advisory Board is a citizen

committee appointed by the City Council and provides recommendations to the City Council and the Municipal Arborist.

The City maintains a Tree City USA designation. The designation must be recertified annually. Walla Walla has been designated a Tree City USA since 1994. The National Arbor Day Foundation sponsors the Tree City USA program in cooperation with the USDA Forest Service and the National Association of State Foresters. To qualify for Tree City USA status, a town or city must meet four standards:

- A Tree Board or Department
- A Public Tree Care Ordinance
- Annual Expenditure of $2 Per Capita on Community Tree Care Activities
- An Arbor Day Observance and Proclamation



Challenges and Opportunities

Future Growth and Development

The City faces a wide range of environmental and natural resource challenges, such as reduced snowpack and rising temperatures. Balancing these concerns with future growth, development needs, and other municipal priorities, especially under limited resources—will require careful planning and sustained commitment. Even so, the City has a strong track record of addressing environmental issues and has built meaningful capacity, expertise, and partnerships that position it well for the work ahead.

Continued implementation of the City's Shoreline Master Program and critical areas regulations will play a central role in protecting natural resources and preserving fish and wildlife habitat. Together, these tools help ensure that environmental stewardship remains integrated into the City's long-term vision.

Walla Walla's Plan

The Environment and Natural Resources Element provides a background for the goals and policies described below. As the City grows, Walla Walla will implement the goals and policies through development regulations, which will ensure environmental compliance and the stewardship of natural resources.

Goals and Policies

ENR Goal 1: Water, air, and soil resources in Walla Walla are protected.

- ENR 1.1: Implement best management practices, where feasible, to ensure protection of surface and groundwater resources and ecosystems.
- ENR 1.2: Identify, study, and rehabilitate contaminated sites to support the safe reuse and, when feasible, repurpose them to community benefiting environments.
- ENR 1.3: Identify and protect critical areas, and keep the City's Critical Areas Ordinance updated, in accordance with the Periodic Update Cycle.
- ENR 1.4: Ensure that measures are in place to protect aquifer recharge areas from contamination.
- ENR 1.5: Encourage cooperation and coordination among communities involved in the Walla Walla 2050 Plan.

ENR Goal 2: Walla Walla residents are aware of local environmental issues and strategies to improve the environment.

- ENR 2.1: Work with partners to develop public awareness and educational programs for the protection and enhancement of natural areas.

ENR Goal 3: The Mill Creek fish habitat and its flood control functions are critical to the City.

- ENR 3.1: Support opportunities for a more naturalized channel that provides flood control for Mill Creek.
- ENR 3.2: Cooperate and coordinate with the Flood Control Zone District to protect properties in the UGA from flooding.

ENR Goal 4: The integrity of Walla Walla's riparian ecosystem is protected by avoiding development and other land use activities within Riparian Management Zones (RMZs).

- ENR 4.1: Take measures to safeguard existing wetlands to prevent continual loss and degradation.
- ENR 4.2: Encourage the voluntary restoration and enhancement of lost or degraded riparian corridors and wetlands to increase their connectivity, quantity and quality over the long term.
- ENR 4.3: Conservation of the natural environment and sustainable use of limited, renewable, and non-renewable resources protects and enhances the natural environment of Walla Walla.

ENR Goal 5: Walla Walla protects and expands its natural areas and tree canopies by prioritizing habitat preservation and strategic planting.

- ENR 5.1: Ensure that buffers are adequately defined, regulated, and controlled to limit the disturbance of vegetation and disruption of ecological function.
- ENR 5.2: Preserve and protect healthy mature trees in the community to the greatest extent possible and promptly plant replacements when they cannot be saved.

Policy Connections

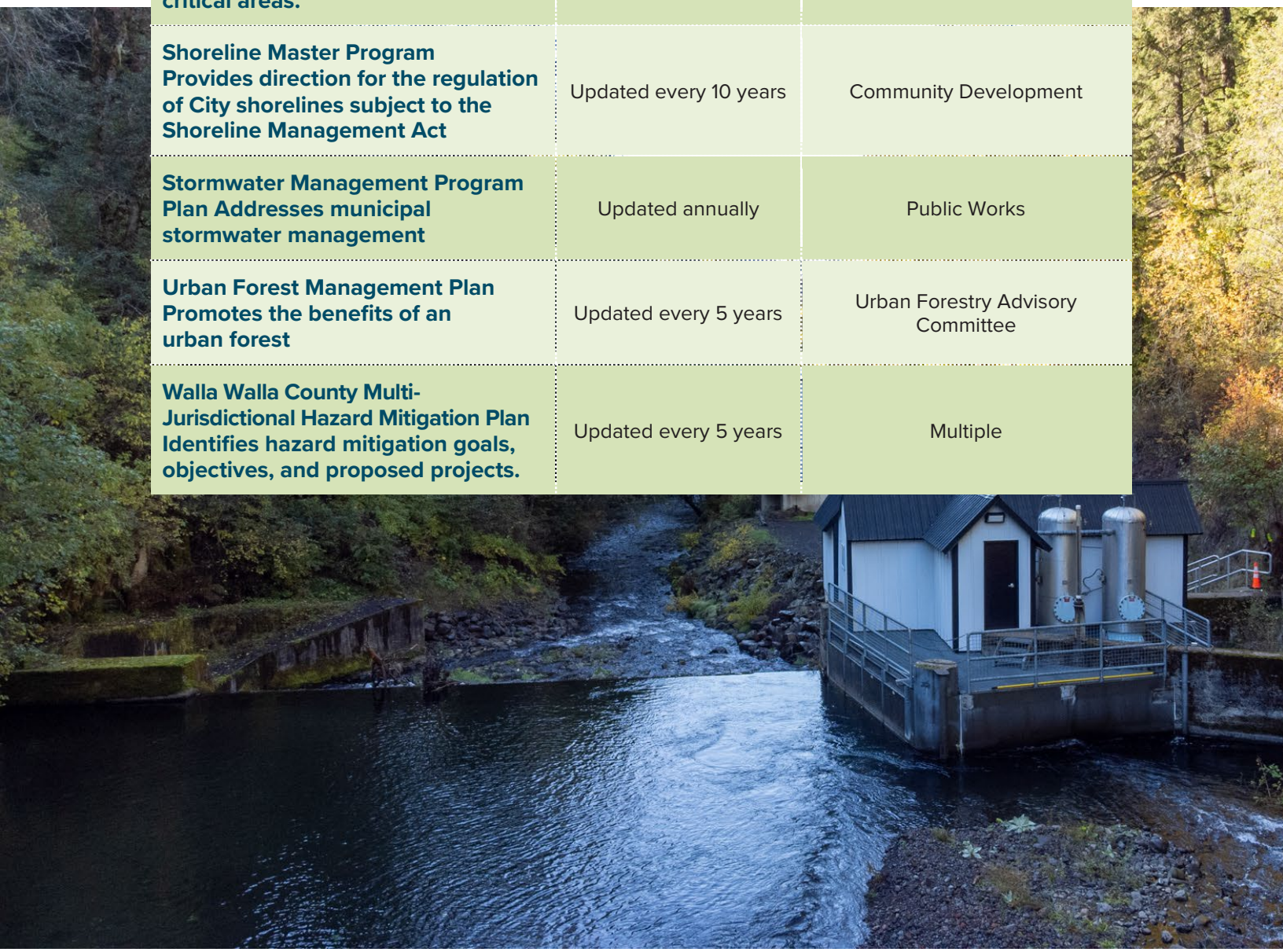
- **The Shoreline Element** contains policies that provide direction for the regulation of City shorelines subject to the Shoreline Management Act, inclusive of critical areas within the shoreline jurisdiction.
- **The Capital Facilities and Utilities Element** provides policies regarding community infrastructure needs, including fire facilities, and recognizes the potential for future development impacts from facility expansion.
- **The Housing Element** includes policies that promote increased diversity of housing types and affordability for all income levels.
- **The Transportation Element** identifies transportation needs to address future growth and expansion.



Translating Policy into Action

Table 22. Environment and Natural Resources Implementation Actions

Implementation Action	Timeline	Responsibility
Building and Land Use Permitting Ensures development complies with adopted City codes	Ongoing	Community Development
Critical Areas Ordinance Regulates environmentally critical areas.	As required by State law	Community Development
Shoreline Master Program Provides direction for the regulation of City shorelines subject to the Shoreline Management Act	Updated every 10 years	Community Development
Stormwater Management Program Plan Addresses municipal stormwater management	Updated annually	Public Works
Urban Forest Management Plan Promotes the benefits of an urban forest	Updated every 5 years	Urban Forestry Advisory Committee
Walla Walla County Multi-Jurisdictional Hazard Mitigation Plan Identifies hazard mitigation goals, objectives, and proposed projects.	Updated every 5 years	Multiple





Shoreline

Introduction

Relationship to Shoreline Management



The Shoreline Management Act (SMA), enacted by the State of Washington, was created to address growing concerns about unplanned and uncoordinated development along shorelines, which posed risks of serious and permanent environmental damage. The SMA's overarching goal is to prevent harm from fragmented shoreline development while balancing ecological protection with appropriate land use.

The SMA establishes three broad policies:

1. **Encourage Water-Dependent and Water-Oriented Uses**
   Prioritize uses that depend on shoreline access and are consistent with pollution control and environmental protection.
2. **Promote Public Access**
   Preserve opportunities for the public to enjoy the physical and aesthetic qualities of natural shorelines to the greatest extent feasible.
3. **Protect Natural Shoreline Resources**
   Safeguard land, vegetation, wildlife, water, and aquatic life from degradation.

In June of 2018, the city adopted an updated version of its Shoreline Master Program (SMP). The Program reflects local visions while complying with state standards. For the City of Walla Walla, this Program becomes part of its development regulations, as required by RCW 36.70A.480. For any future updates, following the adoption of the 2018 Program, the SMP must be reviewed and approved by the Washington State Department of Ecology before taking effect. In 2023, the City of Walla Walla adopted amendments to the SMP under Ordinance 2023-15. The Shoreline Master Program is listed as a reference.

Purpose and Vision

It is the ultimate goal of the City of Walla Walla SMP to prevent harm that results from uncoordinated development of the state's shorelines and to provide plans, policies and regulations consistent with the SMA (RCW 90.58) and with the SMP Guidelines (WAC 173 – 26) which reflect the desires of the citizens of the city and its communities regarding the balanced use of the city shorelines to:

- Ensure no net loss of ecological functions along shorelines.
- Promote public health, safety, and welfare through comprehensive policies and reasonable regulations.
- Fulfill local government responsibilities under RCW 90.58.050.
- Implement state shoreline use preferences outlined in RCW 90.58.020.

Mill Creek is an asset to the city as the only shoreline of the state within the City of Walla Walla's jurisdiction. Portions of Mill Creek are part of the U.S. Army Corps of Engineers Mill Creek Project (Mill Creek Flood Control Project). The City's vision emphasizes restoring Mill Creek to a more naturalized system where feasible, while maintaining critical flood control infrastructure. The SMP seeks to preserve high-quality waters and shorelines for future generations, protect private property rights, and support economic vitality and sustainability.

Environmental Designations

To manage shoreline areas effectively, the SMP classifies them into five environmental designations, each tailored to ecological conditions and development patterns:

- **Urban Conservancy:** Protect and restore ecological functions in open spaces and floodplains within urban settings.
- **Urban Residential:** Accommodate existing and planned residential development while providing public access and recreation.
- **High Intensity:** Support commercial, industrial, transportation, and multi-family residential uses while restoring degraded ecological functions.
- **Urban Downtown:** Apply to areas where Mill Creek flows through artificial or underground channels, allowing urban uses.
- **Mill Creek Flume:** Designate intensively developed areas adjacent to flood control works, accommodating mixed water-oriented and non-water-oriented uses.

These designations ensure that development aligns with ecological protection, public access, and community goals.

Key Outcomes

The City of Walla Walla SMP provides a framework for:

- Coordinated shoreline planning and development.
- Balancing environmental stewardship with economic and recreational opportunities.
- Maintaining compliance with state law while reflecting local priorities.
- Protecting Mill Creek as a vital community asset through restoration and flood control integration.

The shoreline maps are available in the SMP.

Goals and Policies

S Goal 1: To foster a pattern of land use along the shorelines of the City of Walla Walla that balances human use with protection of existing character, habitat, and ecological systems.

- S 1.1: Allow breakwaters, weirs, and groins to be located waterward of the Ordinary High-Water Mark only where necessary to support water-dependent uses, public access, shoreline stabilization, ecological restoration, or other specific public purpose.
- S 1.2: Consider alternative structures with less impact where physical conditions make such alternatives feasible.
- S 1.3: Institutional development in shoreline jurisdiction should be designed and located to result in no net loss of ecological function.
- S 1.4: Develop application processing guidelines that will streamline the review of restoration-only projects.
- S 1.5: Locate and design new development to avoid the need for future shoreline stabilization to the extent feasible.

- S 1.6: Require residential development to make adequate provision for wastewater, water, and stormwater facilities and apply best management practices to protect shoreline water quality and meet the needs of the development.
- S 1.7: Design residential development to prevent the need for new shoreline stabilization or flood hazard reduction measure.
- S 1.8: Design residential subdivisions in shoreline jurisdiction to be compatible with the physical and aesthetic character of the shoreline.
- S 1.9: Where shoreline conditions permit, promote a variety of housing types along shorelines in the City of Walla Walla to increase pedestrian activity and increase market area for local businesses while ensuring no net loss of shoreline ecological function.
- S 1.10: Ensure that signs located in the shoreline jurisdiction do not disrupt visual access to water areas.
- S 1.11: Limit the size and number of signs in the shoreline environment to be compatible with the applied environment designation.
- S 1.12: Locate, design, and maintain signs to minimize impacts to views and be visually compatible with local shoreline scenery as seen from both land and water, especially on shorelines of statewide significance.

S Goal 2: To encourage shoreline development and modifications that are wisely placed, consistent with the physical limitations of the area, serve the needs and desires of the local citizens, and ensure no net loss of ecological function.

- S 2.1: New or expanded agricultural activities should not be allowed within the shoreline jurisdiction.
- S 2.2: Allow shoreline modifications if the use or activity is permitted under the SMP and the modifications are consistent with WWMC Chapter 21.10 Floodplain Management, or where it can be demonstrated that the proposed activities are necessary to support or protect an allowed use or development.
- S 2.3: Allow shoreline modifications if the use or activity is permitted under this SMP and only when adverse individual and cumulative impacts are avoided, minimized, and then mitigated as necessary to result in no net loss of shoreline ecological functions, in accordance with the mitigation sequence of this SMP.
- S 2.4: Allow upland excavation only when necessary to support a use or modification otherwise allowed by this Shoreline Master Program.
- S 2.5: Forest practices shall not be allowed within shoreline jurisdiction.
- S 2.6: Mining activities shall not be allowed within shoreline jurisdiction.

- S 2.7: Allow fill when it is demonstrated to be the minimum extent necessary to accommodate an allowed shoreline use or development and with assurance of no net loss of shoreline ecological functions and processes.
- S 2.8: Allow fill when it is associated with restoration projects.
- S 2.9: Upland fill and excavation should be designed to meet the character of the surrounding shoreline.
- S 2.10: Use structural shoreline stabilization measures only when nonstructural methods are infeasible. Nonstructural methods include building setbacks, structure relocation, groundwater management, and other measures.
- S 2.11: Ensure soft structural shoreline stabilization measures are used prior to hard stabilization measures unless demonstrated to be insufficient.
- S 2.12: Allow new or expanded structural shoreline stabilization only where demonstrated to be necessary to support or protect an allowed primary structure or a legally existing shoreline use that is in danger of loss or substantial damage, or for reconfiguration of the shoreline for mitigation or enhancement purposes.
- S 2.13: Ensure all proposals for structural shoreline stabilization, both individually and cumulatively, do not result in a net loss of ecological functions.

S Goal 3: To give priority to preferred uses of the shoreline, as well as those uses that contribute to the unique character and economic prosperity of the City of Walla Walla, where those uses will not cause a net loss of shoreline ecological function.

- S 3.1: New aquaculture for commercial propagation should not be allowed in shoreline jurisdiction. Encourage aquaculture that supports the recovery of endangered or threatened fish species.
- S 3.2: Restrict aquaculture in areas where it would result in a net loss of ecological functions or significantly conflict with navigation or other water-dependent uses.
- S 3.3: Promote aquaculture in such a manner as to protect the aesthetic quality of the shorelines and adjacent lands, and to protect the soil, air, water, fish, and wildlife.
- S 3.4: Allow aquaculture that supports the propagation of native species, whether for the purposes of recreational activities or the restoration of species.
- S 3.5: Locate new utilities outside shoreline jurisdiction unless alternative locations are unfeasible, the utility requires a shoreline location, or the utility is necessary to support an approved shoreline use.

S Goal 4: To encourage a system of diverse public access opportunities that is safe and convenient, consistent with shoreline character and ecological functions, and compatible with adjacent land uses while recognizing private property rights.

- S 4.1: Ensure that shoreline commercial development provides public or visual access to the shoreline where opportunities exist, provided that such access would not pose a health or safety hazard or such access is demonstrated to be infeasible.
- S 4.2: Limit over-water, and non-water-oriented commercial uses in the shoreline environment.
- S 4.3: Ensure that the provision of public access does not degrade natural features or otherwise contribute to a loss of shoreline ecological function.
- S 4.4: Encourage shoreline institutional development to provide public access to the shoreline where opportunities exist, provided that such access would not pose a health and safety hazard or a security risk.
- S 4.5: Encourage public access as part of new shoreline development, commensurate with the level of public access demand created by the development, and consistent with public safety.

S Goal 5: To encourage coordinated public shoreline access across the City through partnership with Federal, State, and local governments, as well as non-governmental organizations, through incentives to property owners and developers.

- S 5.1: Promote the provision and maintenance of quality physical and visual access to shorelines, with a focus on both public properties and private properties under development.
- S 5.2: Allow for provision of communal public access as part of new commercial and residential shoreline developments.
- S 5.3: Encourage community shoreline access points for multifamily residential development in the shoreline jurisdiction.
- S 5.4: Promote public access or shoreline restoration as potential mitigation measures for impacts associated with shoreline commercial development where opportunities exist, and provided that public access would not pose a health or safety hazard to the public.

S Goal 6: To meet the recreational needs of City residents and visitors while protecting existing recreational resources, shoreline ecological functions, and private property rights.

- S 6.1: Prioritize development and improvement of recreational facilities identified in the City of Walla Walla's parks and recreation plan, to the extent that development of these facilities will not result in a net loss of ecological function.

S Goal 7: To encourage a variety of recreational opportunities tailored to the ecological and land use conditions of the City's diverse shoreline environments.

- S 7.1: Promote public access to and enjoyment of the shoreline at existing and future City parks in shoreline jurisdiction.

S Goal 8: To ensure that economic activity along shorelines is encouraged while also developing in a manner that protects the shoreline environment, is compatible with adjacent land uses, and ensures no net loss of shoreline ecological function.

- S 8.1: New industrial development should consider providing shoreline public access as mitigation for disruption of shoreline resources and values, unless such public access would result in a security risk or life and safety hazard.
- S 8.2: Design new industrial development in the shoreline environment to result in no net loss of ecological function and to minimize disruption of navigation and use of the shoreline by adjacent property owners.
- S 8.3: Allow future industrial and port facilities that are dependent upon a shoreline location in areas where the shoreline is already characterized by industrial development or planned for such uses.

S Goal 9: To recognize the value of water-oriented development to the local economy and promote future economic development activity in shoreline areas where ecological conditions and land use patterns are appropriate for such uses.

- S 9.1: Encourage institutional development in shoreline jurisdiction that provides public benefit with respect to the objectives of the Shoreline Management Act or which provides other scientific, educational, or cultural benefits to the public.

S Goal 10: To recognize that healthy, attractive shoreline areas provide value for the local economy and serve as amenities to citizens and businesses.

- S 10.1: Recognize the urban character of Mill Creek within the City of Walla Walla and give preference to industrial development which encourages cooperative use of existing facilities that promote economic activity and public enjoyment of the shoreline.

S Goal 11: To create and maintain a comprehensive circulation system which provides for the safe and convenient movement of people, goods, and services while minimizing disruption of shoreline areas and the environment.

- S 11.1: New or expanded boating and moorage facilities should not be allowed within shoreline jurisdiction.
- S 11.2: Encourage circulation planning systems for pedestrian and bicycle transportation where appropriate.
- S 11.3: Require that circulation planning and projects support existing and proposed shoreline uses that are consistent with this SMP.
- S 11.4: Design, implement, and locate new roads, railroads, and parking facilities in such a manner as to result in no net loss of shoreline ecological function.

S Goal 12: To maintain adequate safety, environmental, and aesthetic standards for existing and new circulation systems within the shoreline jurisdiction.

- S 12.1: Encourage a circulation system which will efficiently and safely move people, goods, and services to minimize disruption or adverse effect on the shoreline areas.
- S 12.2: Consider viewpoints, parking, trails, and similar improvements for transportation system projects in shoreline areas.
- S 12.3: Ensure new utilities utilize existing transportation facilities (e.g., bridges) and utility rights-of-way easements, or existing cleared areas to the greatest extent feasible.
- S 12.4: New roads and railroads in shoreline jurisdiction shall be located as far landward from the shoreline as possible.

S Goal 13: To protect and preserve shoreline natural resources, including wetlands, native vegetation, fish and wildlife habitat, and scenic resources, both through responsible management of public land and incentives for private landowners and developers.

- S 13.1: Where new developments, uses, and/or redevelopments are proposed, ensure shoreline vegetation, both upland and waterward of the OHWM, is conserved to maintain shoreline ecological functions and processes.
- S 13.2: Encourage management and control of noxious and invasive weeds. Control of such species should be done in a manner that retains onsite native vegetation, provides for erosion control, and protects water quality.
- S 13.3: Vegetation removal not associated with development should be limited to that which is necessary to achieve the intended purpose while maintaining shoreline ecological functions and processes.
- S 13.4: Protect all shorelines of the state in a manner consistent with all relevant constitutional and other legal limitations on the regulation of private property so that there is no net loss of ecological functions from both individually permitted and exempt development.
- S 13.5: Sustain a diverse, productive, and high-quality natural environment for the use, health, and enjoyment of City residents.
- S 13.6: Identify and protect critical fish and wildlife habitat from destruction or encroachment of incompatible uses.
- S 13.7: Preserve wetlands that are important wildlife and game habitat or recreational areas.
- S 13.8: Protect life and property by avoiding inappropriate developments in areas susceptible to natural disasters and hazards, such as floodplains and steep slopes.
- S 13.9: Maintain and improve the water quantity and quality of the shoreline waterbodies and preserve surface and groundwater for the beneficial and economic use of the area's citizens, and to provide for wildlife and wildlife habitat.
- S 13.10: Ensure dredging and dredge material disposal are done in a manner that avoids or minimizes significant ecological impacts. Impacts that cannot be avoided should be mitigated in a manner that assures no net loss of shoreline ecological functions.
- S 13.11: Discourage the disposal of dredge material on shorelands or wetlands within a channel migration zone, unless part of an approved restoration project.

S Goal 14: To encourage restoration of shoreline ecological functions where they have been impaired and to facilitate restoration of shoreline ecological functions and aesthetics to achieve regional goals for water quality and habitat recovery.

- S 14.1: Restoration of impaired shoreline ecological functions and processes should be a component of new industrial development, where applicable.
- S 14.2: Promote restoration and enhancement actions that improve shoreline ecological functions and processes and target the needs of sensitive plant, fish and wildlife species as identified by Washington Department of Fish and Wildlife, Washington Department of Natural Resources, affected tribes, National Marine Fisheries Service, and/or U.S. Fish and Wildlife Service.
- S 14.3: Ensure restoration and enhancement of shorelines are designed using principles of landscape and conservation ecology and restore or enhance chemical, physical, and biological watershed processes that create and sustain shoreline habitat structures and functions.
- S 14.4: Seek funding to implement restoration and enhancement projects, particularly those sources that are identified in the Restoration Plan of this SMP or in other pertinent plans. Funding may be sought by the City or other entities.
- S 14.5: Ensure restoration and enhancement of shorelines is implemented using best management practices and protects adjacent natural resources.
- S 14.6: Protect and, where necessary, apply planning and land use measures to improve the quality and productivity of the City's environmental resources (air, ground and surface waters, and indigenous biology).
- S 14.7: Require that new developments, expansions, or retrofits of existing developments assess the effects of additional stormwater runoff volumes and velocities and mitigate potential adverse effects on shorelines through design and implementation of appropriate stormwater management measures.
- S 14.8: Site and design new development to avoid or, if that is not possible, to minimize the need for new and maintenance dredging.
- S 14.9: Ensure that the location, design, construction and maintenance of in-stream structures give due consideration to the full range of public interests, watershed functions and processes, and environmental concerns, with special emphasis on aquatic species, passage, connectivity, and restoring priority habitats and species.
- S 14.10: Encourage non-structural and non-regulatory approaches as an alternative to in-stream structures. Non-regulatory and non-structural approaches may include public facility and resource planning, land or easement acquisition, education, voluntary protection and enhancement projects, or incentive programs.

S Goal 15: To identify, protect, and preserve shoreline sites that have historic, cultural, educational, or scientific significance or value.

- S 15.1: As part of shoreline permit application review, coordinate with tribal, State, and Federal agencies that maintain inventories of known significant historic, cultural, and archaeological sites.

S Goal 16: Ensure that shoreline development provides for protection and restoration of areas and sites on Walla Walla shorelines that have historic, cultural, archaeological, educational, or scientific value, in compliance with State and Federal laws.

- S 16.1: Avoid potential damage to cultural or archaeological resources and protect such resources if they are discovered during development, including compliance with all applicable state and federal laws.

S Goal 17: To protect property in the City of Walla Walla from losses and damage caused by flooding by applying consistent flood hazard regulations.

- S 17.1: Recognize that existing flood control works, such as levees, are an existing and important feature to protect life and property.

S Goal 18: To guide future shoreline development in a manner that avoids the need for unnecessary new shoreline stabilization or flood control infrastructure.

- S 18.1: Recognize and protect the hydrologic functions of floodplains by limiting the use of structural flood hazard reduction measures.
- S 18.2: Ensure developments subject to damage or that could result in loss of life do not locate in areas of known flood hazards unless it can be demonstrated by the project proponent that the development is sited, designed and engineered for long-term structural integrity impacts to ecological functions are mitigated, nonstructural measures are not feasible, and that life and property on and off-site are not subject to increased hazards as a result of the development.
- S 18.3: Limit new development or uses in shoreline jurisdiction, including subdivision of land that would likely require structural flood hazard reduction measures.

Policy Connections

- **Community Character Policy 5.1:** Work with public and private partners to enhance the Mill Creek corridor with ecological restoration and trails to become a keystone asset in the city's physical identity.
- **Land Use Policy 2.7:** Continue coordination with the Confederated Tribes of the Umatilla Indian Reservation, the Army Corps of Engineers, and Walla Walla County Flood Control District to restore Mill Creek.
- **Land Use Policy 4.5:** Ensure that landowners are educated regarding responsibilities of properties abutting or surrounding surface waters such as wetlands or other water bodies.
- **Parks and Recreation Policy 1.5:** Encourage contiguous access to the Mill Creek corridor through easements and land acquisition.
- **Environment and Natural Resources Goal 3:** Restore Mill Creek to a natural ecosystem and improve fish habitat while recognizing the vital flood control functions of the channel.

Translating Policy into Action

This Element is implemented through City plans and programs, projects, and review of development applications.

Table 23. Shoreline Implementation Actions

Implementation Action	Purpose	Timeline	Responsibility
Critical areas ordinance	Regulates environmentally sensitive areas	Updated every 10 years	Community Development
Shoreline Master Program	Provides direction for the regulation of City shorelines subject to the Shoreline Management Act	Updated every 10 years	Community Development
Stormwater Management Program Plan	Addresses municipal stormwater management	Updated annually	Public Works
Urban Forestry Management Plan	Promotes the benefits of an urban forest	Updated every 5 years	Urban Forestry Advisory Committee
Walla Walla County Multi-Jurisdictional Hazard Mitigation Plan	Identifies hazard mitigation goals, objectives, and proposed projects	Updated every 5 years	Walla Walla County Emergency Management, Police, and Fire



Transportation

Introduction

This chapter tells the story of how the City of Walla Walla's planning efforts are helping the community achieve its desired transportation system. Crucial aspects of the plan are explained in the following sections:

- **Goals and Policies –** explains the City's overall vision.
- **Existing Conditions –** summarizes the current system.
- **Future Conditions –** identifies future transportation needs.
- **Transportation Improvements –** outlines projects and strategies to address needs.
- **Transportation Standards Summary –** summarizes standards that support progress toward the transportation vision.

As the City of Walla Walla grows through the planning horizon, it will remain important for the community to work collaboratively toward a shared transportation vision. The updated Transportation Element establishes a policy framework intended to guide transportation investments, development review, and coordination with regional and state partners. The City's updated goals and policies are intended to support a transportation system that is safe, connected, resilient, and responsive to the needs of people walking, bicycling, riding transit, driving, and moving freight.





Existing Conditions

Walla Walla's transportation system provides a strong framework for travel within the City and for regional access. The City is served by a network of local streets, collectors, arterials, state highways, freight routes, sidewalks, bicycle facilities, transit service, bridges, and traffic control systems. The system generally provides good mobility for motor vehicles and key regional connections via Highway 12 and State Route 125, while also including substantial existing bicycle facilities, pedestrian options, and transit infrastructure.

However, the existing system includes several important gaps and deficiencies. These include discontinuities in the bicycle network, incomplete sidewalks and Americans with Disabilities Act (ADA) barriers in some areas, aging bridge infrastructure, and several corridors where improved multimodal access would better serve existing residents and future growth.

Existing Multimodal Systems

The City's existing bicycle network consists of approximately 16 miles of bicycle lanes, 44 miles of designated bicycle routes, and 19 miles of trails. Key bicycle connections to downtown include Isaacs Avenue, Rose Street, Poplar Street, Alder Street, 2nd Avenue, and the Mill Creek and Highway 12 trail systems.

The pedestrian system includes an extensive sidewalk network, with approximately 289 miles of sidewalks citywide. However, sidewalk coverage is incomplete in some areas, especially in the south and southwest parts of the City, and the City's Sidewalk Condition Rating identifies segments with higher repair and ADA priority.

Valley Transit provides fixed-route transit service throughout Walla Walla and College Place, supplemented by FLEX service, Connector, Job Access, Dial-A-Ride, and rideshare programs. Existing transit routes provide broad community coverage, although access to stops and service frequency remain important long-term considerations.

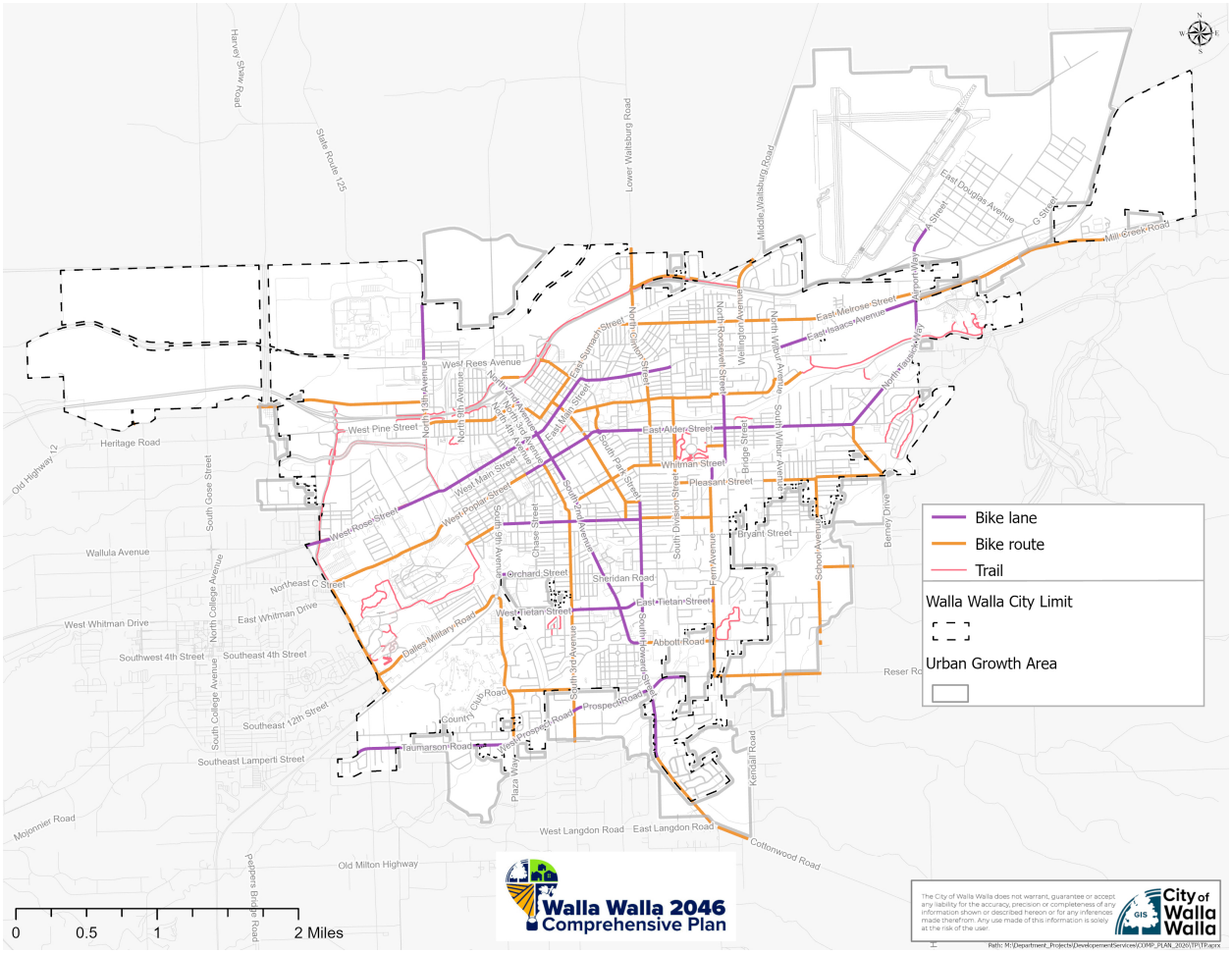


Figure 26. Existing Bicycle Facilities

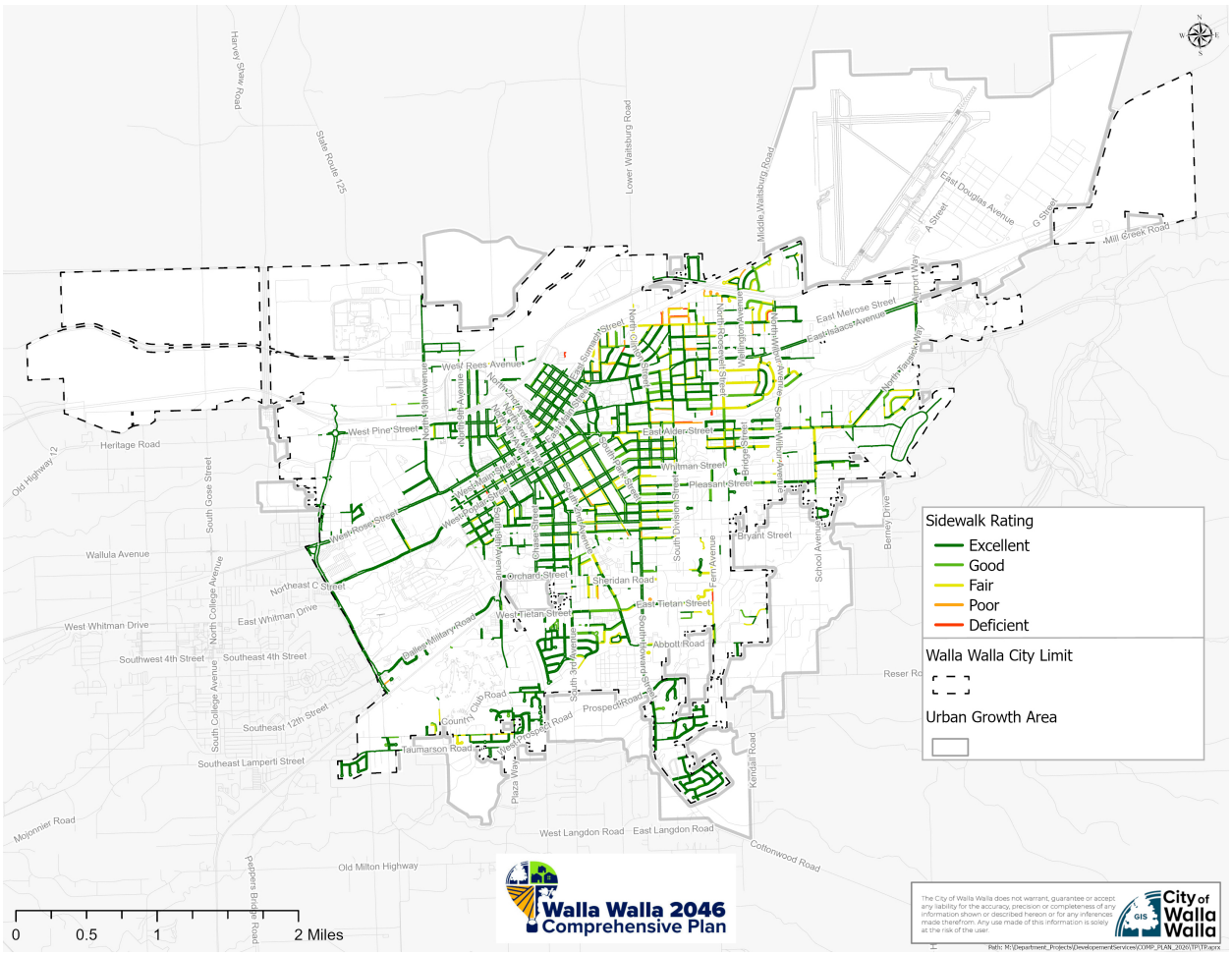


Figure 27. Existing Pedestrian Facilities and Conditions

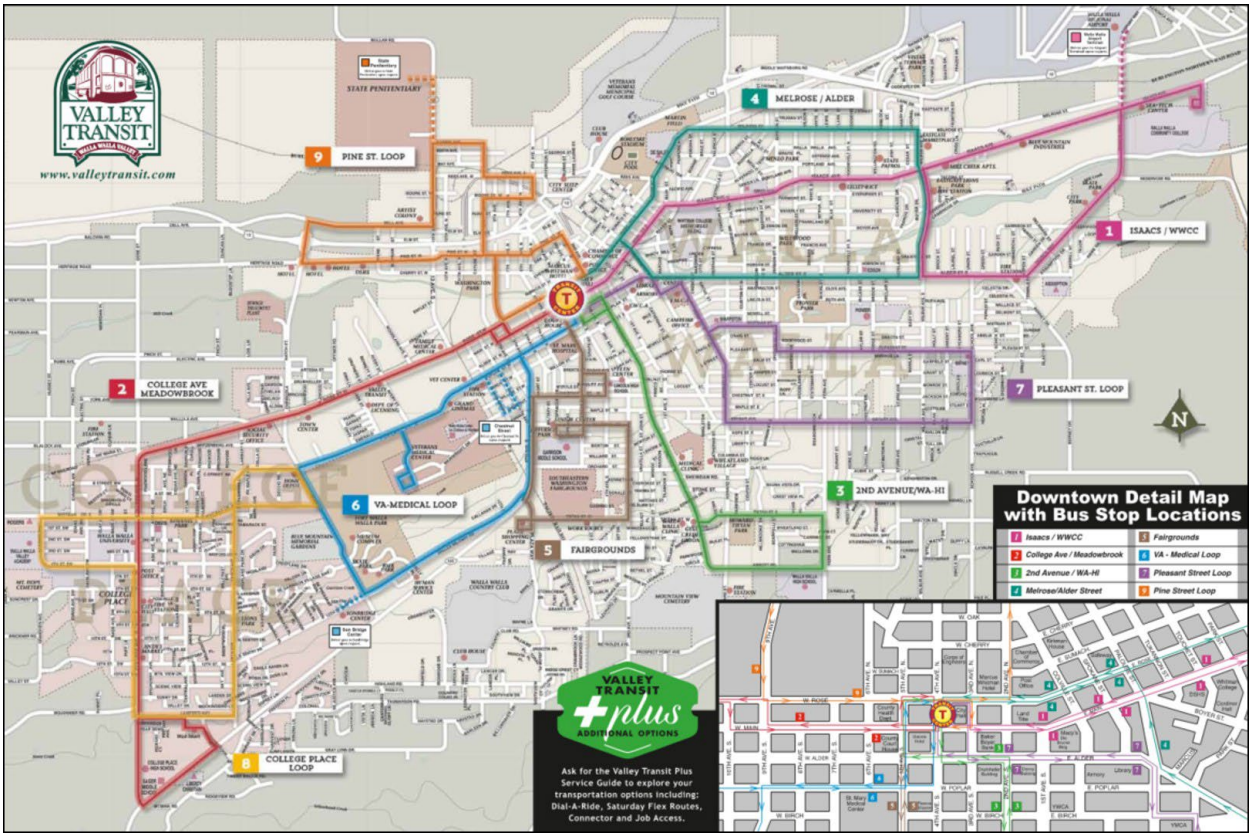


Figure 28. Existing Transit Routes

Street Network, Freight, and Bridges

The existing street system includes the City, Walla Walla County, and WSDOT facilities and serves a mix of local and regional functions. Functional classification helps define roadway roles and guides future design and operations decisions. Existing freight routes connect industrial and commercial areas to regional facilities and are concentrated along Highway 12, SR 125/9th Avenue, Pine Street, Myra Road, Isaacs Avenue, Rees Avenue, Howard Street, and related corridors.

Bridge infrastructure remains an important part of the transportation system. The City's bridge prioritization work identified several structures with significant replacement or rehabilitation needs, and since the prior plan update several bridges have been replaced or are scheduled for replacement. Remaining needs continue to influence system preservation and resiliency priorities.

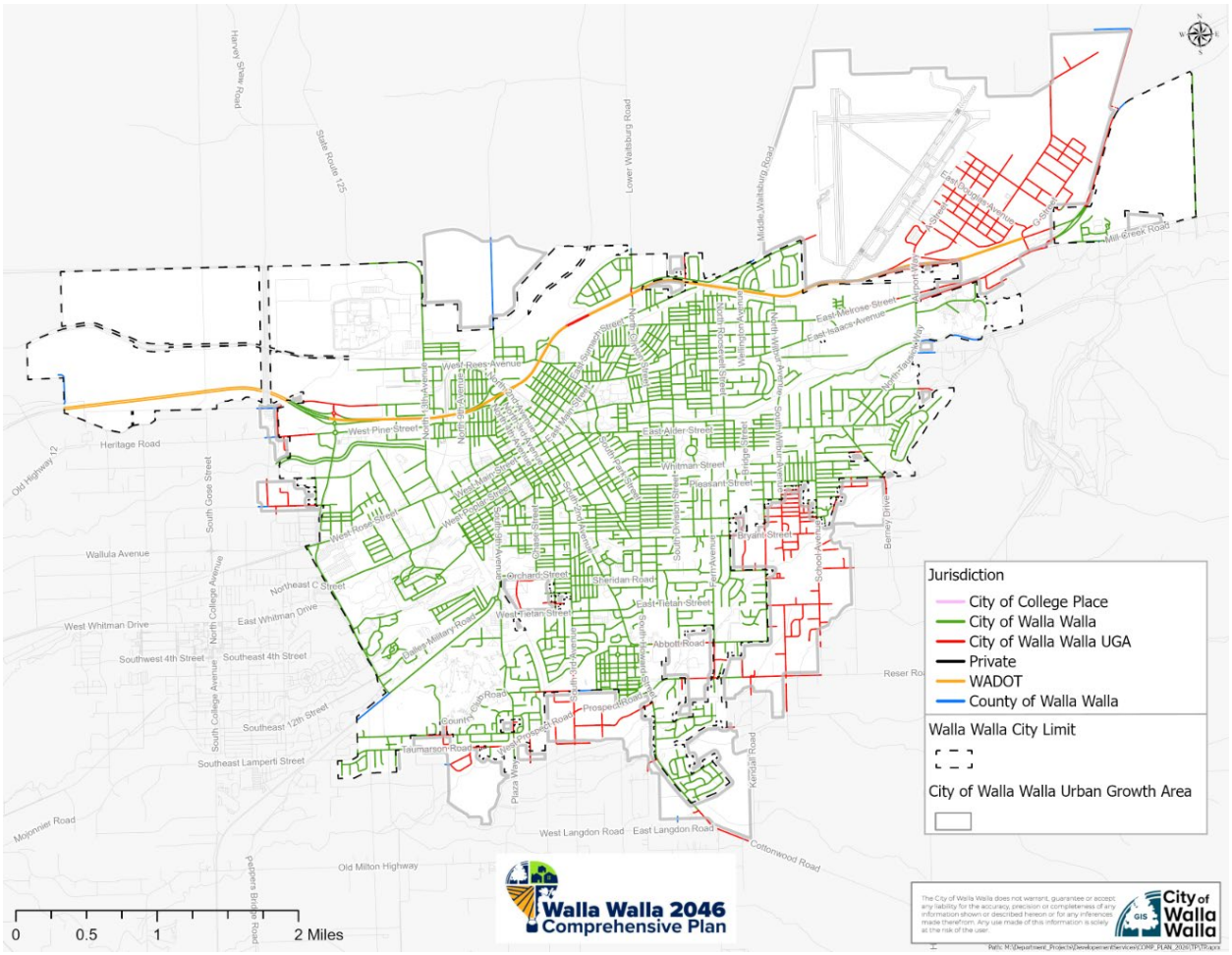


Figure 29. Street Jurisdiction

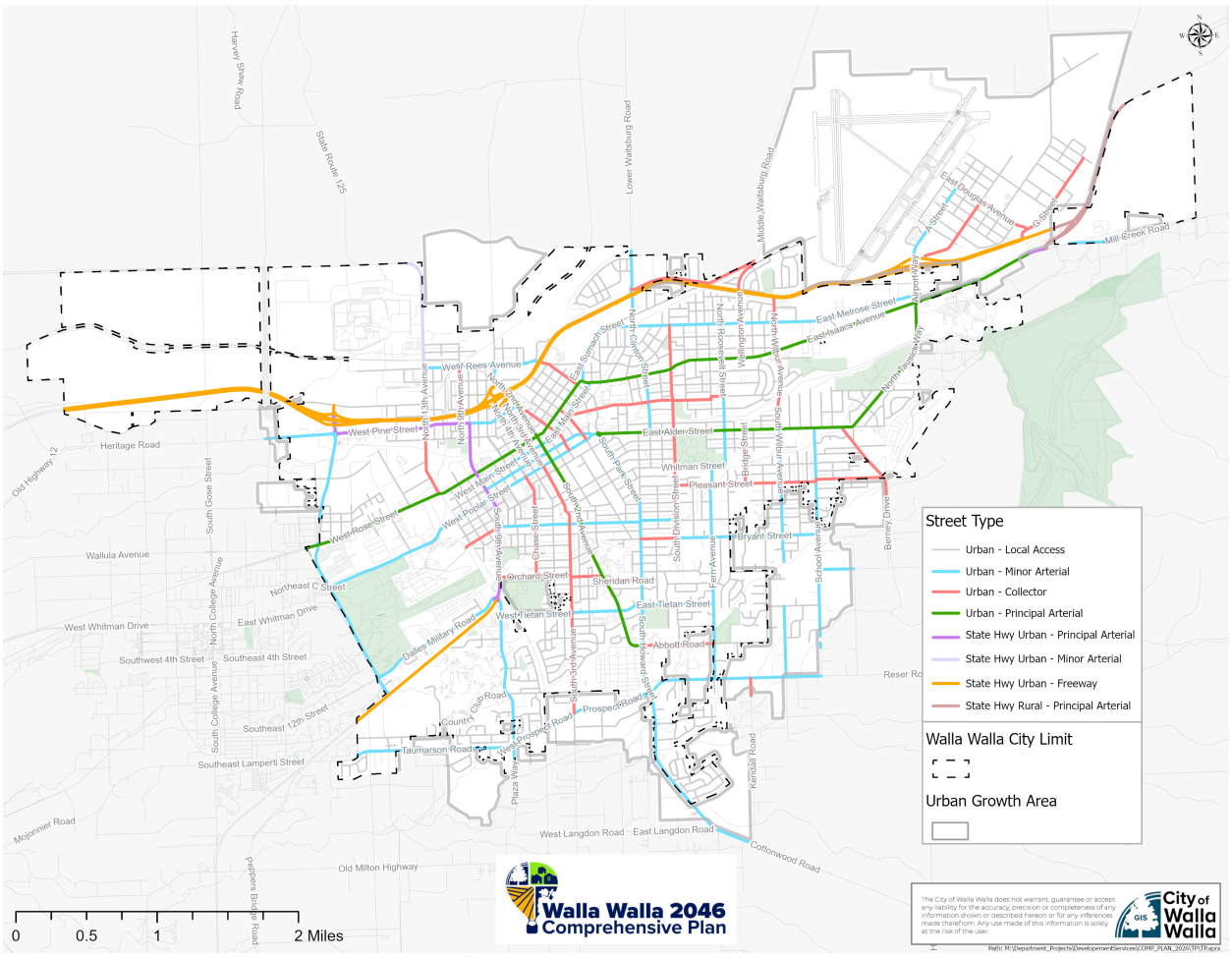


Figure 30. Functional Classification



Figure 31. Existing Freight Routes

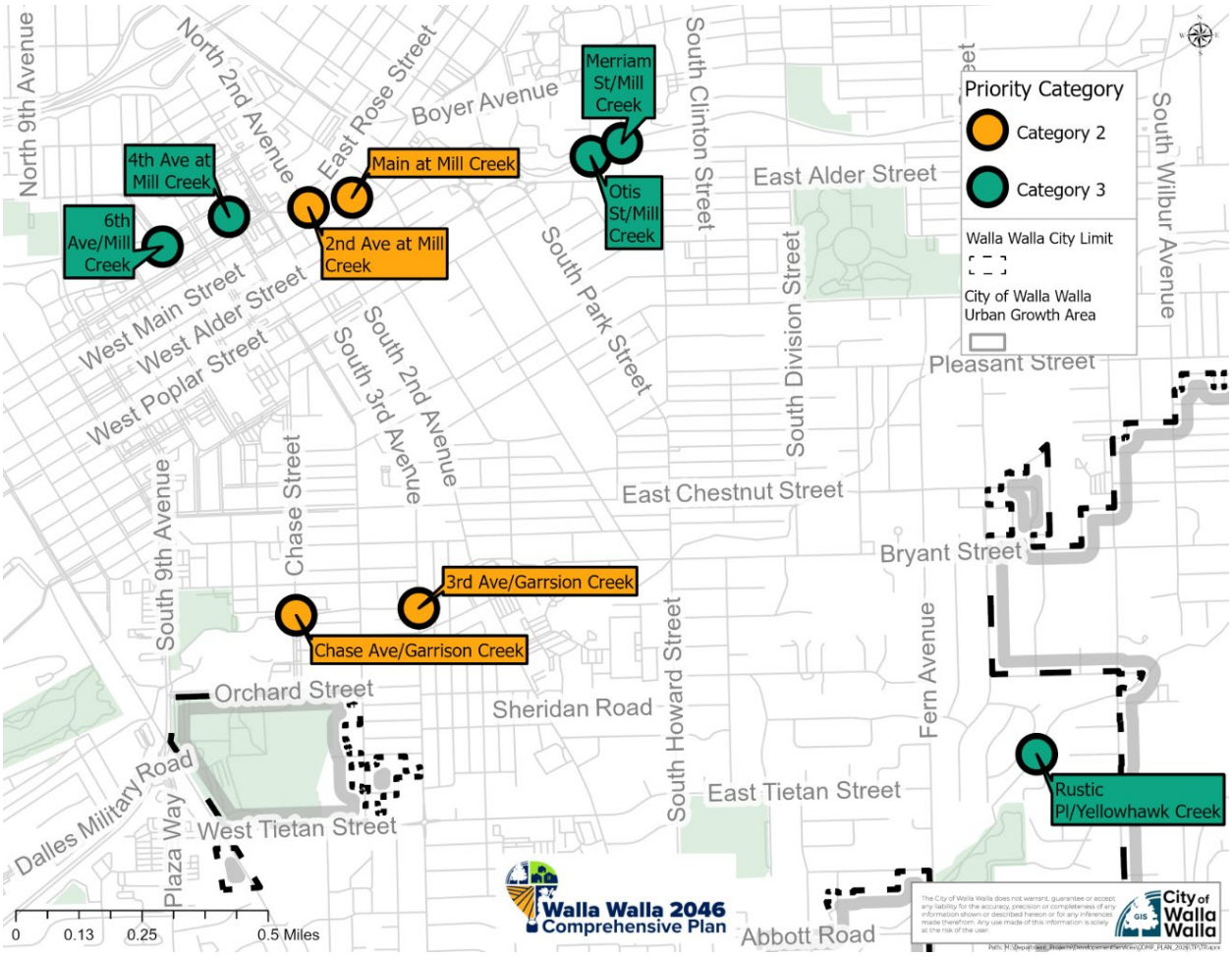


Figure 32. Bridge Conditions

Existing Traffic Control and Operations

The City's existing traffic control system includes traffic signals, roundabouts, railroad crossing signals, flashing beacons, and school zone flashers. Since the prior plan update, additional roundabouts and rectangular rapid flashing beacons have been added to improve safety and traffic operations. Existing intersection operations were evaluated during the PM peak period as part of the Transportation Element update, providing a baseline for identifying current and future needs.

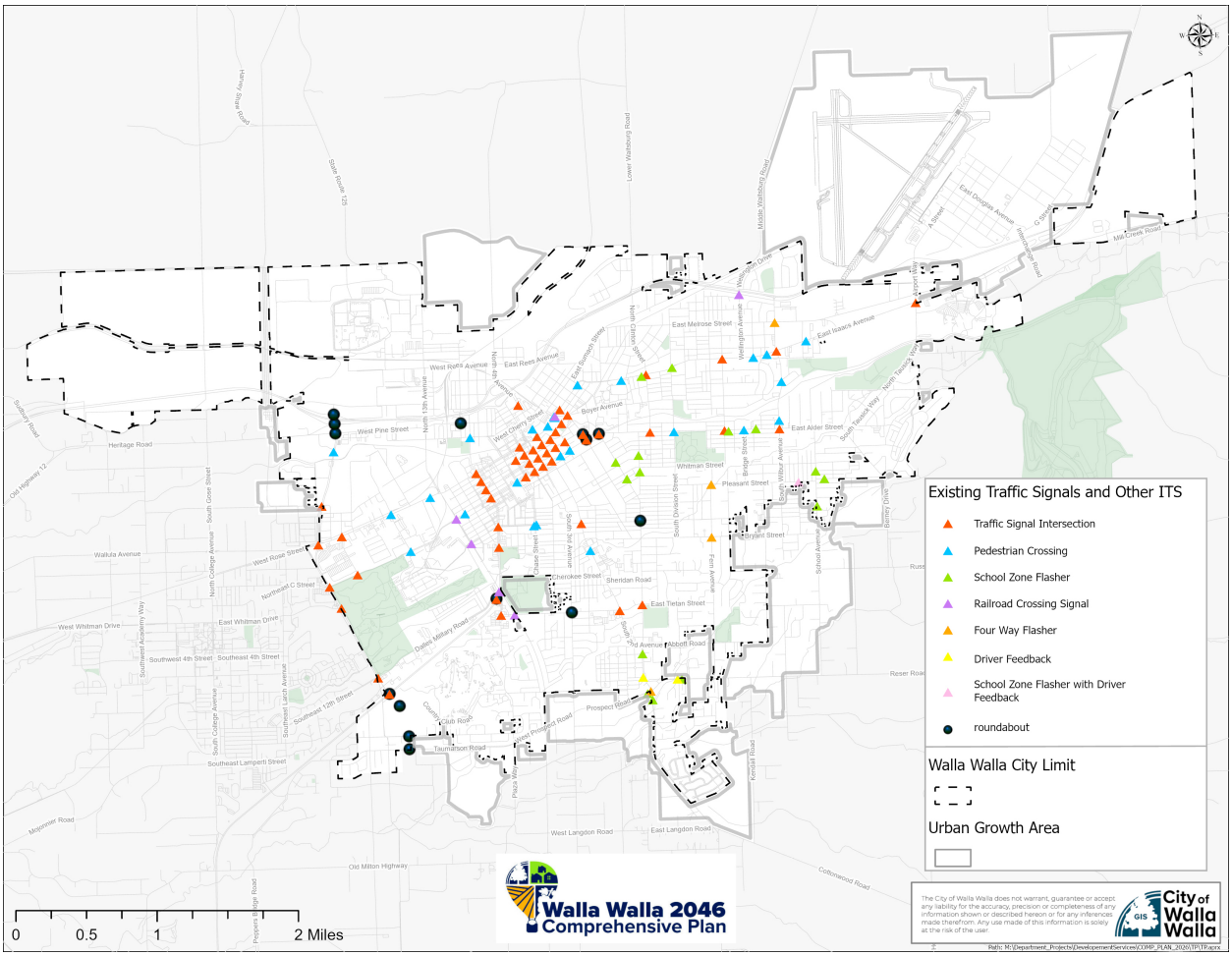


Figure 33. Existing Traffic Signals and Other ITS Systems

Future Conditions

The future transportation system is expected to continue functioning effectively for motor vehicles while accommodating anticipated growth through the 2046 planning horizon. However, meeting the City's long-term vision will require targeted improvements to address multimodal connectivity, accessibility, safety, and system resilience.

Motor Vehicle Operations

An assessment of the City of Walla Walla's future transportation system gaps and deficiencies was completed for all modes of travel to help the City identify projects and strategies needed to support anticipated growth through 2046. The vehicular system is generally expected to continue operating acceptably at most study intersections, with only limited future operational deficiencies identified. Specifically, one of the 25 study intersections evaluated, Bryant Avenue/Howard Street, is projected to exceed the City's operating standard in the 2046 baseline condition.

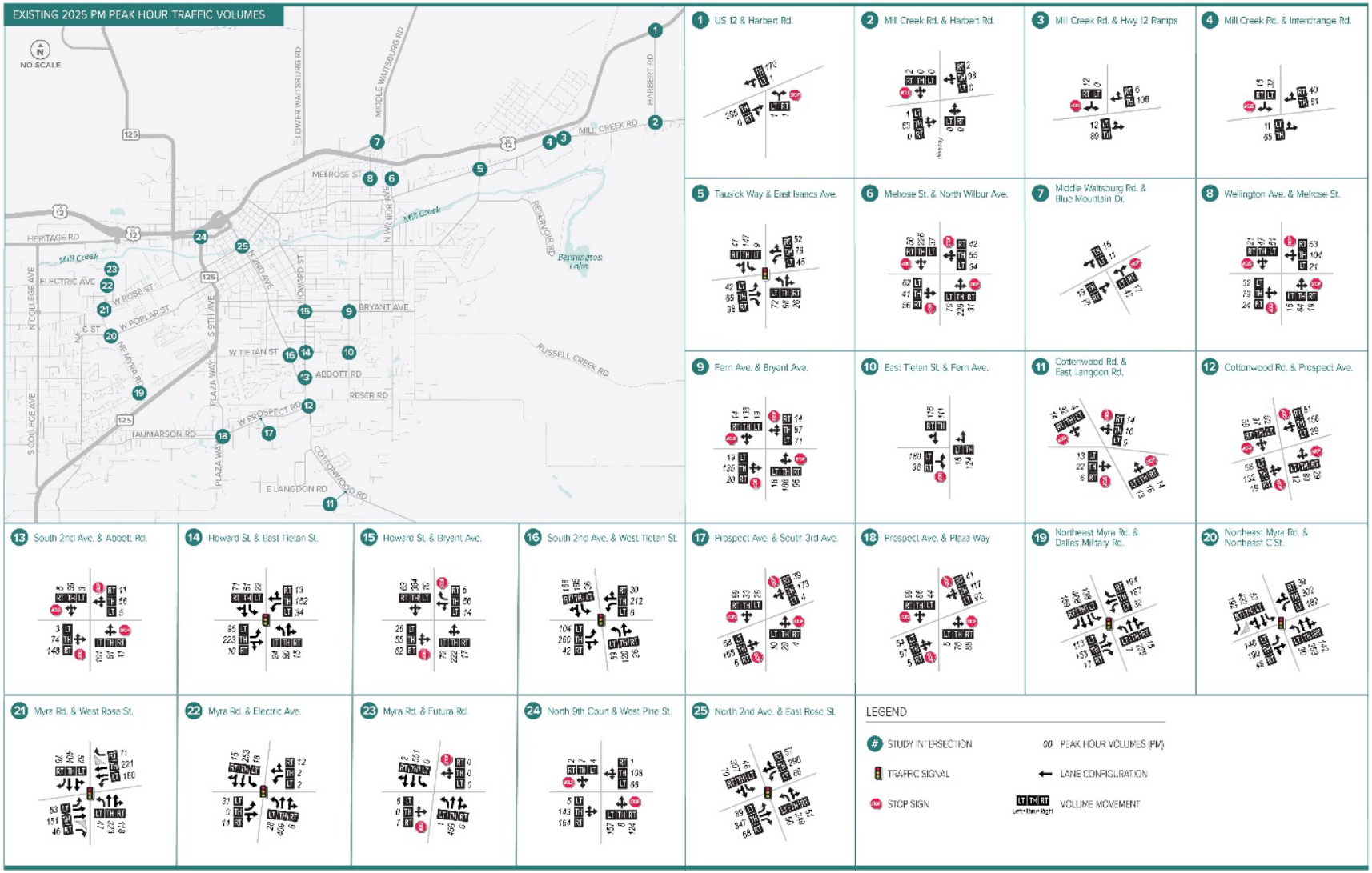


Figure 34. Existing Study Intersection Operations/Conditions. (Existing 2025 PM Peak Hour Traffic Volumes)

Bicycle and Pedestrian Gaps and Deficiencies

The City has made substantial improvements since the last comprehensive plan update, particularly on Isaacs Avenue, Park Street, Rose Street, Chestnut Street, and sections of Poplar Street, among others. Nonetheless, the bicycle network remains fragmented in places, sidewalk coverage is incomplete in selected areas, and additional connections will be needed to serve growth areas and maintain system resiliency. Key bicycle needs through 2046 include improving continuity, expanding facility coverage, and providing more comfortable facilities for a wider range of users. Identified corridors for improvement include Melrose Street, Poplar Street, Pleasant Street, Division Street, School Avenue, 3rd Avenue, and other corridors that can support citywide travel and access to major destinations.

Pedestrian needs include continued sidewalk infill, ADA improvements, improved crossings, and better access to transit, schools, parks, and commercial destinations. These needs are central to achieving the City's safety, connectivity, and quality of life goals.

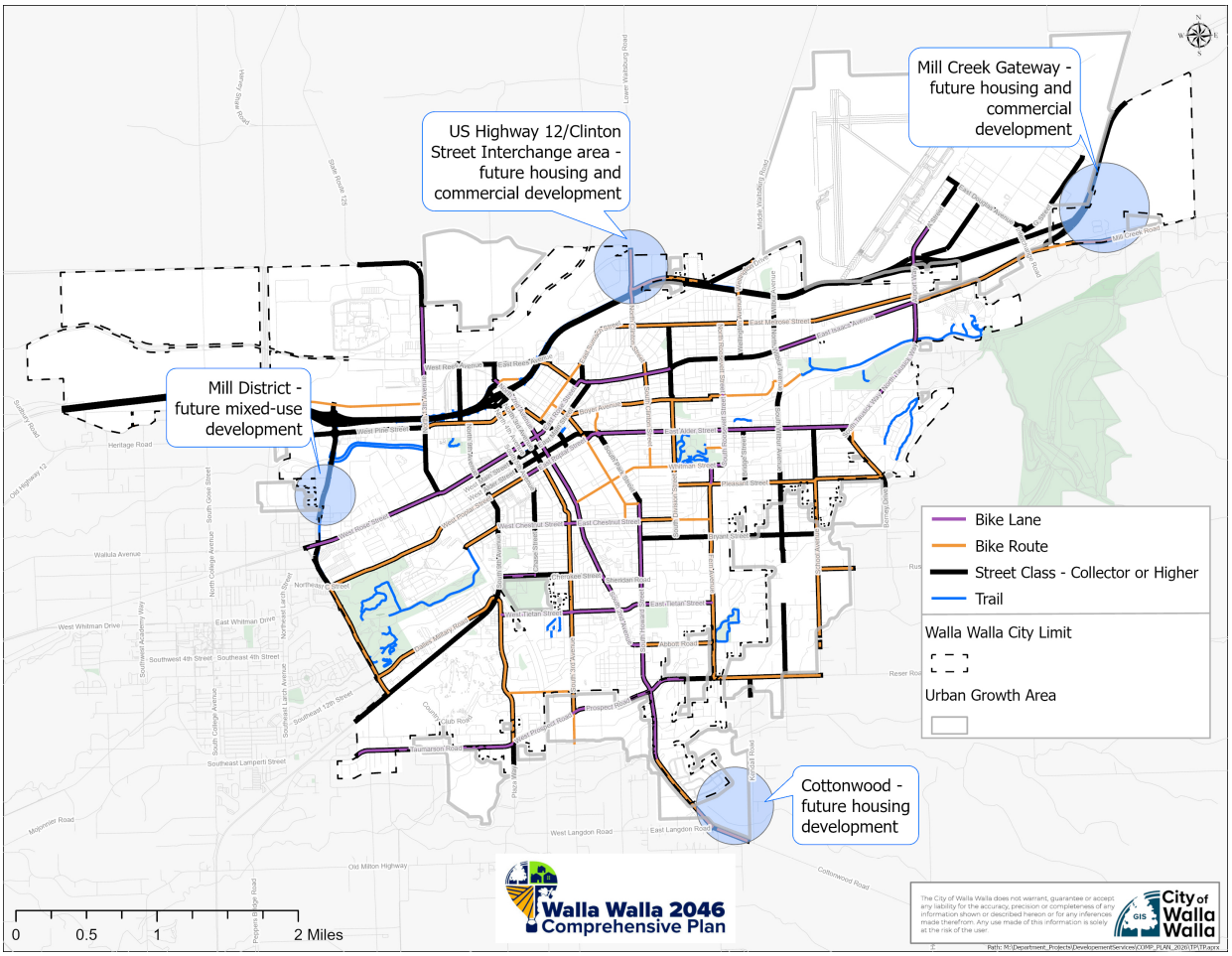


Figure 35. Bicycle Facility Improvement Opportunities

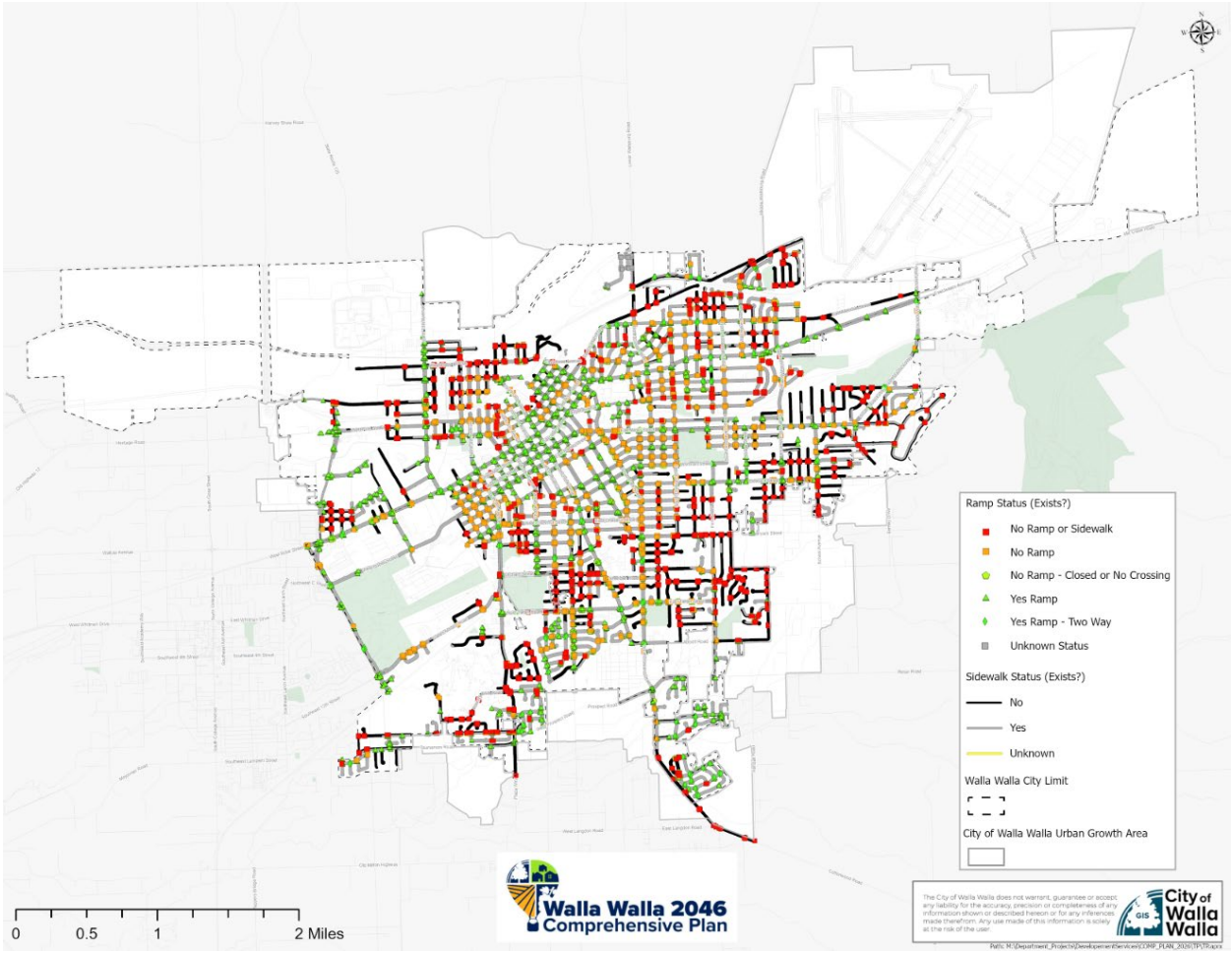


Figure 36. Pedestrian/ADA Priority Areas

Transit Gaps and Deficiencies

Transit service remains an important part of the City's multimodal system. While fixed-route coverage serves much of the developed area, long-term transit effectiveness will depend on continued coordination with Valley Transit. Improving access to transit stops, implementing supportive land use regulations, and utilizing appropriate street design will support pedestrian and bicycle connections to transit.

Freight Gaps and Deficiencies

The transportation system must continue to support efficient movement of goods while balancing safety and multimodal access. Freight-related needs include maintaining reliable freight access to industrial and commercial areas, coordinating with regional routes, and reducing conflicts where freight traffic travels through areas with higher multimodal activity. Existing and future planning work has also identified the importance of maintaining reliable connections to Highway 12 and SR 125/S 9th Avenue.

Freight traffic is currently routed through downtown along S 9th Avenue and Pine Street, creating congestion and inefficiencies. In addition, a 14-foot height restriction at the Pine Street railroad undercrossing limits freight movement, preventing taller vehicles from using this route. Rerouting freight to SE Myra Road would improve travel conditions, particularly if paired with signal coordination and timing enhancements. In the long term, SE Myra Road could also serve as a new alignment for SR 125.

Transportation Improvements

The recommended transportation improvements respond to the needs and deficiencies identified through the Transportation Element update process. The City's recommended projects are organized into eight categories:

- Multimodal projects
- Intersection improvements
- Safety projects
- Future studies
- Freight projects
- New roadways
- Bridge improvements



The proposed solutions represent a comprehensive, multimodal program of improvements designed to address identified transportation needs and deficiencies while supporting anticipated growth through the 2046 planning horizon. Collectively, these projects reflect a balanced approach that emphasizes connectivity, safety, accessibility, and system performance.

A total of 96 projects were identified and organized into eight categories that correspond directly to the project list structure. The full project list is available in Appendix XII. 20-Year Funding Forecast. Table 24 summarizes the number of projects in each category, followed by a discussion of the purpose and role of each project type.

Table 24. Summary of Proposed Projects by Category

Category	Number of Projects
Multimodal (MM)	53
Intersection (INT)	25
Bridge Improvement (BR)	9
New Roadway (NR)	3
Future Study (FS)	3
Safety (SA)	2
Freight (F)	1

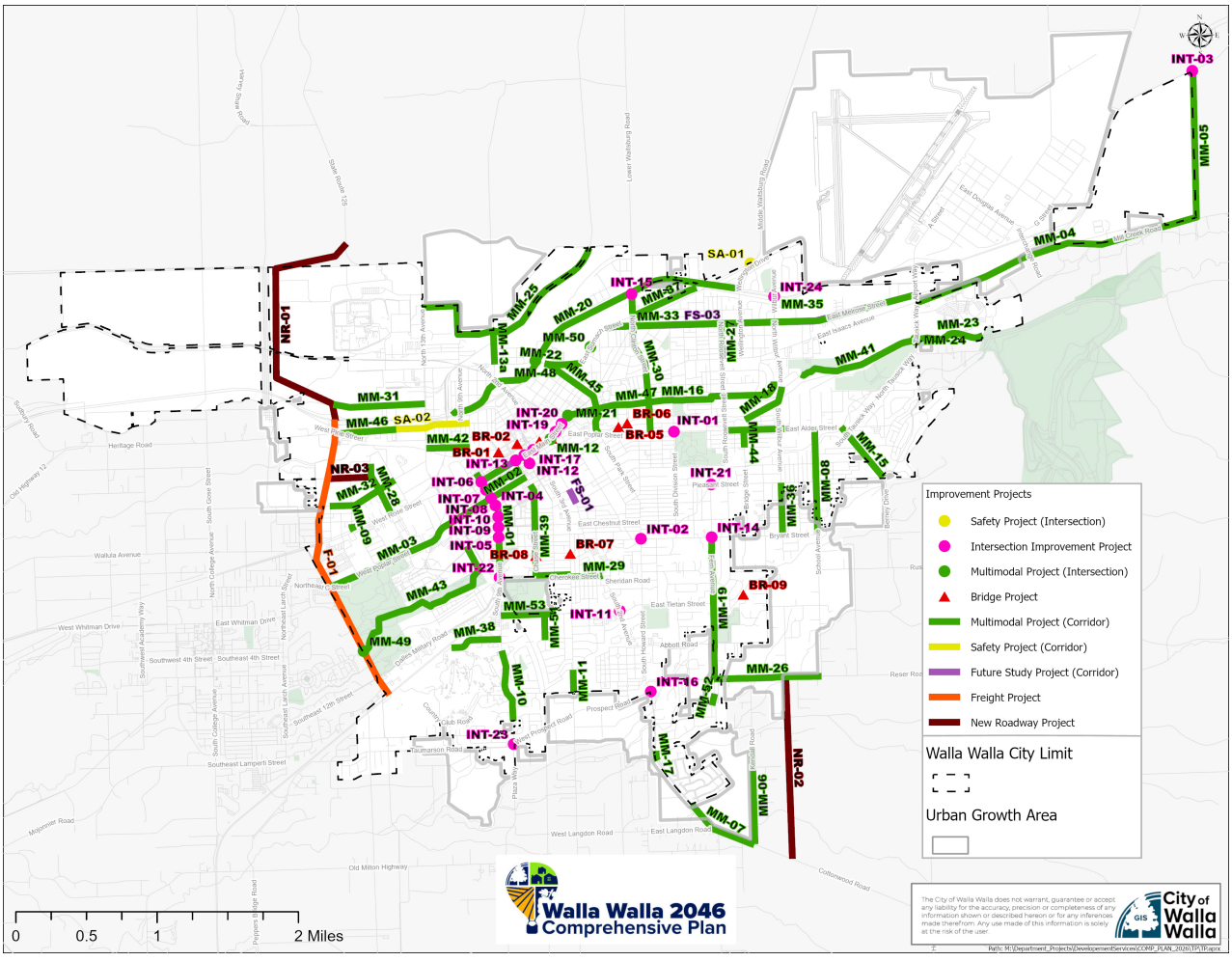


Figure 37. Transportation Improvement Projects



Multimodal Projects

Multimodal projects represent the largest share of the proposed solutions, with 53 projects focused on improving conditions for all modes of transportation but mostly focused on active transportation and the connection to transit. This emphasis reflects the City's policy direction to support a balanced transportation system and the identified need to improve network connectivity and accessibility.

These projects primarily address gaps and discontinuities in the existing system. While the City of Walla Walla has an established network of bicycle and pedestrian facilities, portions of the network remain incomplete, requiring users to travel in mixed traffic or navigate areas without adequate infrastructure. In addition, sidewalk coverage is not uniform across the city, with some areas lacking continuous or ADA-compliant facilities. The City continues to address sidewalk gaps through annual capital projects, development frontage improvements, and grant-funded projects. As new development occurs, frontage improvements required through development review will expand the sidewalk network, improving pedestrian and ADA connectivity.

Typical improvements in this category include:

- Bicycle facility expansion and corridor completion.
- Sidewalk infill and ADA upgrades.
- Enhanced pedestrian crossings.
- Connections to schools, parks, downtown, and employment areas.

Together, these projects are intended to create a more continuous, comfortable, and accessible network that supports users of all ages and abilities.

Intersection Projects

A total of 25 intersection projects are proposed to address localized operational and safety needs at key nodes in the transportation system. Although the most intersections are expected to operate within acceptable standards, targeted improvements are necessary to maintain performance and accommodate future traffic growth.

These projects focus on improving intersection efficiency, reducing delays, and enhancing safety for all users. In many cases, intersection improvements also provide opportunities to incorporate multimodal elements, such as improved crossings or signal timing adjustments that benefit pedestrians and bicyclists.

Common types of improvements include:

- Intersection control modifications (e.g., roundabouts or traffic signal updates).
- Turn lane additions or geometric improvements.
- Pedestrian and bicycle crossing enhancements.

These projects help ensure that intersections continue to function effectively as critical points of interaction within the network.





Bridge Improvement Projects

Bridge improvements represent a significant component of the project list, with nine projects focused on maintaining and upgrading critical infrastructure. Bridges play a key role in maintaining connectivity across physical barriers such as Mill Creek and are essential to the overall functionality of the transportation network.

Existing conditions have found that several bridges have been identified as priorities for replacement or rehabilitation based on condition and performance. Addressing these needs is critical to ensuring long-term system reliability and safety.

In addition to structural improvements, many bridge projects also incorporate multimodal enhancements to improve access for pedestrians and bicyclists.

New Roadway Projects

A total of three new roadway projects are included to expand the street network and improve connectivity, particularly in areas of anticipated growth. These projects are essential for supporting long-term development and reducing pressure on existing corridors.

New roadway projects generally include:

- Street extensions to complete the planned network or provide future connectivity within the Urban Growth Area.
- New connections to improve east-west and north-south travel.

By providing additional routes, these projects improve overall network redundancy, support emergency response, and create a more connected and resilient transportation system.

Future Study Projects

A total of three future study projects are included to address locations or issues that require additional analysis before specific improvements can be defined. These projects recognize that certain transportation challenges are complex and may require further coordination, data collection, or feasibility assessment before recommending an infrastructure improvement.

Future study projects allow the City to:

- Evaluate corridor-level improvements in more detail.
- Assess long-term or emerging transportation needs.
- Coordinate with partner agencies on shared facilities.
- Seek public input to help identify preferred solutions.

By identifying needs early, the City can position itself to respond proactively as conditions evolve.

Safety Projects

The project list includes two safety projects, which are derived directly from the City's adopted Transportation Safety Action Plan. These projects reflect a data-driven approach to addressing locations with elevated crash risk and are consistent with the City's Vision Zero and Safe System policies.

Consistent with the project scope, these safety improvements were not re-analyzed or re-prioritized as part of this effort. Instead, they are incorporated to ensure that the Transportation Element remains aligned with the City's broader safety initiatives.

These projects typically focus on targeted interventions at specific locations or corridors to reduce crash frequency and severity and improve overall system safety.

Freight Project

The project list includes two safety projects, which are derived directly from the City's adopted Transportation Safety Action Plan. These projects reflect a data-driven approach to addressing locations with elevated crash risk and are consistent with the City's Vision Zero and Safe System policies.

Funding

Preservation

Although this Comprehensive Plan identifies numerous projects that expand or improve the transportation system, available funding must also support preservation of the City's existing infrastructure. Pavement maintenance, bridge rehabilitation, traffic signals, sidewalks, ADA improvements, and other preservation needs compete for many of the same funding sources used for new transportation projects. As a result, project implementation will continue to balance investments in system expansion with maintaining existing transportation assets in a state of good repair.

State and Federal Grants

State and federal funding programs represent an important source of funding for larger transportation projects. These funds are typically competitive and may be limited to specific project types or eligibility criteria.

Common grant programs may include:

- State transportation funding programs administered through the Washington Department of Transportation (WSDOT).
- Federal funding programs administered through the Federal Highway Administration (FHWA) or other agencies.
- Regional funding opportunities through the Walla Walla Valley Metropolitan Planning Organization (WWVMPO).

State and federal grants are often used to fund:

- Major capital improvements.
- Bridge replacement projects.
- Multimodal infrastructure projects.
- Safety improvements.

These funding sources typically require a local match and are not guaranteed, which introduces uncertainty into long-range planning. However, they are essential for advancing higher-cost projects that exceed the City's local funding capacity.

Estimated Future Funding Levels

Future funding levels through to 2045 were estimated through discussion with City of Walla Walla staff and are summarized in Table 25. REET and IRRP were assumed to remain flat over the 20-year period, while a 1% annual escalation was applied to TBD and grant funds.

Table 25. 20-year Transportation Funding Estimates

Revenue Source	Funding Restrictions	Estimated Through 2045
Real Estate Excise Tax (REET)	Must be used on capital projects	$13,000,000
Transportation Benefit District (TBD)	Can only be used towards projects identified on the citizen's TBD priority project list	$44,000,000
Infrastructure Repair and Replacement Program (IRRP)	Must be used on streets determined to have failing water, sewer, and street infrastructure	$20,000,000
State and Federal Grants	Varies	$88,000,000
	Total:	**$165,000,000***

**estimate to the nearest million*

Project Cost Estimation

Planning-level cost estimates were developed for each of the proposed projects. The full list of projects is available in Appendix XII. 20-Year Funding Forecast. Table 26 summarizes the total number and cost of projects by project type.

Table 26. Proposed Projects- Total Cost Estimate

Project Type	Number of Projects	Project Cost Estimates
Multimodal	54	$332.7 million
Bridge	9	$39 million
New Roadway	3	$36 million
Intersection	22	$35.8 million
Safety	2	$3.2 million
Freight	1	$500,000
Future Study	3	$240,000
Total	**94**	**$447,000,000***

**estimate to the nearest million*

Prioritized Project List

The Prioritized (financially constrained) Project List identifies the highest priority projects that are expected to provide the greatest benefit while remaining reasonably achievable within anticipated funding available through the 2045 planning horizon. Projects were evaluated based on their consistency with the Transportation Element goals and policies, transportation needs, implementation considerations, estimated costs, anticipated development contributions, and available funding. The resulting prioritization is intended to guide future capital programming and grant applications and may be updated over time as conditions, funding opportunities, and community priorities evolve.

Full Project List

The full project list serves as planning guidance for future transportation investments and identifies projects that may be pursued as funding opportunities arise. The following information is provided for each project:

Project ID: Each project is given a Project ID number according to the project type (MM-XX for Multimodal, INT-XX for Intersection, and so on)

Project Name: The location of the project

Project Type: The type of project

Evaluation Rating: The evaluation rating given to the project based on how it achieves the City's established Goals and Policies.

Cost Estimate: Planning-level cost estimate to construct or implement the project

Estimated Costs Borne by Development: Total costs estimated to be paid for by private funds as part of development

Development Comment: Notes related to development taking place along project extent

Estimate Costs Borne by City: Estimates costs that can be expected to be borne by the City after development costs are subtracted

In 2026-2031 CFP: Whether the project is included in the 2026-2031 CFP

Sponsoring Agency(ies): The expected primary source of planning and funding for implementation purposes, although such designations do not create any obligation for funding.

Prioritized Project: Whether the project is part of the Prioritized Project list, or is only part of the broader full project list

Estimated Prioritized Project Expenditures: This column totals the prioritized projects; the City has $165,000,000 for prioritized projects through the 2045 plan horizon

Description: A short explanation of the project's scope and relevant information

2027-2032 Capital Facilities Plan Projects

Project List

The Project List identifies the projects that could be constructed with anticipated transportation funding through 2045. Developing this list establishes reasonable expectations for planning purposes but does not commit the City to constructing them, nor does it limit the City to constructing those projects first. The list is derived from the Transportation Element Project List. Note that all 2026-2031 CFP projects were included in the Project List.

Table 27. Project List

Project	Project Name	Project Type	Project Total Estimated Cost	Estimated Cost to City *(Subtracting Estimated Costs Borne By Development)*
MM-35	Clinton Street/Highway 12 Interchange	Multimodal	$75,000,000	$4,000,000
MM-33	Melrose Street	Multimodal	$8,350,000	$7,100,000
MM-32	Electric Avenue	Multimodal	$7,900,000	$0
MM-30	Clinton Street	Multimodal	$8,650,000	$8,045,000
MM-39	Chase Avenue Reconstruction	Multimodal	$5,900,000	$5,900,000
INT-15	Wilbur Avenue/Highway 12 Intersection Improvements	Intersection	$2,500,000	$2,500,000
MM-04	Isaacs Avenue	Multimodal	$51,000,000	$12,750,000
MM-10	Plaza Way	Multimodal	$5,300,000	$5,300,000
MM-34	Orchard Street	Multimodal	$2,500,000	$2,500,000
MM-14	Alder Street - Roosevelt to Brock IRRP	Multimodal	$5,250,000	$5,250,000
INT-22	9th Avenue/Orchard Street	Intersection	$4,250,000	$4,250,000
MM-45	Park Street Bike and Pedestrian Improvements	Multimodal	$2,700,000	$2,700,000
MM-38	Village Way Improvements	Multimodal	$2,150,000	$1,955,000

Project	Project Name	Project Type	Project Total Estimated Cost	Estimated Cost to City *(Subtracting Estimated Costs Borne By Development)*
MM-46	Pine Street Sidewalk Infill	Multimodal	$1,600,000	$1,600,000
MM-53	Tietan Street Sidewalks - 4th to Plaza	Multimodal	$1,800,000	$1,350,000
MM-11	3rd Avenue	Multimodal	$600,000	$100,000
MM-19	Fern Avenue	Multimodal	$4,650,000	$4,650,000
MM-36	Wilbur Avenue	Multimodal	$3,700,000	$3,700,000
INT-06	9th Avenue/Main Street	Intersection	$1,650,000	$1,650,000
MM-09	Offner Road	Multimodal	$400,000	$400,000
MM-17	Cottonwood Road Bicycle and Pedestrian Facilities	Multimodal	$650,000	$325,000
INT-05	9th Avenue/Emma Street	Intersection	$320,000	$320,000
FS-03	Melrose Street Corridor Study	Future Study	$150,000	$150,000
MM-03	Poplar Street	Multimodal	$26,600,000	$26,600,000
MM-02	Poplar Street	Multimodal	$15,000,000	$15,000,000
INT-08	9th Avenue/Poplar Street	Intersection	$2,800,000	$2,800,000
INT-09	9th Avenue/Chestnut Street	Intersection	$1,700,000	$1,700,000
INT-07	9th Avenue/Alder Street	Intersection	$1,650,000	$1,650,000
MM-44	Bridge Street Sidewalk Replacement	Multimodal	$1,050,000	$1,050,000
INT-19	Main Street/Colville Street	Intersection	$1,000,000	$1,000,000
INT-20	Main Street/Spokane Street	Intersection	$1,000,000	$1,000,000
MM-50	DeSales School Zone Safety Enhancements	Multimodal	$400,000	$400,000

Project	Project Name	Project Type	Project Total Estimated Cost	Estimated Cost to City *(Subtracting Estimated Costs Borne By Development)*
MM-47	Odd Fellows Home Area - Boyer Avenue - Clinton Avenue	Multimodal	$350,000	$350,000
MM-49	Garrison Village Way at Myra Road Intersection Improvements	Multimodal	$750,000	$0
NR-03	Futura Road Extension	New Roadway	$5,000,000	$0
MM-08	School Avenue	Multimodal	$13,100,000	$13,100,000
INT-02	Bryant Avenue/Howard Street	Intersection	$3,200,000	$3,200,000
INT-24	Fern Avenue/Abbott Road	Intersection	$3,200,000	$2,125,000
INT-11	2nd Avenue/Tietan Street	Intersection	$1,000,000	$1,000,000
INT-12	4th Avenue/Alder Street	Intersection	$1,000,000	$1,000,000
INT-13	5th Avenue/Main Street	Intersection	$1,000,000	$1,000,000
INT-17	Main Street/3rd Avenue	Intersection	$1,000,000	$1,000,000
INT-18	Main Street/4th Avenue	Intersection	$1,000,000	$1,000,000
MM-20	Highway 12 Trail	Multimodal	$550,000	$550,000
MM-28	Avery Street	Multimodal	$1,000,000	$0
INT-16	Reser/Howard/Cottonwood/Prospect Intersection	Intersection	$3,850,000	$1,925,000
INT-01	Alder Street/Division Street	Intersection	$1,300,000	$1,300,000
MM-12	1st Avenue/Main Street	Multimodal	$1,650,000	$1,650,000
BR-01	6th Avenue/Mill Creek	Bridge	$7,300,000	$1,460,000
BR-02	4th Avenue at Mill Creek	Bridge	$5,550,000	$1,110,000
BR-07	3rd Avenue/Garrison Creek	Bridge	$3,250,000	$3,250,000

Project	Project Name	Project Type	Project Total Estimated Cost	Estimated Cost to City *(Subtracting Estimated Costs Borne By Development)*
MM-21	Main/Palouse/Boyer	Multimodal	$700,000	$700,000
MM-23	Mill Creek Bike Path Repaving	Multimodal	$200,000	$200,000
MM-05	Harbert Road	Multimodal	$11,900,000	$0
MM-52	Fern Avenue Pedestrian Bridge	Multimodal	$750,000	$750,000
FS-02	Main Street	Future Study	$50,000	$50,000
MM-40	Alder and Main Re-striping	Multimodal	$200,000	$200,000
	Total (To nearest million $)		**$317,000,000**	**$165,000,000**



Transportation Standards Summary

This section documents the City's functional classification system, designated freight routes, and intersection operation standards. Additional transportation-related standards, including desired cross-sections, minimum access spacing, pedestrian crossing improvements, and lighting requirements, are provided in the City of Walla Walla Transportation Impact Analysis Guidelines and municipal code.

Functional Classification

A street functional classification system is an important tool for managing the transportation system. It establishes a hierarchy of roads based on the balance between mobility and access, helps guide roadway design, supports access management, and provides a framework for identifying future transportation improvements.

The City of Walla Walla's street network is organized into four functional classifications:

- Major Arterials connect major activity centers and the interstate system. They typically include four or more travel lanes, bicycle lanes, and limited access, with a preference for connections to minor arterials.
- Minor Arterials provide direct connections across the city and generally avoid penetrating identifiable neighborhoods. They typically include two to three travel lanes, bicycle lanes, and access to larger developed areas and neighborhoods.

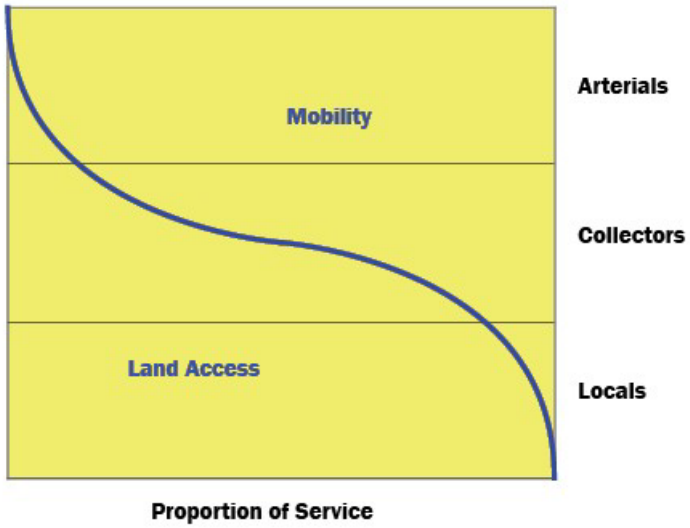


Figure 38. Functional Class Hierarchy

- Collectors support circulation within residential, commercial, and industrial areas, channeling traffic from neighborhoods to the arterial network. They generally include two to three travel lanes, bicycle lanes, optional on-street parking, and some access restrictions.
- Local Streets serve residential, commercial, and industrial areas while discouraging through traffic. They allow on-street parking and provide access to every parcel for all modes.

Functional classification provides a framework for managing the City's transportation system and supports related standards discussed in the following sections, including connectivity, spacing, freight routes, cross-sections, and access management.

Freight Routes

The City of Walla Walla's freight routes connect industrial and commercial areas with the regional and statewide transportation network. Maintaining and improving these routes remains important for economic vitality, while also recognizing the need to protect neighborhoods and enhance safety for people walking and bicycling along or across freight corridors. The updated freight route map, Figure 39, and related discussion reflect current City and regional freight planning and the updated project list.

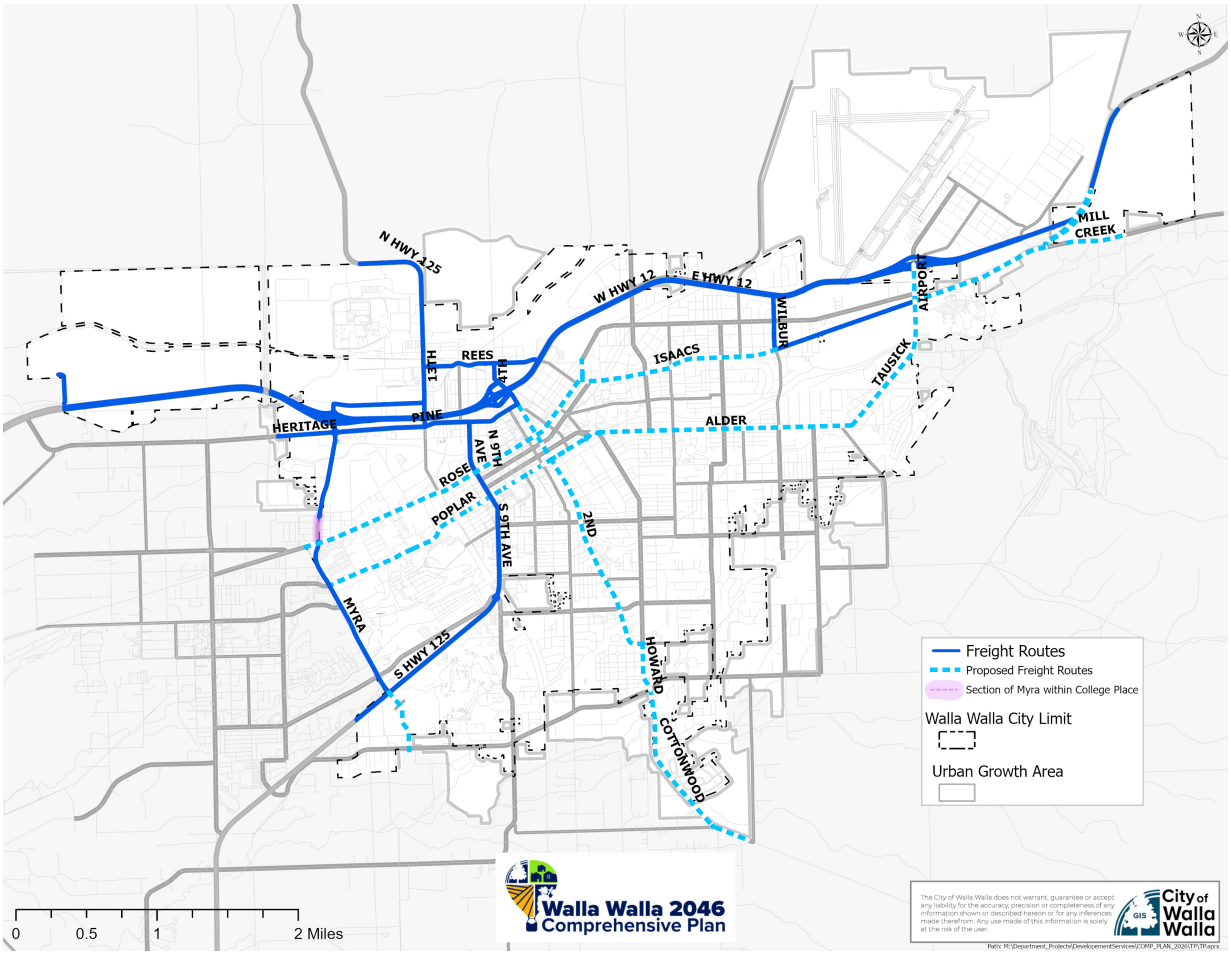


Figure 39. Updated Freight Route Map.

Intersection Operations

Intersection operational standards for long-range planning and development review are established in the City's Transportation Impact Analysis (TIA) Guidelines. These guidelines use Level of Service (LOS) as the primary performance measure, based on Highway Capacity Manual calculations of delay, with thresholds that differ for signalized and unsignalized intersections.

In addition to LOS, the City applies a volume-to-capacity (v/c) standard to provide additional context in cases where LOS alone may not fully reflect operating conditions, such as at all-way stop intersections where a single approach may exceed capacity even if overall delay meets the standard.

The recommended standards are shown in Table 28. The City requires a higher level of service for streets where capacity is greater in quantity and/or importance, such as major arterials and freight routes.

Table 28. City of Walla Walla Operational Standards

Facility	Minimum LOS	Maximum v/c
Myra Road, Poplar Street, Rose Street, 2nd Avenue (excluding CBD), Isaacs Avenue, Tietan Street, Alder Street, Tausick Way, and Mill Creek Road	D	0.90
All other Facilities	E	0.95

Additional Transportation Standards

Additional transportation-related standards are addressed through other City documents and regulations, including:

- Street design standards
- Street lighting standards
- Access spacing standards
- Traffic Impact Analysis standards
- ADA implementation requirements
- Development frontage and multimodal improvement requirements

These standards work together with the Transportation Element to ensure that transportation facilities are improved in a way that is consistent with City policy and supportive of long-term system performance.

Multimodal Level of Service (MMLOS)

Pursuant to RCW 36.70A.070(6), the City shall evaluate transportation system performance using Multimodal Level of Service (MMLOS) standards that consider the needs of pedestrians, bicyclists, transit users, freight movement, and motor vehicle travel.

The City recognizes that transportation system performance should be measured by the ability of people to safely and efficiently access destinations using a variety of travel modes, rather than solely by vehicle delay. MMLOS standards shall serve as a gauge to evaluate transportation system performance and progress toward community goals related to safety, accessibility, mobility, environmental justice, and transportation choice.

For active transportation facilities, the City's preferred framework for evaluating bicycle and pedestrian comfort and connectivity is Level of Traffic Stress (LTS). LTS ratings range from 1 (lowest stress) to 4 (highest stress). The current WSDOT guidance is LTS 2 or better on designated bicycle and pedestrian corridors, providing facilities that are comfortable for most users, including youth, older adults, and less experienced bicyclists.

The City shall continue coordinating with the Walla Walla Valley MPO, WSDOT, Valley Transit, and other transportation partners to develop and refine MMLOS performance measures for locally owned arterials, transit services, active transportation facilities, freight routes, and state facilities. As statewide MMLOS guidance evolves, the City may update its MMLOS standards and performance measures to maintain consistency with state requirements and best practices.



Goals and Policies

T Goal 1: Walla Walla provides a safe and secure transportation system for residents.

- T 1.1: Improve safety for walking, biking, transit, motor vehicles, and freight at high collision locations identified through data-driven safety analysis.
- T 1.2: Enhance existing and promote new crossings for pedestrians and bicyclists where appropriate.
- T 1.3: Provide facilities for all modes of transportation.
- T 1.4: Look for opportunities to increase separation between pedestrian and bicycle facilities as part of roadway improvements when deemed appropriate by the City Engineer.
- T 1.5: Seek opportunities to improve safety for all road users.

T Goal 2: The transportation system supports the movement of goods and services to boost and support the economy.

- T 2.1: Support safe, coordinated, and efficient truck-freight corridors that maintain connections between land uses that generate or receive significant freight trips and the state's strategic freight corridors.
- T 2.2: Seek stable and diverse revenue sources to meet the need for transportation investments in the City.
- T 2.3: Identify transportation improvements that will support and enhance access to and from major employment areas, the Walla Walla Regional Airport, and local tourism destinations.
- T 2.4: Identify transportation improvements needed to support future development in Urban Growth Areas.

T Goal 3: The transportation system is designed and maintained to provide the predictable and reliable movement of all goods, services, and people.

- T 3.1: Implement new or improved transportation connections to enhance efficiency and reliability.
- T 3.2: Develop new and preserve existing arterial and collector corridors to provide alternative routes to US 12 and SR 125 for local traffic.
- T 3.3: Improve travel reliability, safety, and efficiency with system management solutions (e.g., coordinated traffic signal timing).

- T 3.4: Manage roadway access to support mobility and safety. To meet adopted access spacing standards, or where necessary to alleviate safety or traffic operations concerns, require consolidated and joint access as part of development.
- T 3.5: Apply transportation system management and demand management strategies, such as traffic signal coordination, ride sharing, parking management, and travel options programs to reduce dependance on motor vehicles.

T Goal 4: Walla Walla's transportation system connects neighborhoods, parks, schools, employment centers, and retail areas for all users.

- T 4.1: Implement Complete Streets projects where feasible and consider Target Zero/Vision Zero and Context Sensitive Solutions to improve the transportation experience for all modes of transportation.
- T 4.2: Require developments evaluate and provide multi-modal improvements to ensure access and connectivity is provided for all modes of travel.
- T 4.3: Improve multimodal connections to community facilities and amenities (e.g., neighborhoods, parks, schools).
- T 4.4: Coordinate with transit providers on coverage, quality, and frequency of services.
- T 4.5: Integrate multimodal system performance metrics in planning and project prioritization to ensure a connected network for all travel modes.
- T 4.6: For multimodal levels of service, consider frequency, presence, and span of services to evaluate system Level of Service, needs, and deficiencies.
- T 4.7: Work with the Washington State Department of Transportation and other agencies to identify cross-jurisdictional improvements needed to meet multimodal connectivity and safety.

T Goal 5: The City of Walla Walla seeks to maintain, preserve, and extend the life of transportation infrastructure for current and future residents.

- T 5.1: Inventory and prioritize preservation of existing transportation infrastructure (roads, bridges, traffic control devices, lighting, etc.).
- T 5.2: Maintain the existing transportation infrastructure to preserve the intended function and extend the useful life.
- T 5.3: Modify design standards where applicable to build cost effective transportation facilities.
- T 5.4: Require a Traffic Impact Analysis where additional information is needed regarding the transportation impacts of a development proposal on the existing and planned transportation system. Require mitigation as needed to protect and improve transportation facilities in the City.

- T 5.5: When probable funding is insufficient to meet identified needs of the transportation system, consider additional funding sources or reassess land use assumptions or Level of Service (LOS) standards.

T Goal 6: The transportation system is designed to enhance the livability of the City.

- T 6.1: Create a well-connected network of streets, paths, and transit service to provide active transportation options.
- T 6.2: Encourage end-of-trip facilities, such as bicycle parking and changing/showering facilities to support active transportation.
- T 6.3: Support and encourage active transportation such as walking, bicycling, and transit use.
- T 6.4: Require development to provide street frontage improvements consistent with plan and code requirements, either through construction of the project or through deferral or a fee-in-lieu payment, as permitted by adopted code.
- T 6.5: Promote and implement streetscapes that are aesthetically pleasing, safe, and comfortable to residents, visitors, businesses, and property owners.
- T 6.6: Where determined to be needed by the City Engineer, implement neighborhood traffic management using techniques such as curb extensions, median islands, diverters, speed humps, and traffic circles to reduce traffic speeds and enhance safety.
- T 6.7: Identify and remove accessibility barriers in transportation facilities.
- T 6.8: Incorporate Complete Streets principles into design and reconstruction projects to enhance safety and accessibility for all users.

T Goal 7: Transportation facilities and services are planned, funded, and constructed concurrently with development, maintaining adopted multimodal performance.

- T 7.1: Utilize multimodal performance standards for locally owned arterials, transit routes, and active transportation facilities that reflect equitable access.
- T 7.2: As needed, coordinate concurrency analysis methods and standards with WSDOT and other agencies to ensure consistency for state and regional facilities.
- T 7.3: Prioritize safety in developing multimodal transportation alternatives.



Policy Connections

The Transportation Element is closely connected to other parts of the Comprehensive Plan and to related City planning documents. Key connections include:

- **The Land Use Element**, which identifies future growth areas and development patterns that shape transportation demand.
- **The Capital Facilities and Utilities Element**, which helps coordinate transportation improvements with infrastructure investment.
- **The Economic Development Element**, which identifies employment, freight, and access needs.
- **The Safety Action Plan and Local Road Safety Plan**, which guides safety-focused project identification.

This coordination helps ensure that transportation planning supports broader City objectives and that future land use, capital investment, and transportation decision-making remain aligned.

Translating Policy into Action

This section connects the Transportation Element's policy direction to specific implementation tools, plans, and programs. Table 29 shows implementation actions the City uses to move from policy to action through ongoing updates, project programming, development review, and interagency coordination.

Table 29. Transportation Policy Implementation Timeline and Responsibility

Implementation Action	Timeline	Responsibility
6-Year Transportation Improvement Plan (TIP)	Annually Updated	Engineering Division
6-Year Capital Facilities Plan (CFP)	Annually Updated	All City Departments
Development Regulation Guide	1 Year	Community Development



Capital Facilities and Utilities



Introduction

The purpose of this Element is to ensure that the City of Walla Walla has adequate facilities and utilities to serve anticipated growth. Policies in the Capital Facilities and Utilities Element address critical issues such as sustainability, resiliency, urban design, and equitable facility siting.

This Element provides a plan to ensure city facilities and utilities provide acceptable levels of service and a plan for how to fund the maintenance, expansion, and construction of new facilities and utilities. Capital facilities are public assets and infrastructure like roadways, buildings, parks, and utilities such as water and stormwater systems. Capital facilities and utilities included in this plan are operated by the City of Walla Walla, other governmental agencies, (such as the School District) and private providers. City-owned facilities include drinking water, wastewater, stormwater, solid waste, parks and recreation, fire and emergency medical services (EMS), police, library, and municipal buildings. Non-City-owned facilities are public schools, electricity, natural gas, and telecommunications.

This Element includes information about current capital facilities and utilities. It also identifies where to find detailed system plans with inventories, projected future needs, Level of Service standards, and goals and policies.

Today and Tomorrow

This section contains information on Walla Walla's facilities and public services available today, along with anticipated future needs.

Population Projection

Understanding future needs for capital facilities and utilities requires estimating future population growth. Walla Walla is using population forecasted through 2046.

Table 30. Population in the City of Walla Walla by Year

Year	Population
2025	34,580
2030	35,810
2035	37,080
2040	38,392
2046	39,884



City-Owned Services

The City of Walla Walla provides infrastructure for drinking water, wastewater, stormwater, solid waste, fire and EMS, police, streets, parks and recreation, the library, and municipal services. (Streets are covered under the Transportation Element.)

Many city-owned capital facility systems are governed by a dedicated functional plan, including water, wastewater, and stormwater. These plans contain detailed inventories of existing facilities and infrastructure, as well as descriptions of planned improvements.

On the following page is a summary of major city facilities and their functional plans.

Table 31. City-Owned Services, Facilities, and Functional Plans

Service	Facilities	Functional Plan
Water	Infrastructure for providing drinking water.	Water System Plan (2020); update scheduled for 2028. Water System Plans must meet the requirements of WAC 246-290-100.
Wastewater Treatment	Facilities to treat wastewater.	2015 General Sewer Plan Update and Addendum No. 1 to the 2015 General Sewer Plan Update (2021). An updated Facility Plan will be completed in 2026. General Sewer Plans must meet the requirements of WAC 173-240-050.
Stormwater	Infrastructure to convey and treat stormwater.	Comprehensive Stormwater Management Plan (2015).
Solid Waste	Facilities to collect and dispose of residential and other solid waste.	Walla Walla County Comprehensive Solid and Hazardous Waste Management Plan (2024); Landfill Facility Master Plan (2023). Plan must meet the requirements of RCW 70A.205.045.
Sewer Collection	Infrastructure for conveying sewage	2015 General Sewer Plan Update and Addendum No. 1 to the 2015 General Sewer Plan Update (2021). An updated General Sewer Plan will be completed in 2026. General Sewer Plans must meet the requirements of WAC 173-240-050.
Fire & EMS	Fire stations and emergency service facilities.	N/A
Police	Headquarters building.	N/A
Parks and Recreation	Parks, trails, recreation facilities.	Walla Walla Parks and Recreation
City-Owned Facilities	Capital Facilities and Infrastructure	Capital Facilities Plan that includes level of service standards, concurrency, and capital structures, improvements, and equipment.
Library	Library Building.	Library Expansion and Renovation Master Plan (2024).





Water

The City of Walla Walla operates a Group A community water system, providing service to approximately 35,000 people through 11,800 connections, with 10,222 connections being residential. The City's Mill Creek surface water supply is classified as an unfiltered supply, which originates from the protected Mill Creek Watershed and provides 85 to 90 percent of the City's water.

The City also operates seven municipal wells which are primarily used during summer low-flow periods, high-turbidity-water-quality events affecting Mill Creek, and emergencies. The water right from Mill Creek allows for a diversion of up to 18.1 million Gallons per Day (MGD). The total instantaneous water right from the municipal wells is 26.46 MGD. Even if Mill Creek is temporarily unavailable, the City can meet projected Maximum Day Demand (MDD) through the 20-year planning horizon.

The Mill Creek Water Treatment Plant (WTP) utilizes UV Light for primary disinfection, and chlorination to maintain distribution system residual disinfection. The WTP has a capacity of 24 MGD and produces roughly four billion gallons of water per year.

The City's Comprehensive Water System Plan (WSP) update was prepared by Murray Smith and adopted by the City Council in March 2020. The WSP is a guiding document for future water system improvements and documents key information and recommendations for operational decisions. The WSP updated the framework for the City's water service through 2038 and the capital improvement plan to 2028. The City's water facilities include water storage, water treatment, pump stations, and the distribution system, and are described in the 2020 Water System Plan Update and 2021 Well Master Plan.

There are approximately 180 miles of water mains in the distribution system (excluding the 14.5 miles of raw water pipeline), 88 miles of which are considered at risk of failure due to age, condition, and material type. Forty-three of these miles were eligible for the City's Infrastructure Repair and Replacement Plan (IRRP) when established by the City Council and funded by a six-year utility rate increase in the 2017–2022 Capital Facilities Plan. As of 2025, the IRRP has completed 28 projects, which replaced 14.2 miles of pipe.

The City began the Aquifer Storage and Recovery (ASR) Plan in the 1990s and received a permit from the Washington State Department of Ecology in 2016 to draw, treat, and store water during times of surplus. This water is used when surface water is unavailable. The City operates two ASR wells, which help to meet water demand by providing a consistent supply of water year-round. The City hopes to expand ASR capabilities further in the future.

Future Needs

The 2020 Water System Plan includes a summary of past water use and projections for future water demand. Future projections were based on population growth estimates and accounted for intertie agreements, water losses, increased demand, and a reduction in demand from the water conservation program.

Population projections in the Water System Plan were based on a 2016 service population of 34,754 with an estimated 1.0 percent compounded population growth rate. The Plan showed water demand would be relatively steady through 2028 because of low population growth and a significant reduction in water system losses resulting from the City's efforts associated with the Infrastructure Repair and Replacement Program (IRRP), water capital projects, and operations.

Table 32. Forecast Water Use (With Conservation) by Millions of Gallons per Day

Service	2028	2038	2068
Population	39,162	43,259	58,306
Average Daily Demand (ADD)	8.6	9.4	12.7
Maximum Daily Demand (MDD)	18.4	18.4	27.2

The Water System Plan Update was based on a slightly higher rate of growth than the Comprehensive Plan, projecting a larger population in 2038 than the Comprehensive Plan projects for 2046 (43,259 compared to 39,884). Thus, the 2038 water demand projections account for a higher population than is currently projected for 2046.

Funding for water projects for the next six years is shown in the 2026-2031 Capital Facilities Plan. Most of the funding comes from rate revenues, grants, and/or loans. In 2026, the City will review rates to determine if revenues can cover projected infrastructure needs.

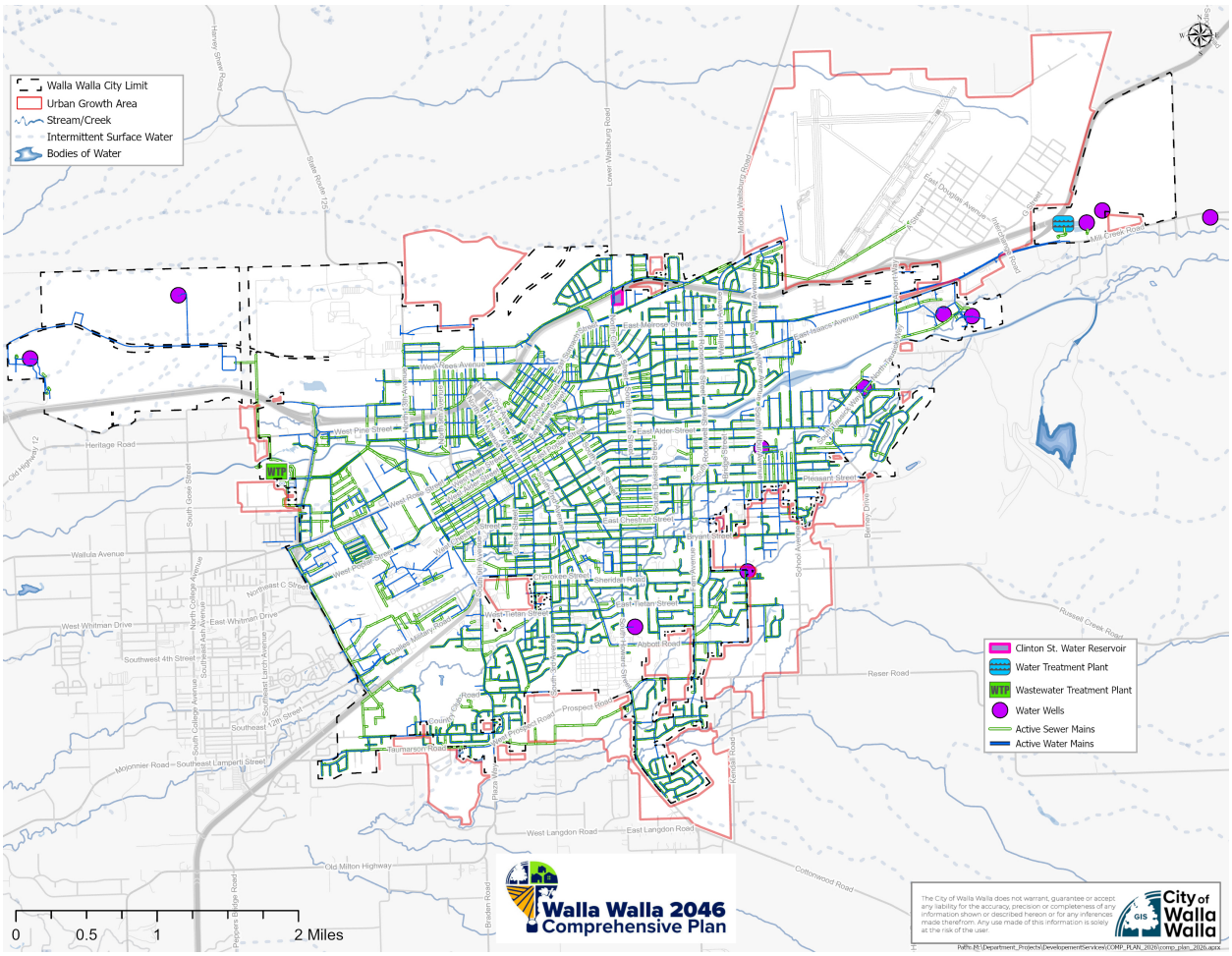


Figure 40. Water Mains, Wells, and Sewers Map

Wastewater

The City adopted a General Sewer Plan Update in 2015 and an amendment in 2021, both prepared by J-U-B Engineers. The City is currently updating the General Sewer Plan and Facility Plan (for the wastewater treatment plant, WWTP), which will be finalized in 2026.

The City of Walla Walla operates an advanced secondary domestic wastewater treatment plant, which provides Class A effluent. The facility is permitted by the Washington State Department of Ecology. A 1927 court-ordered water rights agreement obligates the City to provide reclaimed water to two irrigation districts, Gose and Blalock. Both irrigation districts provide water for food crop production, and therefore, the facility required an upgrade to meet Class A reclaimed water standards.

Sewage generated in the City is collected and transported to the treatment plant via gravity service laterals, collection sewers, five lift stations, including Myra Road, Spring Terrace, Cottonwood, Fairway, and Valley Acres, and force mains. The system contains approximately 146 miles of sewer mains and 3,200 manholes. Funding for wastewater projects is listed in the General Sewer Plan Update and in the 2026-2031 Capital Facilities Plan.



Future Needs

The City is in the process of updating the General Sewer Plan, and during that update, the consultant has found that the Wastewater Treatment Plant has adequate capacity for the 20-year planning horizon, but there is a need for renewal and replacement of equipment that is nearing the end of its useful life.

Planning for both near-term and long-term replacement needs of the wastewater system is ongoing for both the capacity and replacement needs of the wastewater system. The 2026–2031 Capital Facilities Plan shows capital projects for Wastewater Utility over the next six years. Much of the funding comes from the wastewater fund, but some money comes from loans. In 2026, the City will review rates to determine if revenues are able to cover projected infrastructure needs.

Stormwater

Stormwater infrastructure includes storm drains, inlets, pipes, swales, ponds, and other structures to collect, move, treat, and dispose of rainfall and snowmelt. The City designs and maintains its stormwater facilities to prevent flooding and to protect water quality. A Comprehensive Stormwater Management Plan was prepared for the City by URS in 2015.

The City's Municipal Separate Storm Sewer System (MS4) serves a population of approximately 34,000 people within approximately 13.2 square miles (650 impervious acres).

The system consists of approximately 800 manholes, 2,400 catch basins, 400 drywells, 50 stormwater management facilities, 50 miles of storm pipe, 36 miles of open conveyance channels, 200 outfalls, and 300 culverts.

At this time, the City has no plans to construct additional stormwater facilities. Stormwater management for new development is handled on a site-by-site basis. New regulations require on-site stormwater management whenever feasible. The Stormwater Management Plan addresses service standards for future development.

The 2026-2031 Capital Facilities Plan identifies capital projects funded through rates and/or grants.

Solid Waste

The City has adopted the Walla Walla County Comprehensive Solid and Hazardous Waste Management Plan, which guides long-term solid waste management in the region through 2029. The City has also adopted (by reference) the 2023 Sudbury Road Landfill Facility Master Plan, which guides the capital facilities planning for solid waste handling for the next 20 years.

Refuse from Walla Walla County is primarily disposed of at the City-owned Sudbury Road Landfill, with a smaller amount (22% in 2021) at the Finley Buttes Landfill in Oregon. In 2025, Sudbury Landfill received approximately 64,000 tons of waste. The Sudbury Landfill facilities include a household hazardous waste facility, composting facility, and municipal solid waste handling operations.

Future Needs

The Solid Waste Management Plan projects waste generation for the period 2020-2043, based on Washington State Office of Financial Management population projections, past per capita disposal and recycling amounts, and estimated diversion rates. The Solid Waste Management Plan projects approximately 55,500 tons of disposed waste per year with increased recycling and organics diversion in the year 2043.

According to an evaluation in 2018, the landfill has potential capacity to last at least another 240 years. Capital projects for the Solid Waste utility for the next six years are shown in the 2026-2031 Capital Facilities Plan. Landfill funds are the primary source of funding, with some grants and loans.



Fire and Emergency Medical Services (EMS)

The Walla Walla Fire Department (WWFD) endeavors to minimize the loss of life and property, pain and suffering endured by the residents of the City of Walla Walla, and the surrounding areas because of accidents or natural disasters.

The Department operates two fire stations with a full-time staff of 56 employees, including 45-line firefighters, many of whom are cross-trained as firefighters and paramedics.

The WWFD provides comprehensive all-hazards emergency services, including fire suppression, advanced and basic life support emergency medical services, fire prevention and public education, training, and specialized technical rescue capabilities. These technical response specialties include hazardous materials response, high-angle rope rescue, confined space rescue, and swift water rescue. WWFD delivers these services throughout the City of Walla Walla and supports surrounding jurisdictions through established mutual aid and interlocal agreements. The department provides Advanced Life Support (ALS) services to the City of College Place and to multiple Walla Walla County fire agencies, including Fire District 2, North County Fire, Fire District 8, and Fire District 6. Collectively, WWFD's service and response areas encompass approximately 1,200 square miles

When utilizing the county population of approximately 62,068 residents, the Walla Walla Fire Department operates at .72 responders per 1,000 population. Utilizing the City of Walla Walla's 2025 population of 34,580, the Department operates at 1.36 responders per 1,000 population.

CARES Program

A division of the Walla Walla Fire Department, the CARES team, provides community outreach and assistance to residents to improve population health and advance injury and illness prevention within our community. Our program identifies members of the community who use the 911 system or emergency department for low acuity assistance calls (calls that are nonemergency or nonurgent) and connects them to their primary care providers, other health care professionals, low-cost medication programs, and other social services.

We aim to reduce hospital readmissions and emergency room visits by navigating resources for chronic health and social needs. We provide nonemergency contact information to provide an alternative resource to the 911 system.

The City of Walla Walla has two fire stations: Fire Station No.1 is located at 200 S. 12th Ave., and Fire Station No.2 is located at 170 N. Wilbur St. The Department also has a drill and training facility at 300 Cayuse St. WWFD operates several pieces of specialized equipment, including engines, a ladder truck, and ambulances. A full list of WWFD facilities is included in the 2026-2031 Capital Facilities Plan.

Future Needs

Today, WWFD can respond to 90 percent of all reported fire and EMS emergencies in the city limits, within 5 minutes and 20 seconds. A response capability that meets the National Fire Protection Association Standard 1710. While the Department strives to meet NFPA standards and recommendations, it should be noted that this is not a formally adopted level of service by the Department. To maintain our current effective level of service based on forecasted population projections, an additional eight responders would be needed by 2046.

Population growth through annexation of the Urban Growth Area (UGA) south of the city may require new facilities to ensure response capabilities are maintained. The 2026-2031 Capital Facilities Plan identifies a new fire station in the south end of the city. Future road connections, such as the Myra Road extension or Wilbur Avenue connection, could also improve response times to the south.

The 2026-2031 Capital Facilities Plan identifies a number of repair, rehabilitation, and maintenance projects for fire and EMS facilities, in addition to the new fire station. These will be funded through the General Fund and through bonds.



Police

The Walla Walla Police Department (WWPD) maintains the quality of life in the community by providing a safe environment for residents through responding to calls for service, community policing, and other community-based efforts.

The WWPD has a Headquarters building at 54 East Moore Street, which was built in 2012, and a Police Evidence Storage Building north of the City Service Center. A full list of WWPD facilities is included in the City's 2026-2031 Capital Facilities Plan. There are currently 47 commissioned officers and 14 civilian employees. Based on the 2024 population of 33,901 for the City of Walla Walla, the department has 1.39 officers per 1,000 people.

Walla Walla Emergency Services Communications (WESCOM) provides emergency services communications in Walla Walla County. WWPD operates an enhanced 911 call center for all law enforcement, fire, and ambulance services in Walla Walla County, except Walla Walla County Fire District 5. WESCOM has 17 employees.



Future Needs

Calls for service to the WWPD fluctuated between 2019 and 2025, ranging from a low of 22,948 in 2023 to a high of 30,349 in 2019. As the population grows, the number of calls will grow. To maintain the current level of service, approximately eight new commissioned officers will be needed by 2046.

The WWPD Headquarters building was designed for 54 officers and 42 civilian staff. This should provide adequate space for future needs until 2046. However, as city limits expand, there may be a need for additional facilities to provide more efficient and timely service. The 2026-2031 Capital Facilities Plan anticipates the development of a satellite police station in conjunction with a south side Fire Station. This station would not be staffed full-time but would provide a workspace for officers assigned to that area. This is anticipated to be paid for with General Funds and/or bonds. The 2026-2031 Capital Facilities Plan also includes funding to support WESCOM operations, including maintenance and repair, new equipment, and a new dispatch center. Funding for these facilities is a shared WESCOM expense. The voters in August 2025 passed a two-tenths-of-one-percent sales tax to fund public safety/dispatch. Funding for WESCOM operations and capital expenses will come from this revenue beginning in 2027.



Parks and Recreation

Walla Walla has three categories of city parks: community parks, neighborhood parks, and mini parks. Community parks are the largest category, with a desirable size of 25 acres and a service area radius of two miles. There are four community parks that include a total of 325 acres. Neighborhood parks have a desirable size of 5-10 acres and a service area radius of a half mile. The city has seven of those, and they are a total of 72 acres. Lastly, mini parks are typically 1 acre or less and have a service area radius of under one-quarter mile; there are four total, and they cover an area of 2.2 acres.

The City also owns other park facilities, trails, and recreational facilities. This includes the Senior Center, a 15,000 square foot space at 720 Sprague Ave. serving primarily seniors but also providing programming for all ages, including a pottery studio. Other recreational facilities include an 18-hole golf course and a seasonal swimming pool.

An inventory of current park and recreation facilities and planned projects is included in the 2026-2031 Capital Facilities Plan. Funding for the projects over the next six years comes primarily from the General Fund, although other sources of funding include donations, loans, bonds, grants, and local funds. In June 2018, the City of Walla Walla published a comprehensive park and recreation plan, which goes into further detail on the future of parks and recreation in Walla Walla.

Future Needs

With approximately 600 acres of parkland for 34,580 people, the effective level of service for parks is currently 17.3 acres of parks per 1,000 people. The historic standard for the level of service for parks and open space is 10 acres per 1,000 people, but there are multiple accepted methods to calculate this, ranging from 2.1 acres to 9.3 acres per 1,000 people. This means Walla Walla exceeds all standards of service. To maintain this level of service, the projected demand for additional park space in 2046 would be approximately 92 acres.



Municipal Services

Walla Walla's City Hall is located at 15 N. 3rd Ave. and houses several government offices, including the City Manager's office, City Council Chambers, City Attorney's office, Human Resources, Support Services, Technology Services, and Finance. It has 22,170 square feet of general office space and houses 38 full-time employees. The Service Center is located at 55 E. Moore St. on an 8.7-acre site with seven buildings that total about 106,680 square feet. The Service Center is used by 81 full-time employees from Public Works, Fleet Services, and Community Development. The Parks and Recreation Department, with 24 full-time employees, is housed in the Veterans Memorial Golf Course facility, which occupies 16,468 square feet. The Sudbury Regional Landfill, located at 414 Landfill Road, houses 14 employees and consists of multiple structures totaling 10,468 square feet. The Mill Creek Water Treatment Plant, at 581 Mill Creek Road, is used by eight employees and consists of several buildings, totaling 29,764 square feet.

Future Needs

The latest space planning guidelines from the Washington State Department of Financial Management recommend a minimum standard of 79 square feet per resident user or full-time worker, and 40 square feet per person for shared spaces, such as workrooms. The total City office space square footage exceeds the recommended ratio for full-time workers. Remodeling or reprogramming existing spaces would improve efficiency and enhance the quality of the workspace.

The City has planned several upgrades, repairs, and rehabilitation projects for certain municipal facilities over the next six years, as shown in the 2026-2031 Capital Facilities Plan. Funds will come primarily from the General Fund, supplemented by grants, bonds, and loans.

Public Library

The Walla Walla Public Library provides Walla Walla residents with lifelong learning and community resources. The library is located at 238 East Alder Street and has 18,140 square feet of space. The level of service today is approximately 535 square feet per 1,000 residents. The library served an average of 400 people per day in 2024.

A full library renovation is planned for completion in 2027, which will reprogram the space and add 711 square feet, bringing the total to 18,851 square feet. The plan will address current building deficiencies and create flexibility as library service continues to evolve. After the renovation and addition, the library will have adequate space to serve the projected population to 2046.

Summary of Projected Demand for City-Provided Services

Table 33. Future Needs and Adopted Level of Service by Facility Type

Facility Type	Future Needs and Adopted Level of Service
Water	The City must provide sufficient supply to meet the projected Average Daily Water Demand and Maximum Daily Demand. The Comprehensive Water System Plan estimates that the current capacity of 24 MGD is enough to serve a population of 41,058. This exceeds the growth projection of 39,884 in 2046.
Wastewater	The General Sewer Plan estimates there is adequate capacity within the system until at least 2046.
Stormwater	Future needs are addressed on a site-by-site basis for new development.
Solid Waste	Sufficient capacity to meet disposal needs for 200 years.
Fire and EMS	Approximately eight new responders would be needed by 2046. Additional facilities are already being planned for the south area of the City in the 2026-2031 Capital Facilities Plan.
Police	Approximately eight new officers would be needed by 2046. The current facilities are adequate to meet this increased need.
Parks and Recreation	Approximately 92 acres of new parks would be needed by 2046. Additional details about the type of facilities and locations will be determined through Parks, Recreation, and Open Space Plan.
Public Library	The Library Expansion and Renovation Master Plan includes expansion of the library to 18,851 square feet. This should meet future needs for library service in 2046 and beyond.
Municipal Services	Facilities are adequate but may require remodeling, reprogramming, or upgrades.

Source: City of Walla Walla, 2025



Non-City Owned Services

There are several utilities and capital facilities that are not owned by the City, including schools, electricity, natural gas, telecommunications, and other services.

Public schools are operated by Walla Walla Public Schools, while electricity, natural gas, and telecommunications are provided by private companies.

The Washington Utilities and Transportation Commission (WUTC) oversees privately-owned utilities that offer service to the public in the State of Washington. Electric, gas, and wireline telecommunications companies are among the eight industries regulated by WUTC. Companies under the jurisdiction of the WUTC are required to provide service upon demand. Cellular phone companies and internet service providers are not regulated by the WUTC; cellular service is regulated by the Federal Communications Commission (FCC).

Schools

Walla Walla Public Schools served 5,490 students and employed a total of 782 staff members for the 2024-2025 school year. The student-to-teacher ratio was approximately 15.9:1. In June 2018, Walla Walla Public Schools approved a long-range Capital Facilities Plan, overseen by a Community Facilities Task Force. No updates have been made to the CFP since its adoption.

Electricity

Pacific Power, headquartered in Portland, Oregon, provides electric service to the City of Walla Walla and a majority of its Urban Growth Area. Pacific Power also obtains energy from a hydroelectric generation plant that is owned and operated by the City of Walla Walla. Pacific Power conducts annual studies of substation capacities to ensure that capacity exists to accommodate growth in demand.

Columbia Rural Electric Association distributes power purchased from the Bonneville Power Administration to serve its customers in the City of Walla Walla and Walla Walla UGA.

Natural Gas

Cascade Natural Gas Company is the primary natural gas provider for the City of Walla Walla and Walla Walla UGA. AmeriGas also provides natural gas for the area. Cascade Natural Gas can efficiently serve its approximately 300,000 customers across Washington and Oregon with 385 dedicated employees. The company anticipates being able to accommodate the projected population with existing facilities and pipeline extensions. Offices are located at 324 W. Rose Street in the City of Walla Walla.

Telecommunications

Telecommunications services include phone (landline and cellular), cable television, and internet. A variety of private companies compete for the telecommunication services business within the Walla Walla market. Carriers include AT&T, Ziply Fiber, Columbia iConnect, EarthLink, Verizon, T-Mobile, Spectrum, PocketiNet, CenturyLink, and others. Satellite internet providers include Columbia iConnect, HughesNet, and Viasat. The capital facilities and expansion plans of these businesses tend to be private and are based on market demand and private capital investment. At this time, however, there are no current or expected future gaps in telecommunications service within the Walla Walla city limits or UGA.

State and Regional Facilities

Other community facilities include hospitals and medical facilities, higher education institutions, the Washington State Penitentiary, and the Walla Walla Regional Airport. Long-range planning for these facilities is often done in consultation with the City of Walla Walla. However, these facilities serve state and/or regional needs that go beyond an assessment of local growth.



Figure 41. Aerial of the Walla Walla Regional Airport

Challenges and Opportunities

Aging Infrastructure

Walla Walla is facing failure of three infrastructure systems: water, sewer, and streets. In 2010, the City had 115 miles of failing facilities, and 43 miles where all three systems were failing along the same stretch of road. To address this issue, the City Council established the Infrastructure Repair and Replacement Plan (IRRP) in 2010, funded by a six-year utility rate increase. The program is funded by utility revenues at an annual rate of approximately $5 million per year. Through 2024, the City has replaced 14.2 miles of the 43 miles of failing infrastructure.

Accommodating Future Demand

The City is projecting moderate population growth over the next 20 years, with an increase of 5,034 new people for a total estimated population of 39,884 people expected within the City by 2046. There are two ways to address demand: adding capacity or managing demand. Capacity can be added by increasing the number of facilities or services provided, for example, by increasing the capacity of a water treatment plant or extending or enlarging water mains to increase service. Demand can be managed by reducing consumption or limiting the use of a facility, for example, by programs that improve water conservation. Ultimately, successful demand management may improve levels of service. For example, water conservation could reduce the average daily demand for water despite population growth.

Maintaining Community Character

Capital facilities and utilities create the need for utility boxes, cell towers, substations, and other facilities. Facilities should be located in places necessary to provide adequate service, while minimizing visual aesthetic and other aesthetic on community character. With good locational criteria and design guidelines, utilities and capital facilities can be integrated into the City in a way that supports the community.

Walla Walla's Plan

Access to high-quality utilities and capital facilities, from drinking water to parks to law enforcement, is essential to the health and well-being of Walla Walla residents. The City is committed to maintaining this access as the community grows. We will also ensure that facilities are located to provide safe and equitable access while maintaining community character. We will keep plans, regulations, and facilities up to date to meet advancing technology and evolving community needs. We will accomplish these goals through coordination with other public agencies and private companies, and with a focus on fiscal sustainability.

The following goals and policies guide how the City plans for, provides, and regulates capital facilities and utilities to maintain these values.

Goals and Policies

CFU Goal 1: Walla Walla's capital facilities and utilities are well maintained to meet the current demands of the City and forecasted growth.

- CFU 1.1: Maintain updated plans for the provision of public utility services.
- CFU 1.2: Monitor all public or private water systems; regularly maintain public systems.
- CFU 1.3: Ensure that the City's wireless communication facilities ordinance is updated to account for new technology, so it remains consistent with the community's vision and needs.
- CFU 1.4: Ensure that telecommunications services are provided at a level that enables residents and businesses to compete in the global marketplace while minimizing negative impacts on the aesthetic character of the community.
- CFU 1.5: Decommission public facilities that are no longer needed and where applicable, reallocate land for appropriate uses.
- CFU 1.6: Recognize the Walla Walla Regional Airport as an Essential Public Facility and comply with state and federal regulations that place limitations on land development within the influence area of the airport.

- CFU 1.7: Reassess the Land Use element if the City cannot provide funding to maintain adopted levels of service for public facilities and utilities that it manages.

CFU Goal 2: Capital facilities and utilities are located in such a way as to provide safe and efficient service to all residents.

- CFU 2.1: Provide community facilities and public services that are appropriate for the size and composition of the population.
- CFU 2.2: Plan to provide utility services in areas of the city and where appropriate in the UGA.
- CFU 2.3: Design and distribute public facilities and services, including streets and utilities, to ensure equitable supply and access to all segments of the population.
- CFU 2.4: Locate emergency service facilities to maximize ease of access and minimize response time.
- CFU 2.5: Require underground installation of new utility services and encourage conversion of existing overhead systems to underground systems.
- CFU 2.6: Ensure that facilities and infrastructure are designed and located with consideration of their impacts on community character.

CFU Goal 3: The provision of capital facilities and utilities is coordinated through collaboration with neighboring governments and private providers.

- CFU 3.1: Work with State and regional partners to ensure a safe and sufficient supply of potable water is provided to residents, keeping demand in balance with natural supply and growth.
- CFU 3.2: Cooperate and coordinate with private utility providers to ensure sufficient and uninterrupted service to residents as growth occurs.
- CFU 3.3: Coordinate and collaborate with public agencies to site essential public facilities and to ensure their impacts on adjacent uses at proposed or alternative locations have been anticipated.
- CFU 3.4: Encourage coordination among utility providers as they undertake improvement projects to minimize impacts of utility infrastructure on the community.

CFU Goal 4: The City is committed to waste reduction, recycling, energy efficiency, and the use of renewable energy sources to meet current and future needs.

- CFU 4.1: Support recycling of municipal and household waste as part of the City's commitment to sustainability.
- CFU 4.2: Maintain and operate the City's hydroelectric generating facility as a source for renewable energy and revenue for the City; explore other renewable energy opportunities.

- CFU 4.3: Support energy efficiency by encouraging the use of energy efficient building designs and land use.

CFU Goal 5: The sound fiscal management of government services and facilities promotes a transparent and collaborative relationship between government and residents.

- CFU 5.1: Plan for rehabilitation of the City's utility infrastructure to ensure safe, reliable, and efficient service.
- CFU 5.2: Encourage and pursue, whenever feasible, opportunities to share facilities and costs with different public or private agencies/entities.
- CFU 5.3: Anticipate demand for services to ensure that the City can maintain an appropriate level of service within its financial resources while serving new growth.

Policy Connections

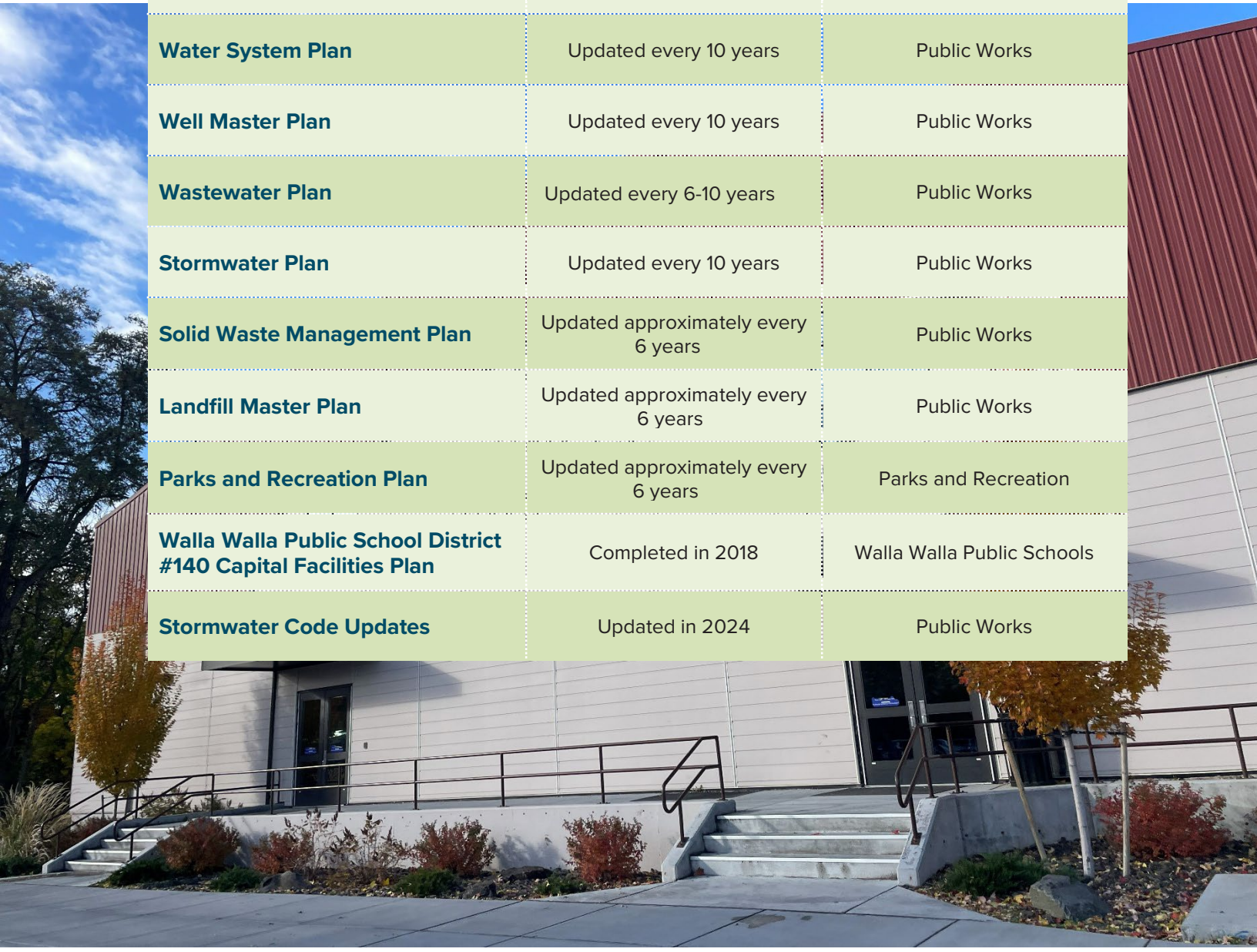
- Capital facilities and utilities must be planned to accommodate future growth, with adequate financing available. **The Land Use Element** includes policies and information about projected growth.
- **The Environment and Natural Resources Element** addresses conservation of natural resources.
- **The Community Character Element** includes policies to preserve community character.

Translating Policy into Action

The Capital Facilities and Utilities Element is implemented by the City through capital investments, day-to-day operations, adjustments to City code, and partnering with other jurisdictions and private providers.

Table 34. Capital Facilities Documents Update Schedule

Document	Update Schedule	Responsibility
Capital Facilities Plan	Updated annually	Finance/Public Works
Water System Plan	Updated every 10 years	Public Works
Well Master Plan	Updated every 10 years	Public Works
Wastewater Plan	Updated every 6-10 years	Public Works
Stormwater Plan	Updated every 10 years	Public Works
Solid Waste Management Plan	Updated approximately every 6 years	Public Works
Landfill Master Plan	Updated approximately every 6 years	Public Works
Parks and Recreation Plan	Updated approximately every 6 years	Parks and Recreation
Walla Walla Public School District #140 Capital Facilities Plan	Completed in 2018	Walla Walla Public Schools
Stormwater Code Updates	Updated in 2024	Public Works





Climate Resilience Element

The City of Walla Walla needs to prepare for the increasing impacts of climate change to protect its people, environment, and infrastructure. As the city expands, it plays a vital role in strengthening resilience to climate hazards, such as extreme heat, drought, wildfire, and flooding. This Climate Resilience Element evaluates current and future climate risks, highlights key vulnerabilities, and sets goals and policies to help Walla Walla adapt and thrive in a changing climate.

Introduction

As part of the 2026 Comprehensive Plan update, the City of Walla Walla is introducing a new Climate Resilience Element focused on advancing community resilience. This addition responds to amendments made by House Bill 1181 to RCW 36.70.70A, part of Washington State's Growth Management Act (GMA), which now requires cities and counties to include climate change-related goals and policies in their long-range planning efforts. [14]

Climate change refers to long-term shifts in temperatures and weather patterns, primarily driven by human activities, such as the burning of fossil fuels for electricity and transportation, or other activities that release heat-trapping gases into the atmosphere (commonly referred to as greenhouse gas emissions). [15] These changes are already impacting the City of Walla Walla through more frequent and intense extreme heat, droughts, flooding, and wildfire smoke. In this context, resilience means the ability of individuals, communities, and ecosystems to anticipate, prepare for, and adapt to climate-related hazards, such as the changes the city is already experiencing, while continuing to thrive.

This Climate Resilience Element is designed to meet three core requirements:

1. **Address natural hazards** by planning for risks caused or worsened by climate change, including extreme heat, wildfire and smoke, drought, and flooding.
2. **Identify, protect, and enhance natural areas** by safeguarding and restoring natural spaces to build climate resilience and support healthy ecosystems.
3. **Strengthen community resilience** to climate impacts with a focus on social, economic, and built-environment factors that help communities adapt and advance environmental justice.

Planning for climate hazards is essential to ensure the city remains a safe, healthy, and vibrant place to live, work, and play for all. This Element aims to protect everyone in Walla Walla, and

[14] Washington State Department of Ecology, 2025, Climate Planning Guidance, https://www.commerce.wa.gov/growth-management/climate-planning/climate-planning-guidance/
[15] City of Walla Walla, 2025, City of Walla Walla Climate Impacts Summary, https://www.wallawallawa.gov/home/showpublisheddocument/10960/638784138265630000

especially frontline and overburdened communities. Frontline communities refer to those that will be disproportionately impacted by climate change; these are the populations that face historic and current inequities, often experience the earliest and most acute impacts of climate change, and have limited resources or capacity to adapt. Overburdened communities are geographic areas where vulnerable populations experience multiple, compounding environmental harms and health risks. In addition to supporting frontline and overburdened communities, this Element will help reduce long-term costs and lead to additional benefits such as cleaner air and water, improved public health, and economic resilience for all.

The development of this Element has been a collaborative effort involving City staff, the Climate Policy Advisory Team (CPAT), and a variety of community engagement efforts. The City's CPAT team includes community members, City leaders, and City staff, all of whom contributed valuable insights to inform the development of the goals and policies outlined in this Element. The City gathered public input through in-person Comprehensive Plan open houses, a community survey, shared information while tabling events, such as the Return to the River Salmon Festiva and Walla Walla Watershed Strategy (2050 Plan) Open House event, and shared information through flyers and the City's website, communications platform, and social media accounts.

The policies within the Climate Resilience Element are closely related to other chapters in the Comprehensive Plan as they guide land use, infrastructure, emergency preparedness, and natural resource management. Continued collaboration and cross-departmental coordination will be key to achieving the overarching goal of creating a resilient City of Walla Walla, one that is equitable, sustainable, and prepared for future challenges.



Today and Tomorrow

The following sections provide an overview of current climate change impacts and their effects on local sectors. This assessment seeks to establish a foundational awareness to inform the City's Climate Resilience Element.

Climate Hazards and Impacts

Walla Walla is already experiencing the impacts of climate change, and these effects are expected to intensify in the coming decades. Four climate hazards, events, or trends related to climate that can cause damage or disruption to people, infrastructure, ecosystems, and the local economy—pose risks to the City of Walla Walla. These hazards include extreme heat, wildfire and smoke, drought, and extreme precipitation and flooding (Figure 42). Understanding these hazards is vital for building resilience and guiding future planning decisions.

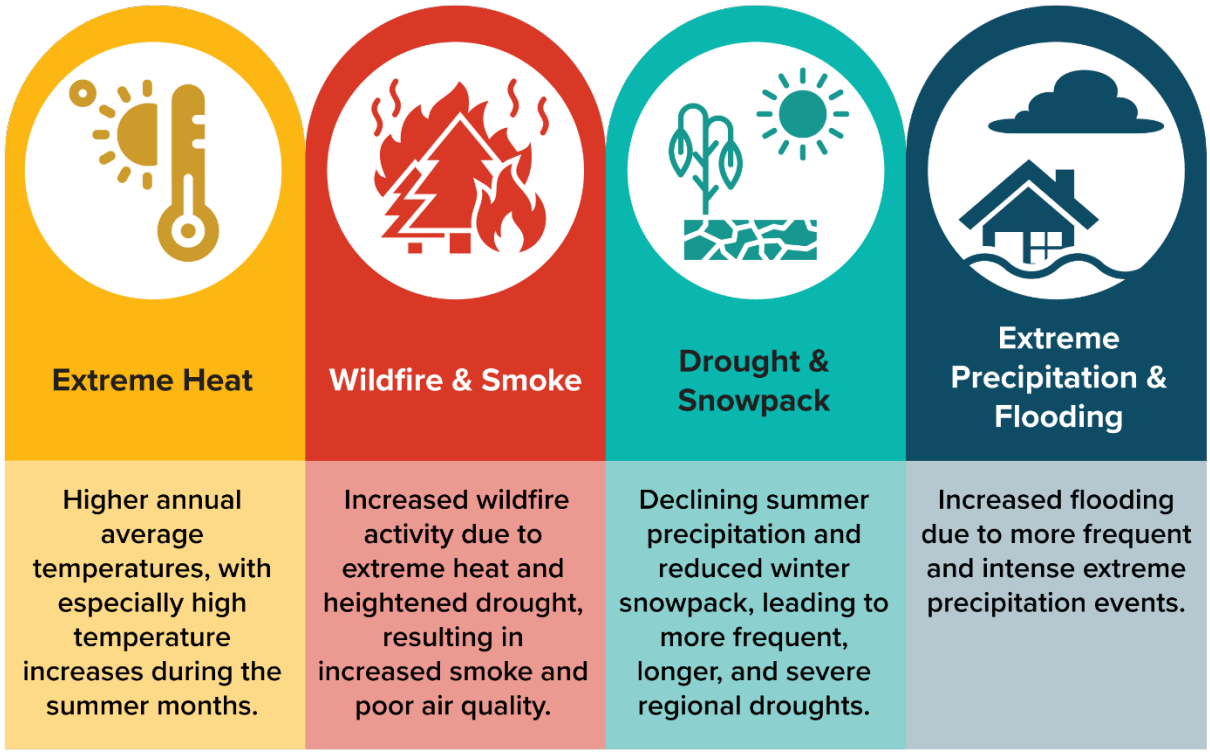


Figure 42. Climate Impacts in Walla Walla

Extreme Heat

Across Washington state, average temperatures have warmed throughout the last century and are expected to warm at a faster rate throughout the next century. In Walla Walla, average annual temperatures have increased by approximately 2.05°F since 1900 (Figure 43). [16] Between 1981 and 2010, there were an average of 17.6 days per year above 95°F in Walla Walla County; however, projections indicate that this is expected to increase to 35.3 days by 2059 and to 42 days by 2099 under a more conservative scenario. [17] Rising temperatures are expected to intensify regional climate impacts, including more frequent and severe drought conditions, increased wildfire risk, and greater exposure to wildfire smoke.

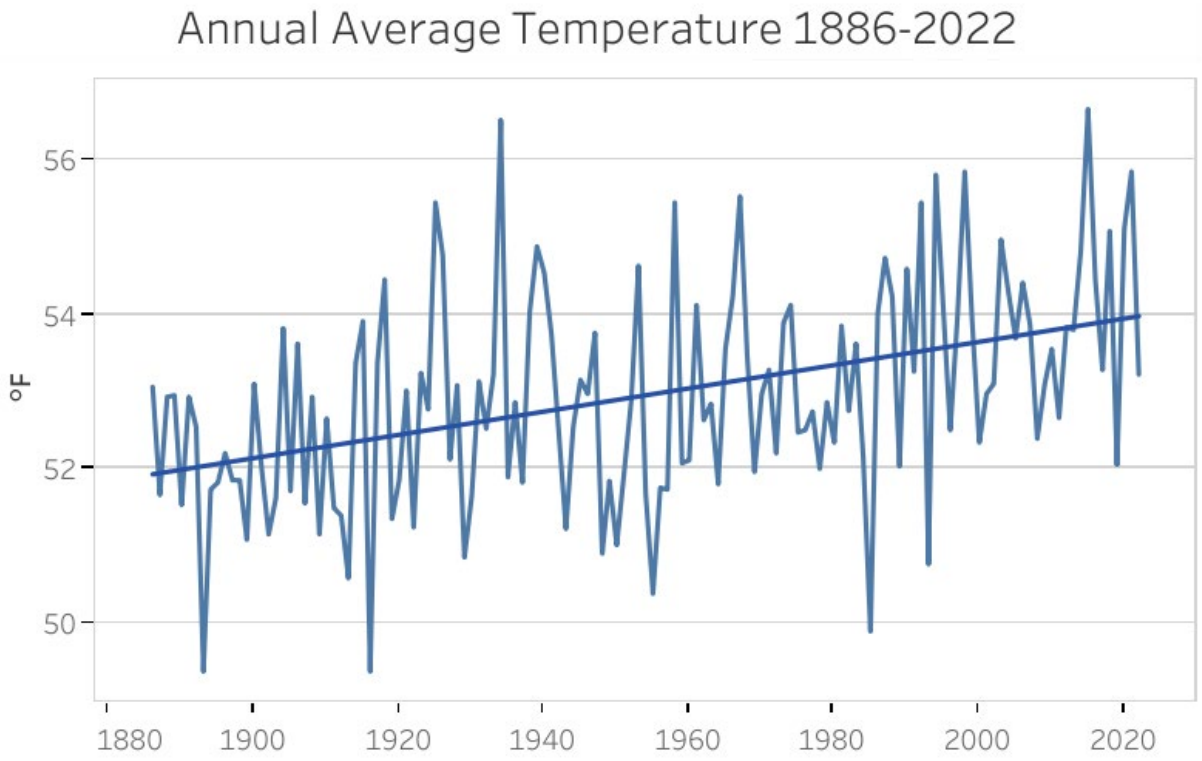


Figure 43. Historical Annual Average Temperatures, City of Walla Walla

[16] Office of the Washington State Climatologist, 2023, PNW Temperature, Precipitation, and SWE Trend Analysis Tool, https://climate.washington.edu/climate-data/trendanalysisapp
[17] Walla Walla Watershed Management Partnership, 2021, Walla Walla Water 2050 Strategic Plan, https://apps.ecology.wa.gov/publications/SummaryPages/2112011.html

Drought

The city is expected to face more frequent and severe droughts as summer precipitation declines across the region. By the end of mid-century (2050-2079), summer rainfall in Walla Walla County is projected to decrease by approximately 16-35%, and by an additional 10-34% by the end of the century. [18] These projected changes create an increasing wildfire risk, could reduce water availability, and are especially concerning given the City's reliance on the Mill Creek Municipal Watershed, which supplies 90% of its water.

Table 35. Precipitation Drought in Walla Walla County

	2050-2079	2070-2099
Precipitation Drought *(Salathé, E.P. et al., 2010) Accessed via Climate Mapping for a Resilient Washington.**	Walla Walla County	Walla Walla County
Likelihood of a year with summer precipitation below 75% of historical normal	22% (16% to 35%)	27% (10% to 34%)

**Likelihood that summer (June-August) precipitation in any given year is below 75% of the average precipitation, the historical normal for the period 1980-2009.*

Drought conditions will be exacerbated by rising temperatures, which will shift precipitation from snow to rain in winter months, dramatically reducing snowpack—a key source of stored water for the city in the drier summer months. The Walla Walla basin is projected to experience one of the largest snowpack declines in the Pacific Northwest. [19] Furthermore, streamflow in the Walla Walla River is expected to decrease by up to 66% by the 2040s and up to 89% by the 2080s, threatening water supplies for agriculture, ecosystems, and communities throughout the region.[6] Considering that Mill Creek is a tributary of the Walla Walla River and is located within the Walla Walla basin, the City's primary water supply is also expected to face similar impacts from drought.

[18] Salathé, E.P. et al., 2010, Regional climate model projections for the State of Washington, https://link.springer.com/article/10.1007/s10584-010-9849-y
[19] Washington Department of Ecology, 2023, Addressing Walla Walla's Water Woes, Ecology Blog

Wildfire and Smoke

Walla Walla's mild climate, high exposure to the sun, and low precipitation make the region highly susceptible to wildfire. Native vegetation and farmland often dry out early in the season and remain flammable until rain and cooler weather become more common in the fall and winter. As temperatures rise and droughts become more frequent and severe, wildfire activity in central and eastern Washington is expected to increase significantly. The average annual number of high fire danger days in Walla Walla County is also expected to rise, increasing by approximately 10 days by mid-century (Table 36), relative to the historical average of 54 days between 1971 and 2000.[20] These conditions pose risks to critical infrastructure and water supply sources, such as the Mill Creek Watershed, which is particularly vulnerable to wildfire due to the surrounding vegetation and its proximity to undeveloped lands. Public health will also be at risk due to increased exposure to wildfire smoke. Smoke events are especially harmful to older adults, children, pregnant individuals, and those with respiratory or cardiovascular conditions.

Table 36. Wildfire Danger in Walla Walla County

	2010-2039	2040-2069
Wildfire Danger *(T. Sheehan, et al., 2015) Accessed via Climate Mapping for a Resilient Washington.**	Walla Walla County	Walla Walla County
Change in annual high-fire-danger days	6 days (-2 to 10 days)	10 days (three to 15 days)

** Table shows the change in annual high fire danger days compared to the 1971-2000 average of 54 days. The values represent the model's median for each indicator, while the range (in parentheses) indicates the 10th and 90th percentiles of values.*



Aerial view of the Paradise Fire from the week of August 24, 2026. Photo by Jeff Schardt

[20] T. Sheehan, et al., 2015, Projected major fire and vegetation changes in the Pacific Northwest of the conterminous United States under selected CMIP5 climate futures, https://doi.org/10.1016/j.ecolmodel.2015.08.023

Extreme Precipitation and Flooding

The Northwest is expected to experience more frequent and intense extreme precipitation events, with a growing share of winter precipitation falling as rain rather than snow and more severe heavy rainfall events. [21] Washington's heaviest rainstorms could be 22% more intense by the 2080s, particularly in the fall, while summer precipitation is projected to decrease by 6-8% on average, and with some estimates showing up to a 30%. [22] In Walla Walla County, average total annual precipitation is expected to increase by 13% by 2079 and by an additional 14% by the end of the century (Table 37). [23] These changes heighten the risk of flash flooding, erosion, and infrastructure damage.

Table 37. Total Annual Precipitation Projections

	2050-2079	2070-2099
Total Annual Precipitation *(Salathé, E.P. et al., 2010) Accessed via Climate Mapping for a Resilient Washington.*	Walla Walla County	Walla Walla County
Percent change in average total annual precipitation for future 30-year periods compared to the 1980-2009 average.	12.9% (9.7% to 20.9%)	14.4% (10.0% to 28.2%)

Most models show increases in winter, spring, and fall precipitation, while summer precipitation continues to decline. These seasonal changes will affect water storage, agriculture, and emergency preparedness, as more winter rain and less snowpack reduce natural water reserves and increase runoff-related hazards.



[21] Chang, et al., 2023, Fifth National Climate Assessment, Chapter 27, https://toolkit.climate.gov/sites/default/files/2025-07/NCA5_2023_FullReport.pdf
[22] Walla Walla Watershed Management Partnership, 2021, Walla Walla Water 2050 Strategic Plan, https://apps.ecology.wa.gov/publications/SummaryPages/2112011.html
[23] Salathé, E.P. et al., 2010, Regional climate model projections for the State of Washington, https://link.springer.com/article/10.1007/s10584-010-9849-y

Climate Vulnerability

The climate hazards outlined above—extreme heat, drought, wildfire and smoke, and extreme precipitation and flooding—are already affecting the City of Walla Walla and are expected to intensify in the coming decades. Vulnerability to these hazards is shaped by three factors: exposure, sensitivity, and adaptive capacity (Figure 44). In short, vulnerability reflects the City's level of preparedness to manage risks associated with climate impacts.

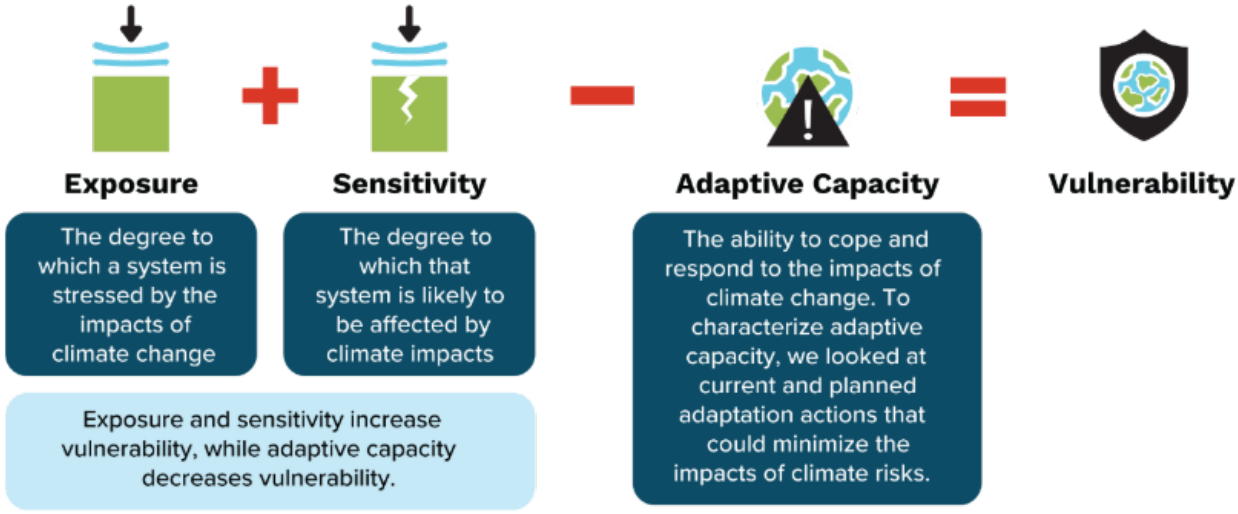


Figure 44. Climate Vulnerability Framework

To support climate resilience planning, the City assessed how these hazards impact three key sectors that are most relevant to Walla Walla's long-term sustainability and planning priorities [24]:

- **Community Health and Well-Being**. Frontline and overburdened populations—including the elderly, disabled, unhoused, low-income households, and those living with chronic health conditions—face heightened risks from extreme heat, wildfire smoke, and flooding. These events can also strain emergency services and public health systems, especially during prolonged or overlapping climate events.
- **Natural Environment and Water Resources**. Drought, wildfire, invasive species, and declining snowpack increasingly threaten ecosystems, parks, open spaces, and water supplies. The Mill Creek Watershed, which supplies most of the city's drinking water, is particularly vulnerable to wildfire and drought-related impacts.
- **Built Infrastructure**. The City of Walla Walla's transportation, housing, and water infrastructure face moderate to high risks from extreme heat, flooding, and wildfire smoke. High temperatures can damage roads, while more intense precipitation events may overwhelm stormwater systems, increasing the risk of localized flooding. Older homes and multi-family housing, especially those occupied by low-income or elderly residents, are more vulnerable to heat and smoke exposure.

[24] City of Walla Walla, 2025, Walla Walla Climate Element Climate Vulnerability Assessment

These sectors were selected through collaboration with City staff and the CPAT to align with local planning priorities and with Commerce guidance on assessing infrastructure and assets impacted by climate hazards. While some overlap exists (e.g., water appears in both natural and built systems), these sub-sectors represent the most relevant connections within each sector. Additionally, this structure helps city departments and stakeholders quickly access relevant information and understand how prepared they are for a variety of climate impacts.



While the City has taken proactive steps to improve Walla Walla's resilience and decrease its vulnerability, such as establishing cooling centers, expanding green infrastructure, and supporting home retrofit programs, gaps remain in several key areas. Emergency response systems may be strained during prolonged or overlapping climate events, particularly those involving extreme heat or wildfire smoke. Infrastructure systems, including stormwater and transportation networks, are not yet fully equipped to handle the intensity and frequency of projected climate hazards. Additionally, more support is needed for vulnerable and overburdened populations who face disproportionate risks and may lack the resources to adapt. Addressing these gaps by translating policy into action will be critical to ensuring that all residents can thrive in a changing climate.

Together, these findings highlight where the City of Walla Walla is already prepared and where it should improve its preparation and infrastructure to respond to climate impacts. These insights inform the goals and policies in this Climate Resilience Element and will help guide future planning efforts.

Challenges and Opportunities

As the City of Walla Walla continues to grow, the City will need to accommodate new development while preparing for the impacts of climate change and associated hazards. Rising temperatures, more frequent extreme weather events, and changing precipitation patterns will place increasing pressure on infrastructure, the natural environment, and the community's health and well-being, with a heightened impact falling on overburdened populations. These climate-related stressors necessitate a coordinated, long-term approach to planning, as they intersect with existing challenges, including housing affordability, aging infrastructure, and equitable access to resources for all residents. Despite these challenges, the City has a unique opportunity to build a more resilient and sustainable community for everyone in Walla Walla, with an additional focus on addressing risks to frontline and overburdened communities. The City's strong agricultural heritage, engaged community, and commitment to environmental stewardship provide a solid foundation for climate action, and the Climate Resilience Element will be used to continue shaping future planning efforts. By integrating climate resilience across planning and development, the City of Walla Walla can protect its natural assets, support community health, and ensure that future growth enhances the well-being of all residents.

Walla Walla's Plan

The above sections provide background for the City's goals and policies, which are described below. As the city and its population grows, incorporating climate resilience into land use, infrastructure, housing, and natural resource management will lessen risks for everyone in Walla Walla, safeguard frontline and overburdened populations, and support long-term sustainability. The goals and policies in this Climate Resilience Element are meant to guide Walla Walla toward a more adaptable and equitable future—one where the City addresses climate challenges while also enhancing quality of life, strengthening local ecosystems, and boosting community resilience.

Maps

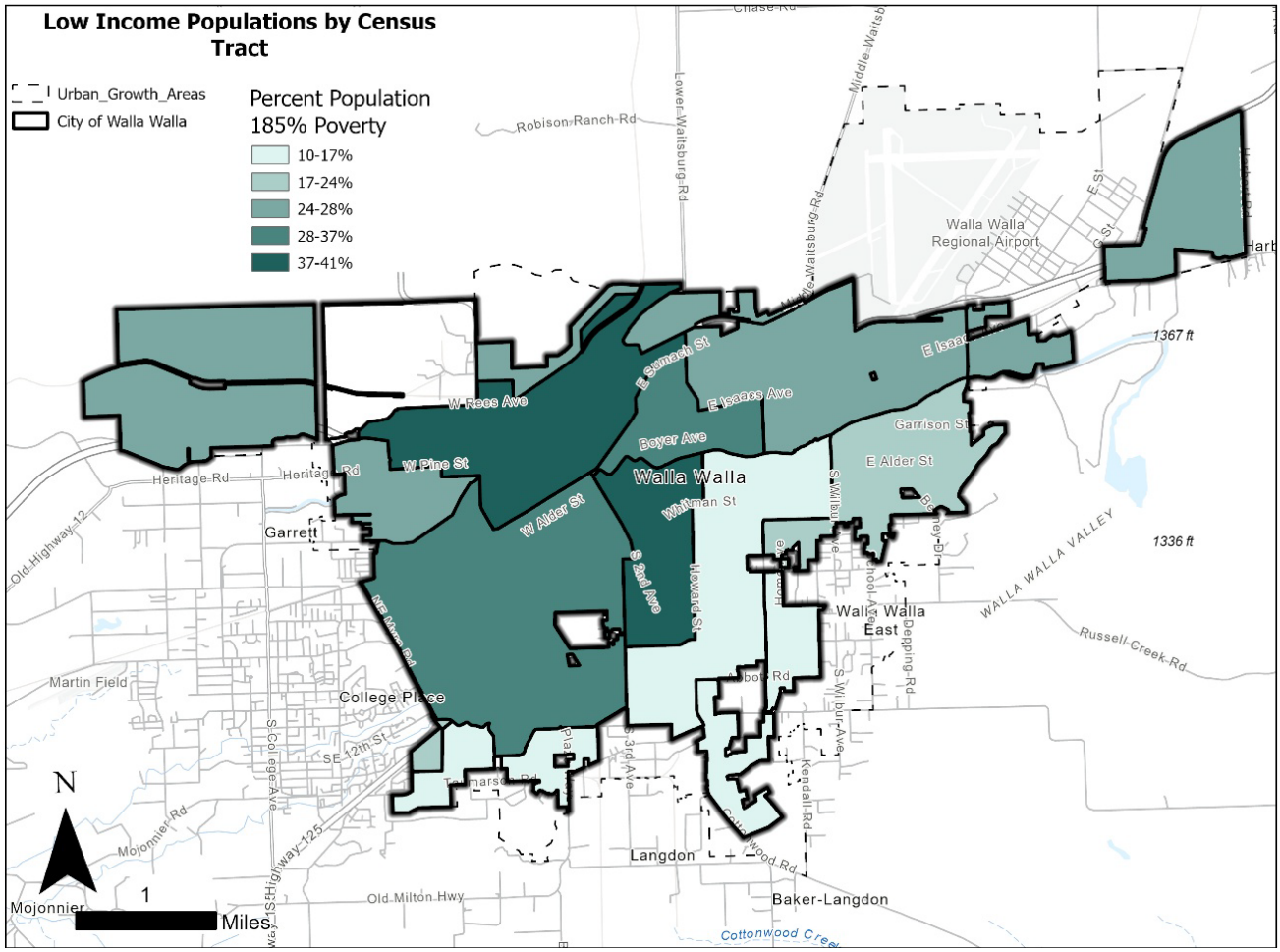


Figure 45. Percent of Low-Income Population by Census Block Group

Note: The low-income population is defined as household income less than 185% poverty level.
Source: Map by Cascadia Consulting Group, data from U.S. Census Bureau, 2023

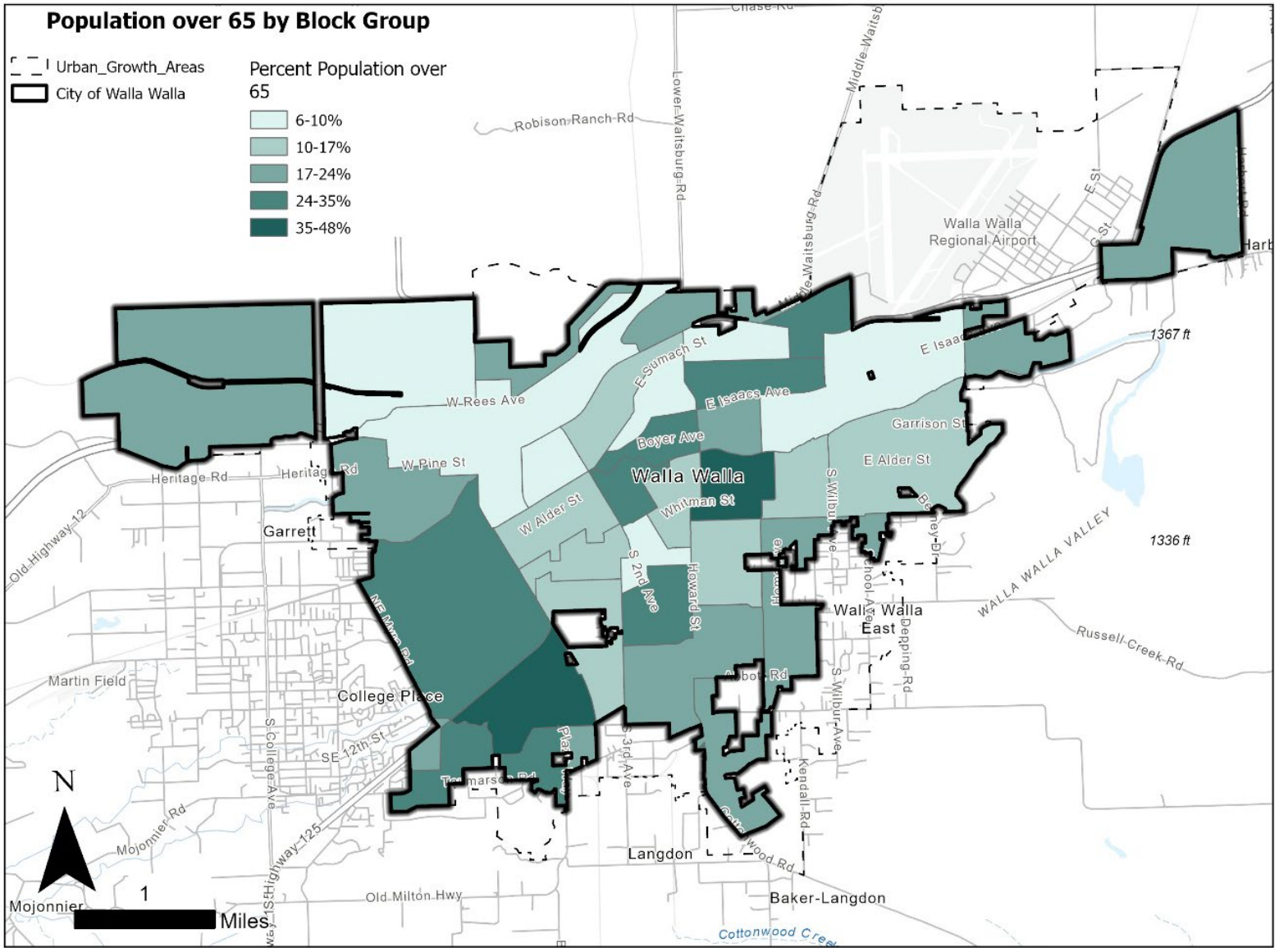


Figure 46. Percent of Population Over 65 Years by Census Block Group

Source: Map by Cascadia Consulting Group; U.S. Census Bureau, 2023

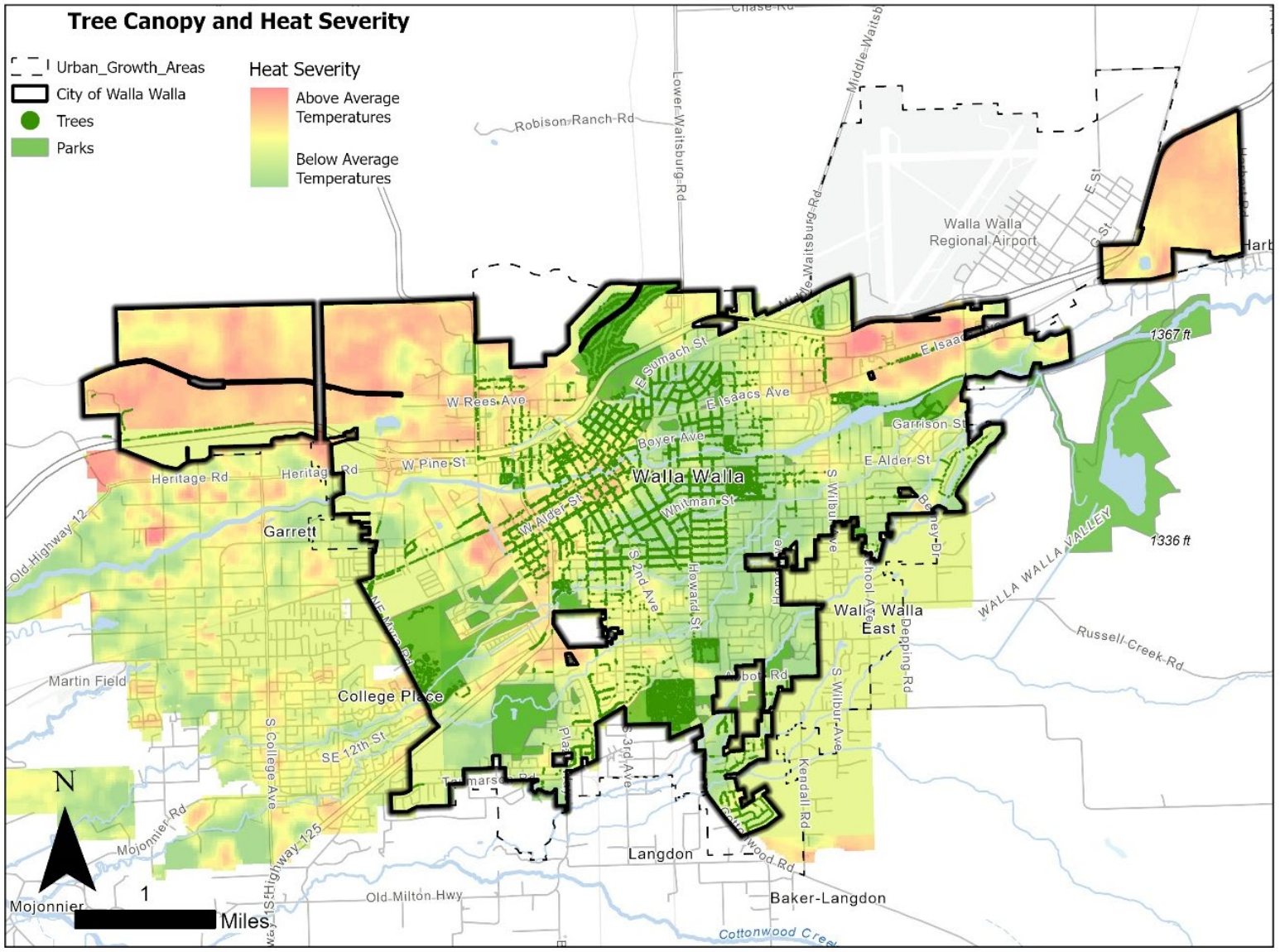


Figure 47. Heat Severity, Tree Canopy, and Green Spaces in Walla Walla

Source: Map by Cascadia; Trust for Public Land, 2025; City of Walla Walla, 2025

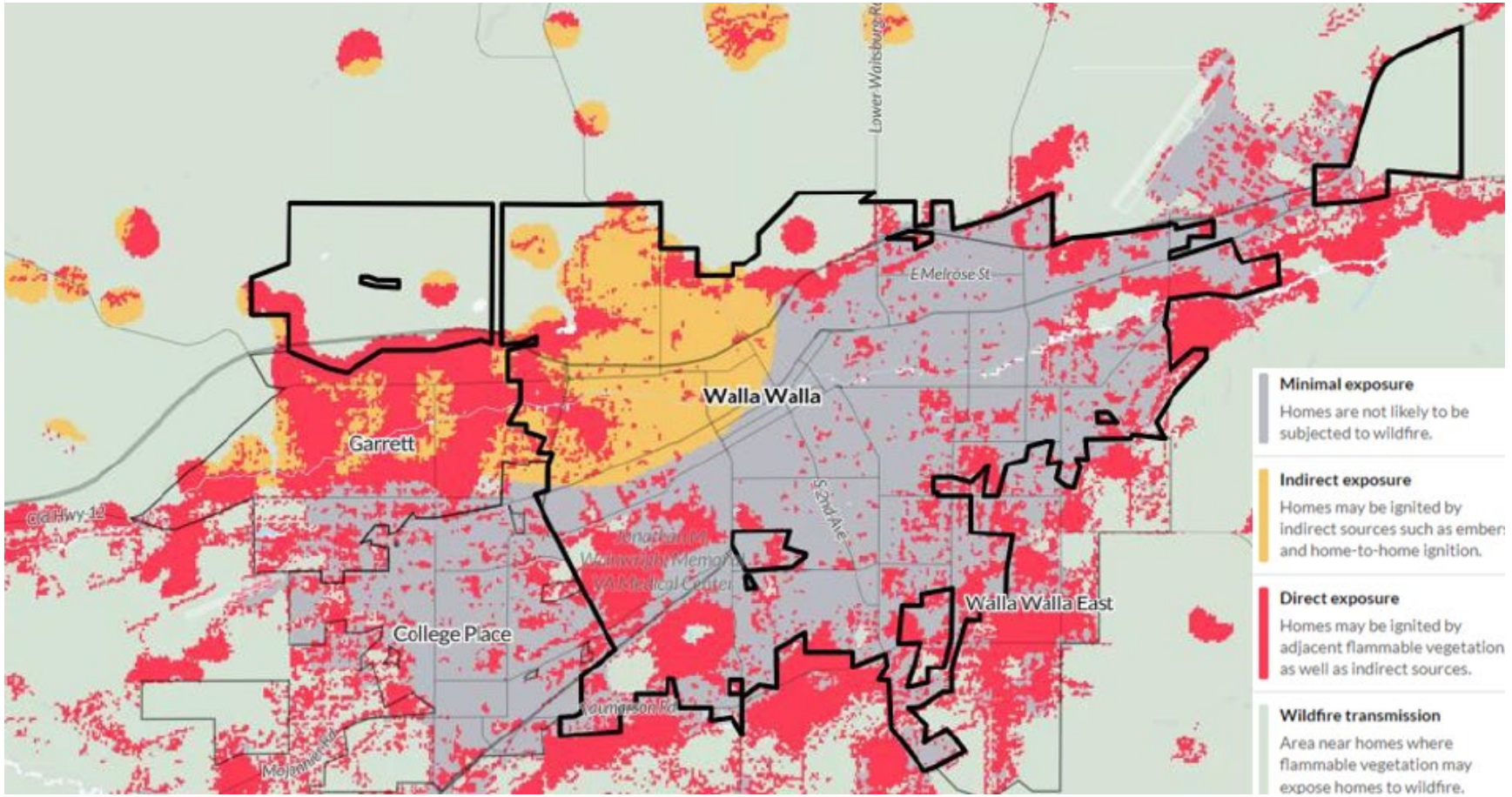


Figure 48. Wildfire Risk Reduction Zones

Source: Walla Walla County – Emergency Management, 2024



Figure 49. Aboriginal Title Lands Map

Source: Confederated Tribes of the Umatilla Indian Reservation, n.d.

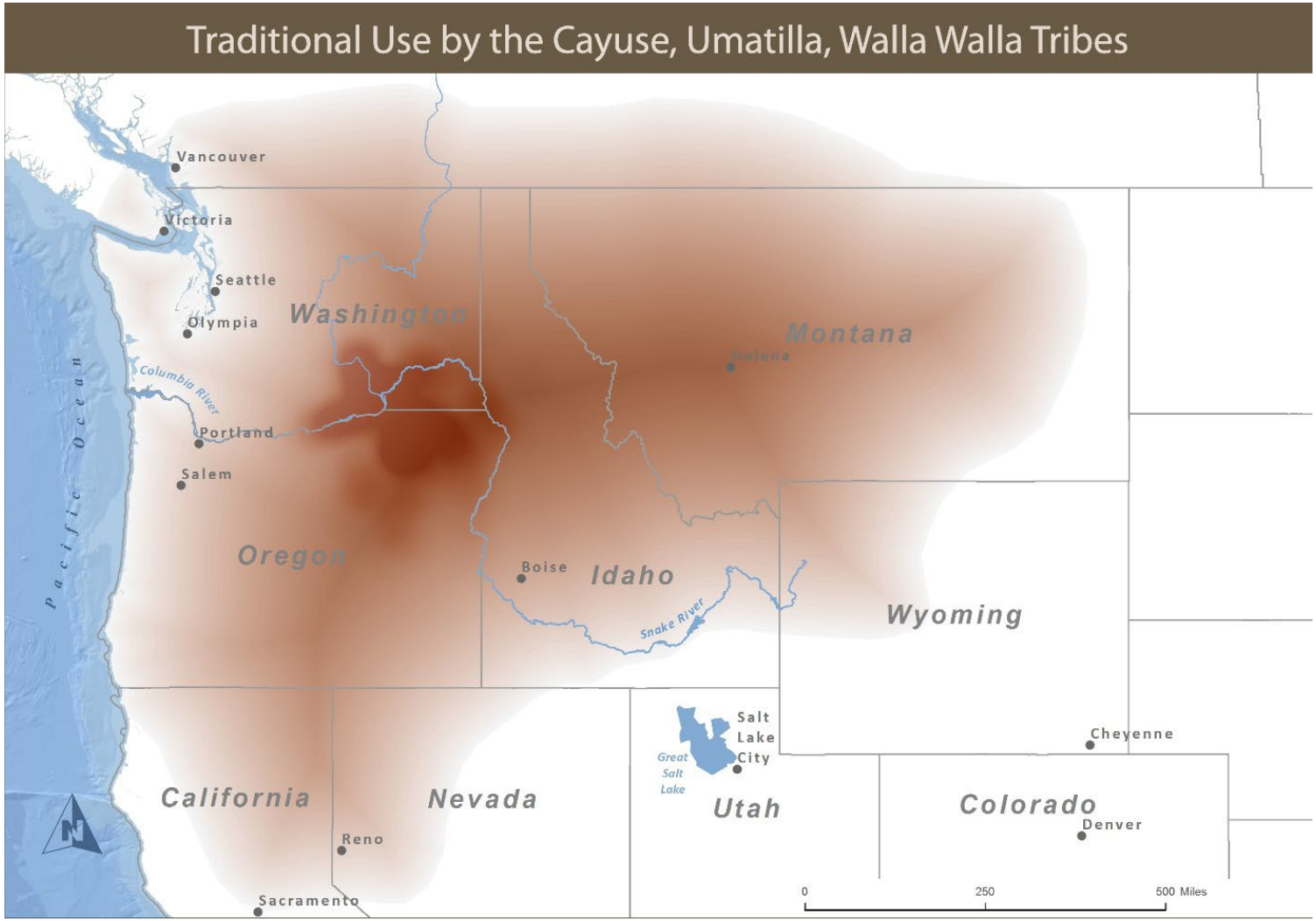


Figure 50. Traditional Use by the Cayuse, Umatilla, and Walla Walla Tribes Map

Source: Confederated Tribes of the Umatilla Indian Reservation, n.d.

Goals and Policies

CR Goal 1: Climate resilience and adaptation are considered in the City's planning and resource allocation process.

- CR 1.1: Assess the resources needed to implement the Climate Resilience Element (CRE), including partnerships, staffing, and funding. Strengthen ongoing collaboration with public and private partners in the region to advance hazard mitigation, land use planning, and natural resource protection efforts.
- CR 1.2: Cultivate and maintain City staff expertise and skills in climate change and environmental justice to support the equitable implementation of Climate Resilience Element policies.
- CR 1.3: Strengthen the City's capacity to track and report on climate resilience policy implementation with the use of tools such as progress reports, dashboards or other techniques to monitor and communicate progress over time.
- CR 1.4: Address climate change impacts (such as increased flooding, reduced winter streamflow, extreme heat risks, heightened wildfire threats, and broader ecosystem vulnerabilities), in future planning, design, and management of critical infrastructure, services, and natural resources.
- CR 1.5: Participate in the County annual review of the Community Wildfire Protection Plan (CWPP) to strengthen wildfire preparedness in ways that:
    a) Improve emergency response within the City.
    b) Create fire-resilient landscapes and fire-adapted communities.
    c) Protect the local economy.
    d) Provide strategies that support recovery from wildfires and smoke impacts.
- CR 1.6: Strengthen the long-term health and resilience of the Mill Creek Watershed by preparing for climate-related risks—such as wildfire—and identifying ways to protect and enhance the municipal water supply, such as those included in the Watershed Resiliency Plan.
- CR 1.7: Support the implementation of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) Climate Action Plan (CAP, 2022) through practices like knowledge sharing, collaboration, and partnerships.
- CR 1.8: Engage and inform community members, especially those most vulnerable to extreme heat, flooding, and other related climate impacts, through targeted community education, early-warning systems, and inclusive communications to support the implementation of the Climate Resilience Element.

CR Goal 2: Walla Walla seeks to identify, protect, and enhance community resilience to priority climate impacts, focusing on overburdened communities, to ensure that the most vulnerable residents do not bear the disproportionate impacts.

- CR 2.1: Identify overburdened populations within the community and assess their specific vulnerabilities to climate change to inform resilience and adaptation strategies that reduce disproportionate impacts and support the health and well-being of those most at risk.
- CR 2.2: Coordinate with community organizations to strengthen the overall community well-being by maintaining and, when possible, seeking funding to expand shelter programs which can serve as resilience hubs for vulnerable neighborhoods during climate and other emergencies.
- CR 2.3: Take steps to ensure that any climate program benefits, educational outreach, or investments are equitably distributed and that climate impacts are minimized for all residents. Consider strategies such as:

    a) Targeted outreach and education to inform residents and workers in high-risk areas, such as current and future flood zones about climate hazards and risks, preparedness strategies, and available resources, ensuring that vulnerable communities are equipped with the knowledge to respond effectively. Outreach and education would be available in English and Spanish.

    b) Community adaptation programs to reduce climate-related health and safety risks, such as establishing a program to distribute cooling units, install heat pumps, or reduce exposure to wildfire smoke by providing protective equipment, air filtration devices, and incentivizing infrastructure upgrades.

- CR 2.4: Support improvements to existing buildings commercial, public, and residential housing stock with incentives that improve energy efficiency, reduce utility costs, and ensure the availability of safe, affordable, and climate-resilient housing especially for vulnerable renters in low-income rental and group housing communities.
- CR 2.5: Educate employers and employees on protocols regarding extreme heat and poor air quality and consider outreach efforts to businesses and outdoor workers to promote safety, ensure compliance, and reduce exposure to climate-exacerbated hazards.

CR Goal 3: Walla Walla seeks to strengthen the resilience of the built infrastructure by integrating climate adaptation strategies, prioritizing sustainable infrastructure, and reducing vulnerability to climate-related hazards.

- CR 3.1: Enhance the safety and reliability of utilities to withstand climate impacts by collaborating with utility providers to strengthen infrastructure and support continuous service.

- CR 3.2: Support the resilience of street transportation systems against climate hazards by identifying and updating segments of infrastructure at risk—when feasible and/or funded—establish alternative routes for critical corridors to prevent community isolation.
- CR 3.3: Prioritize the use of resilient design strategies and materials in transportation infrastructure upgrades and projects that will allow the system to be more tolerant to repeat floods, flash floods, and extreme heat.
- CR 3.4: Prioritize the development of infrastructure projects that create safe, accessible parks and other public spaces year-round by incorporating shaded walkways, flood-resistant features, and heat-reducing design elements.
- CR 3.5: Encourage new development and retrofits to pursue green building standards and explore incentives that prioritize low-impact development, sustainable design, climate-conscious materials, and environmentally friendly landscaping, especially for climate-impacted multifamily and low-income housing communities.
- CR 3.6: Continue efforts to enhance water use efficiency and upgrade water, wastewater, and stormwater infrastructure to better adapt to future climate conditions.

CR Goal 4: Walla Walla strives to increase the resilience of natural areas to support healthy, climate-resilient ecosystems.

- CR 4.1: Prioritize the protection and restoration of critical habitats such as floodplains, wetlands, and riparian ecosystems and other critical areas to reduce the severity of climate impacts, support long-term ecosystem health, and improve climate adaptability.
- CR 4.2: Continue to support fish and habitat recovery efforts to improve the climate resilience of streams and watersheds.
- CR 4.3: Coordinate climate resilience efforts in future updates of other city plans, including the Shoreline Master Program and critical areas regulations, through conservation area designations, buffers, and the development of open space corridors.
- CR 4.4: Prioritize the use of advanced erosion control and sustainable land management practices for effective flood management as feasible.
- CR 4.5: Promote local and regional conservation, open space, and land management planning efforts that explicitly consider and address climate change risks.

Policy Connections

- **The Community Character Element** addresses the importance of protecting and restoring natural areas through policies on stream corridors, increasing access to community green spaces and parks, and creating a tree planting program.
- **The Land Use Element** guides growth toward existing infrastructure, protects natural resources, and promotes sustainability through policies that promote coordinated regional efforts, green standards, the conservation of open space, flood protection, and community adaptability to hazards.
- **The Housing Element** addresses climate resilience through reducing energy use and emissions, strengthening community livability and equity, and ensuring homes are retrofitted or built to withstand environmental and social stresses.
- **The Economic Development Element** fosters adaptable business models that can evolve in response to changing community needs by strengthening local skills and seeking to diversify employment opportunities.
- **The Historic Preservation Element** supports the Climate Resilience Element through policies that address waste reduction, resource efficiency, and preservation of existing community assets.
- **The Parks and Recreation Element** focuses on maintaining, expanding, and connecting green spaces, trails, and recreation areas, while also ensuring the long-term sustainability and funding for these community resources.
- **The Environmental and Natural Resources Element** includes policies that directly address climate change impacts and strategies the city can implement to address those impacts.
- **The Transportation Element** fosters a connected, multimodal system with reduced reliance on single-occupancy vehicles, improved access to transit and active transportation, supports public safety, and aims to preserve and maintain infrastructure to withstand long-term stresses.
- **The Capital Facilities and Utilities Element** includes policies that enhance emergency response capabilities, reduce the vulnerability of utility infrastructure, and promote sustainable waste management practices.



Translating Policy into Action

This Element is implemented through City plans and programs, projects, and review of development applications.

Table 38. Climate Resilience Implementation Action and Responsibility

Implementation Action	Timeline	Responsibility
Offer incentives that improve energy efficiency for commercial and residential buildings.	5 years	Community Development
Educate employers and employees on protocols for extreme heat and poor air quality.	2 years	Communications
Support the update of the Watershed Resiliency Plan.	1 year	Community Development and Public Works
Prioritize community education to support the implementation of the element.	Ongoing	Community Development and Communications
Complete a prioritization exercise and resource needs assessment in collaboration with partners and across City departments to determine a timeline for implementation of each policy and identify partnerships, staffing, and funding sources.	2 years	Community Development
Identify overburdened communities within the City and assess their specific vulnerabilities to climate change to inform policy implementation and future plans.	1 year	Community Development

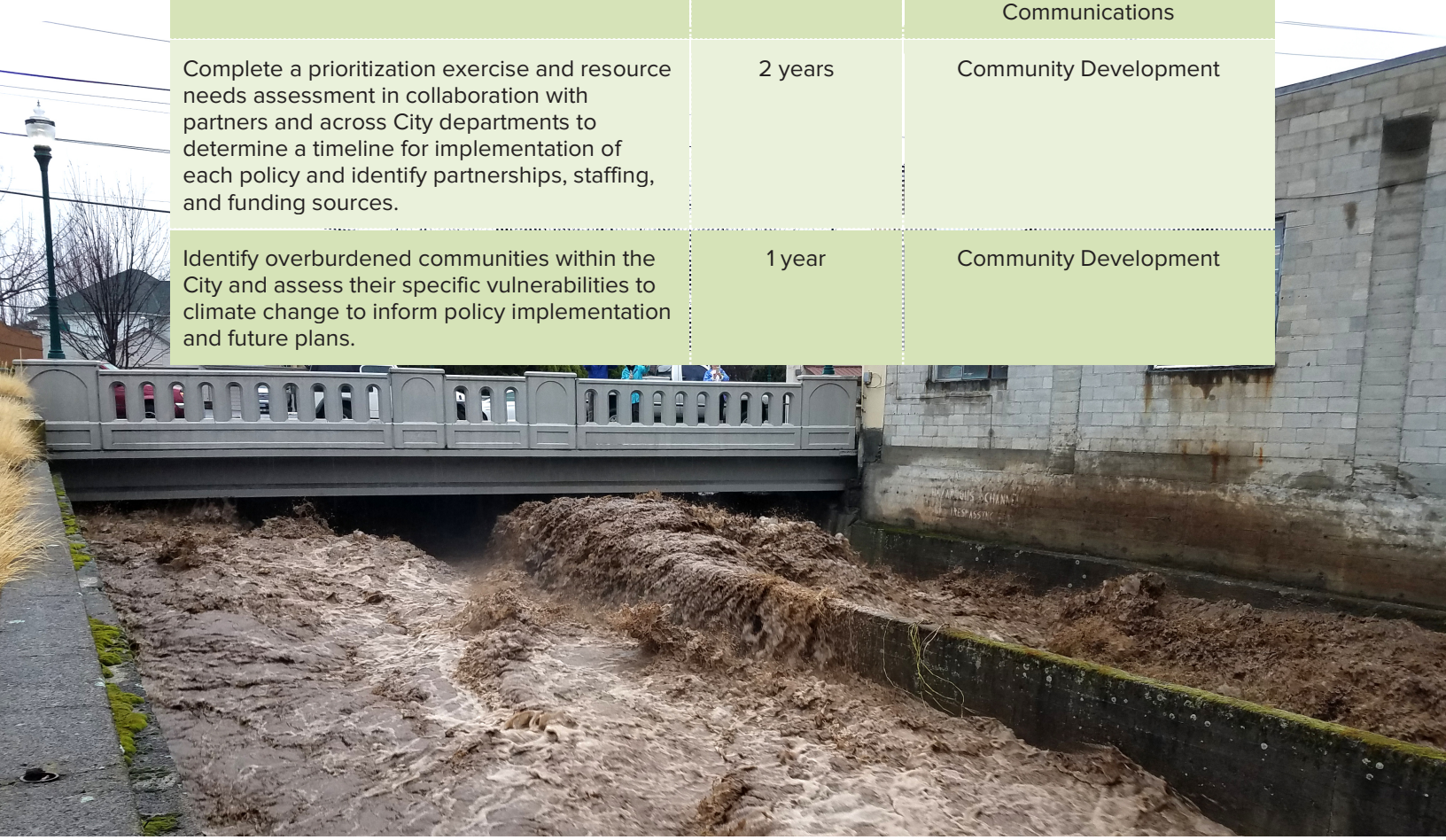


Table of Appendices

Appendix I. Housing Needs Assessment....A2
Appendix II. Land Capacity Analysis....A40
Appendix III. Adequate Provisions Analysis....A58
Appendix IV. Racially Disparate Impacts Analysis....A78
Appendix V. Economic Profile....A96
Appendix VI. Comprehensive Plan Final Environmental Impact Statement....A127
Appendix VII. Engagement Report....A166
Appendix VIII. Countywide Planning Policies (CWPP)....A208
Appendix IX. Climate Vulnerability Assessment....A258
Appendix X. Community Profile....A320
Appendix XI. Capital Facilities Plan....A353
Appendix XII. 20-Year Funding Forecast....A396
Appendix XIII. Transportation Elements Project List....A398

Appendix I. Housing Needs Assessment

Date January 12, 2026

To City of Walla Walla

From Jennifer Shuch and Andrew Oliver, Leland Consulting Group

CC Gen Dial, SCJ Alliance

Introduction

This Housing Needs Assessment (HNA) has been prepared to support the updated Housing Element of the City of Walla Walla's 2026 Comprehensive Plan Update. It has been developed under the guidance of the recently updated Walla Walla Countywide Planning Policies, and in compliance with the Washington State Growth Management Act (GMA), under RCW 36.70A.130. Requirements for Housing Elements under the GMA were substantially amended in 2021 by House Bill 1220, requiring detailed analysis of future housing needs by income level, as well as new considerations for racially disparate impacts, exclusion, and displacement in housing. This report analyzes potential gaps in housing supply, type, and affordability, and identifies current and future housing needs to serve all income groups of the community over the 20-year planning horizon.

In addition, this HNA builds off the City's previous housing needs assessment completed for the 2018 Comprehensive Plan Update, as well as the regional needs assessment completed for the 2021 Walla Walla Regional Housing Action Plan (HAP). The Regional HAP, developed together with representatives from public agencies throughout Walla Walla County, identified that middle income families and local workers have the most pressing housing needs throughout the region. In order to find attainable housing, many such households must travel long distances between their homes and their jobs, and/or must pay more than 30% of their household income (rent or mortgage) to attain a home. The types of housing that would benefit these households most and meet the identified need in the region include apartments, duplexes, townhomes, cottages, manufactured homes and accessory dwelling units (ADUs), as the more common single-family detached dwelling is unaffordable to the average Walla Walla resident or worker.

The analysis shown in this report can be used to assess the City of Walla Walla's progress in addressing identified housing needs and gaps from both the 2018 Comprehensive Plan and the HAP, as well as those identified through state mandated planning targets, and ultimately will help to identify new and updated policies to address current and future housing needs.

Data Sources

This HNA utilizes data from the U.S. Census Bureau, particularly the 2020 Decennial Census, as well as the most recently available 2018-2022 American Community Survey (ACS) 5-year Estimates, and data from the 2016-2020 HUD Comprehensive Housing Affordability Strategy (CHAS). Additional data was sourced from the Washington State Office of Financial Management. All data sources are cited throughout the document.

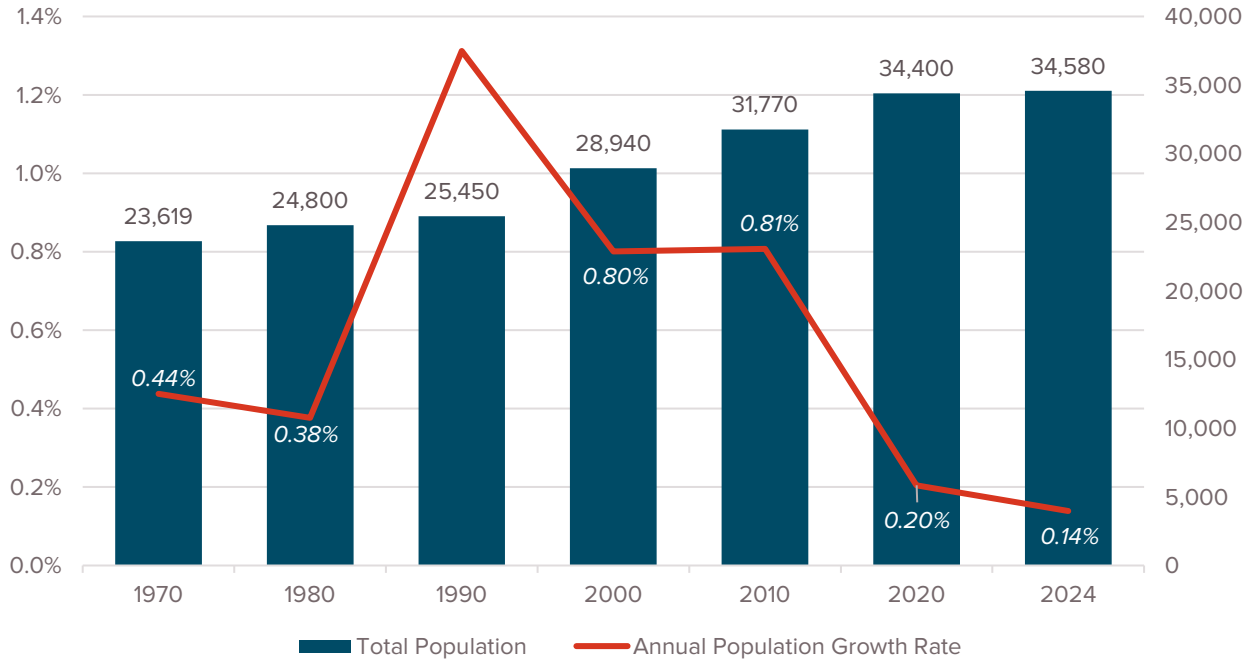
Community Profile

This section summarizes key data on Walla Walla's population, demographics, and household characteristics to understand current and future housing needs in the city.

Population Characteristics

Population Growth

Walla Walla's population is growing, but at a slower rate than in past decades. Recent and projected population growth are important indicators for predicting future housing demand. According to the Washington Office of Financial Management (OFM), as of 2024 there were an estimated 34,580 residents in Walla Walla. Since the 2020 Census, the city's population has grown by about 0.14 percent. The decade of the fastest population growth was the 1990s, with a 1.31 percent annual growth rate, slowing down since the 2000s.

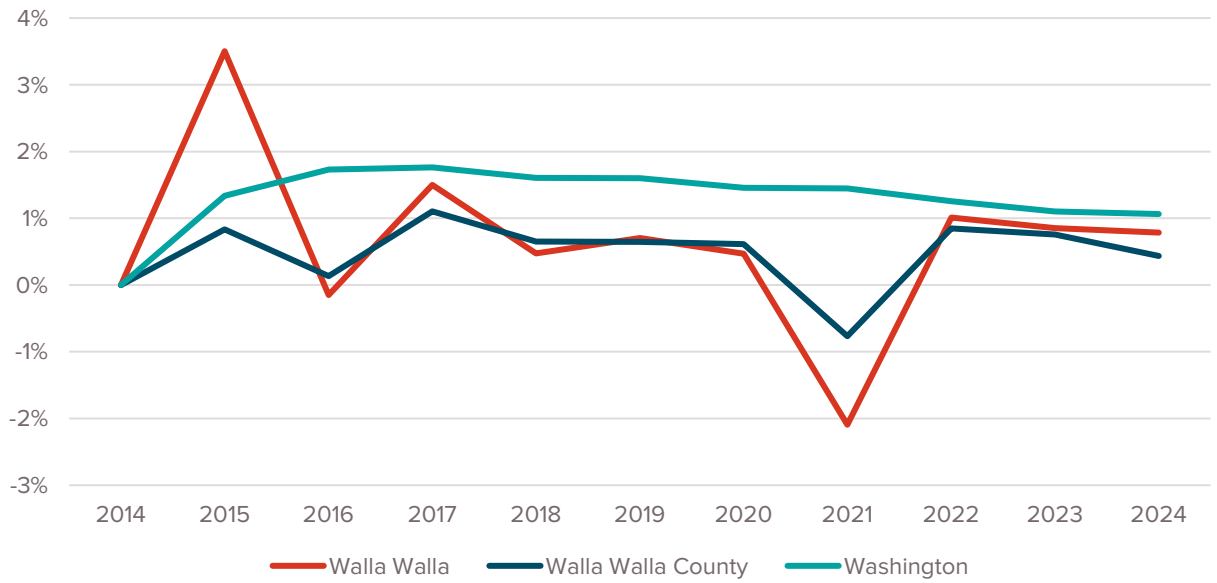


Appendix I Figure 1. Historic Population Growth in Walla Walla, 1970-2024

Source: U.S. Census Bureau Decennial Census, Washington Office of Financial Management (OFM) Historic Population Data and April 1 Population Estimates.

Figure 2 shows that the Walla Walla population has generally grown at a slower rate than Washington State's total population over the past decade but has mostly kept pace with Walla Walla County. The city's growth rate has been as high as 3.5 percent in 2015, and as low as negative two percent in 2021, indicating a drop in the regional population during the COVID-19 pandemic that is largely explained by the loss of those living in group quarters.

"Group quarters" consist of military barracks, retirement and nursing homes, jails or prisons and student dormitories. With Walla Walla's prevalence of higher education institutions like Whitman College and Walla Walla Community College, and the location of the Washington State Penitentiary, it is estimated roughly 4,000 Walla Walla residents resided in group quarters between 2015 and 2020, a significant portion of which did not hold their residence in Walla Walla during 2021.



Appendix I Figure 2. Walla Walla Population Change with Regional Comparison, 2014-2024

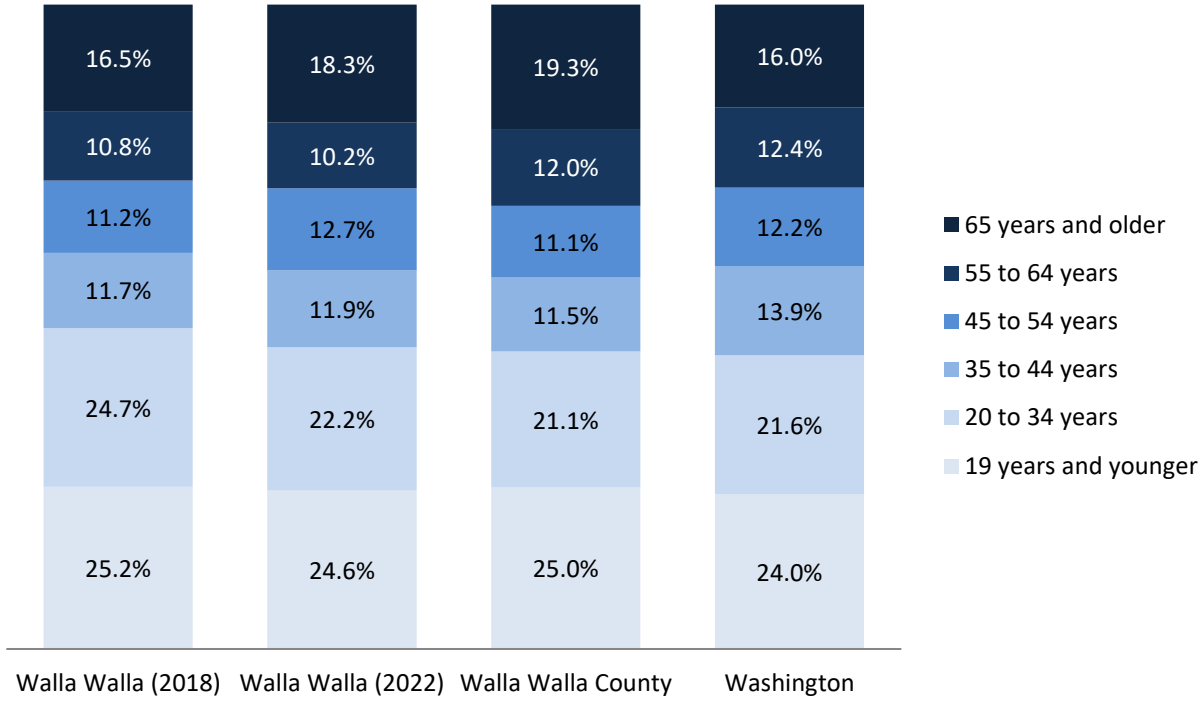
Source: U.S. Census Bureau Decennial Census, Washington Office of Financial Management (OFM) Historic Population Data and April 1 Population Estimates.

Population Projections

Based on Walla Walla County's adopted population projections, the City of Walla Walla has adopted a planning target of 39,884 residents in the city and 2,894 in the UGA by 2046. The city's population will account for 54.6 percent of the total county population. To accommodate this growth, the city has been allocated a target of 2,348 new housing units by 2046.

Population Age Distribution

Walla Walla's population is aging. The city's median age is 37.2 which aligns with the state and is slightly younger than the county's median age of 38. Since 2018, Walla Walla's population has witnessed a slight decline in the share of children and prime working-age adults, and a rise in the presence of seniors and retirees. The share of residents younger than 35 years old shrank from 49.9 to 46.8 percent of the population, while the 65 and older age bracket grew from 16.5 to 18.3 percent of the population. This could indicate that Walla Walla is in need of more starter homes for families to live and grow in town, which could include small lot, single-family detached units, as well as townhomes or multiplexes. These housing types may also contribute to a growing need for smaller housing units like condominiums, townhomes, and apartments amongst the city's aging population as they look to downsize. The Walla Walla Regional HAP determined a projected senior housing demand of 379 additional dwelling units by 2040.

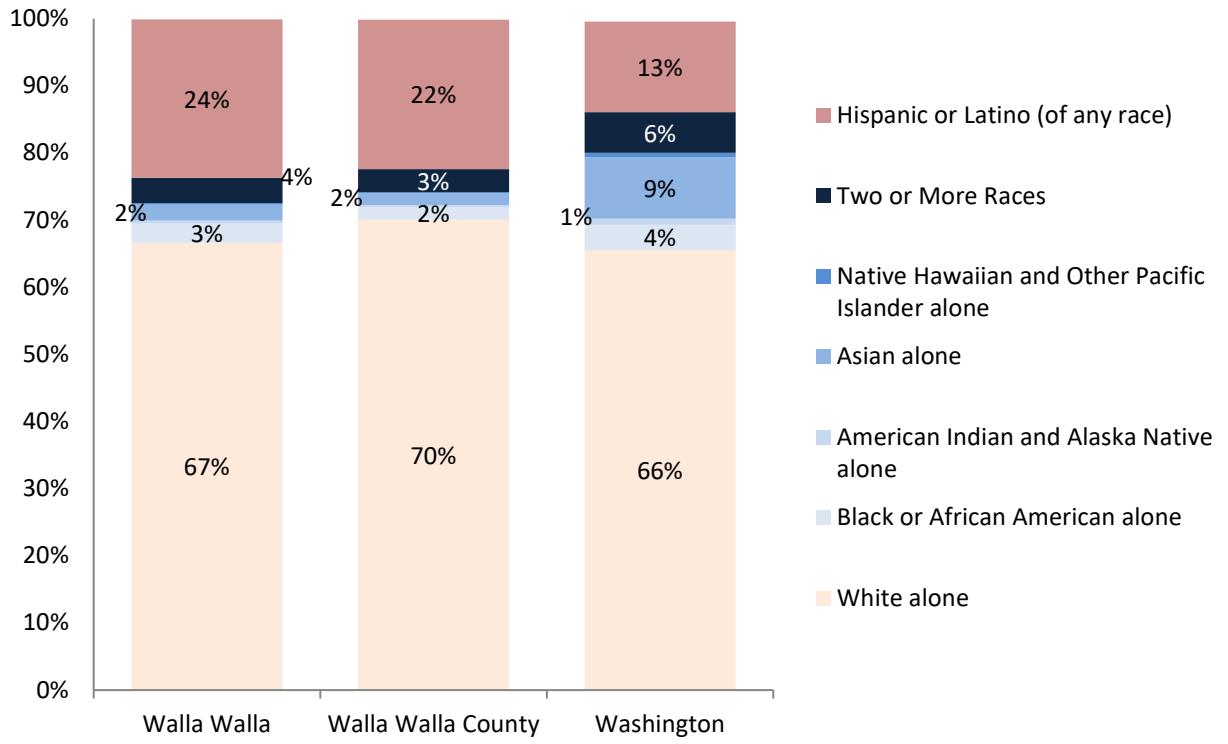


Appendix I Figure 3. Age Distribution in Walla Walla with Regional Comparison, 2022

Source: U.S. Census Bureau 2018, 2022 American Community Survey 5-Year Estimates, Table DP05

Population Diversity

In 2022, Walla Walla's racial and ethnic composition nearly mirrored the county's – both have a significantly larger proportion of Hispanic or Latino residents than the state, and both have become more diverse in recent years. Overall, all three geographies were about three-quarters White. However, the percentage of city and county residents who identified as Hispanic or Latino (24 and 22 percent, respectively) was almost double the share across the rest of the state (13 percent). The City of Walla Walla also had a lower share of Asian residents (2 percent), compared to statewide (nine percent). Notably, Walla Walla's share of Hispanic population has increased by 10 percentage points compared to the 2018 Comprehensive Plan housing study. The share of Black population also saw a 2.5 percentage point increase in that same period. Appendix IV. Racially Disparate Impacts Analysis explains more of the specific housing needs across race and ethnicity in Walla Walla.



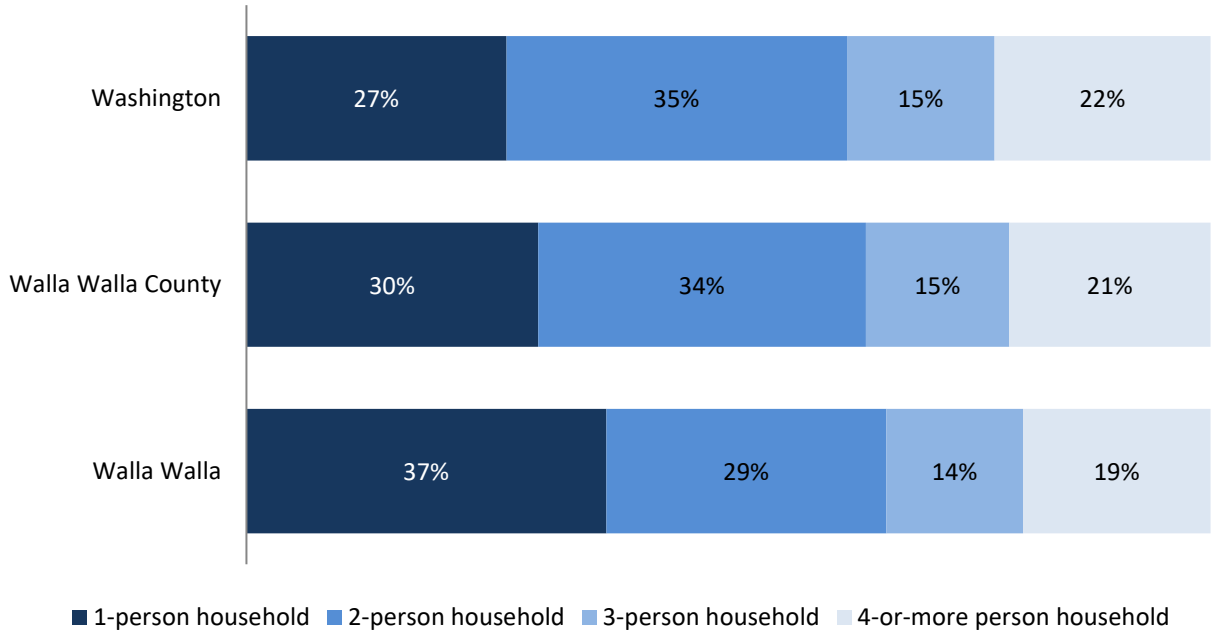
Appendix I Figure 4. Race and Ethnicity in Walla Walla with Regional Comparison, 2022

Source: U.S. Census Bureau 2022 American Community Survey 5-Year Estimates, Table DP05

Household Characteristics

Household Count and Size

The ACS estimates there are 12,865 households in Walla Walla, with an average household size of 2.36. This is slightly smaller than Walla Walla County's 2022 average household size of 2.5 and the statewide average of 2.53. A third of households have three or more people, in line with the county. Meanwhile, Walla Walla has a larger share of one-person households (37 percent) than the county (30 percent) and state (27 percent). Figure 5 visualizes the distribution of households in the city and the region. According to the Washington Office of Financial Management, the 2024 Postcensal estimated that the total number of housing units in Walla Walla is 14,189.



Appendix I Figure 5. Household Size in Walla Walla with Regional Comparison, 2022

Source: U.S. Census Bureau 2022 American Community Survey 5-Year Estimates, Table S2501

Household Types

Walla Walla has a lower share of family households than the county and the state, as well as a larger share of households living alone or households 65 years and over than the state. This may indicate a shortage of starter homes in the city to support young families, as well as indicate a potential need for smaller housing units or senior-accessible housing units. Table 1 below shows the makeup of Walla Walla households. Overall, 56 percent of households are family households, defined as two or more related family members living together in any combination. That percentage is lower than Walla Walla County (63 percent) and Washington State (64 percent). Of Walla Walla's family households, there is a lower share of married couples, yet a higher share of other family identities compared to the county and state. 45 percent of Walla Walla households have children, which is slightly higher than the county and state. The share of one-person households has decreased by 1.5 percentage points since 2018, and 2 and 3-person households have increased very slightly, accounting for the slight increase in average household size.

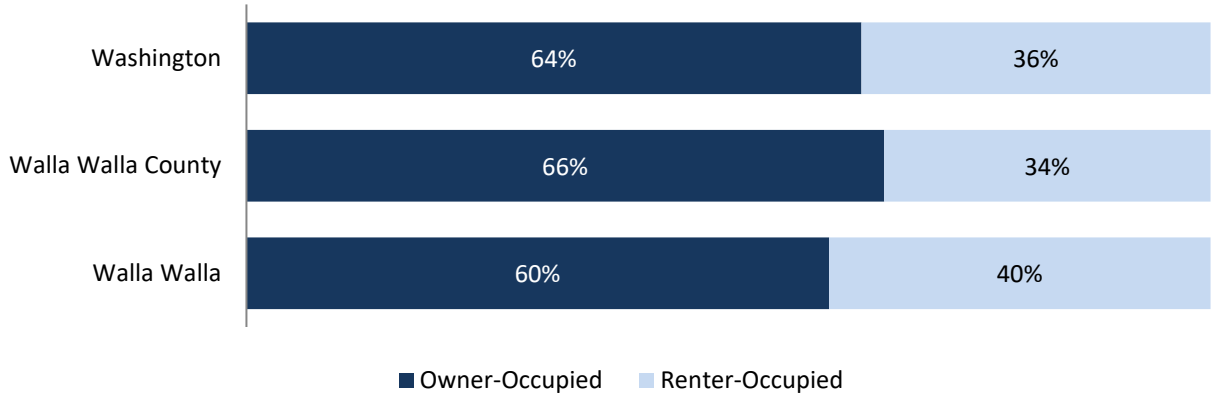
Appendix I Table 1. Household Types in Walla Walla with Regional Comparison, 2022

	Walla Walla Total	Walla Walla Share	Walla Walla County Total	Walla Walla County Share	Washington Total	Washington Share
Total Households	**12,865**		**22,978**		**2,979,272**	
Family households	**7,155**	**56%**	**14,526**	**63%**	**1,910,770**	**64%**
Married-couple family	5,231	73%	11,402	78%	1,482,230	78%
Other family	1,924	27%	3,124	22%	428,540	22%
With own children of householder under 18 years	3,218	45%	5,999	41%	814,890	43%
Nonfamily households	**5,710**	**44%**	**8,452**	**37%**	**1,068,502**	**36%**
Householder living alone	4,801	84%	6,950	82%	803,383	75%
Householder 65 years and over	2,207	39%	3,278	39%	313,547	29%

Source: U.S. Census Bureau 2022 American Community Survey 5-Year Estimates, Table S2501

Household Tenure

In Walla Walla, most housing units are owner-occupied, a similar percentage to that of Walla Walla County and Washington State. As shown below in Figure 6, renters represented 40 percent of households as of 2022, a slight decrease from 2018.

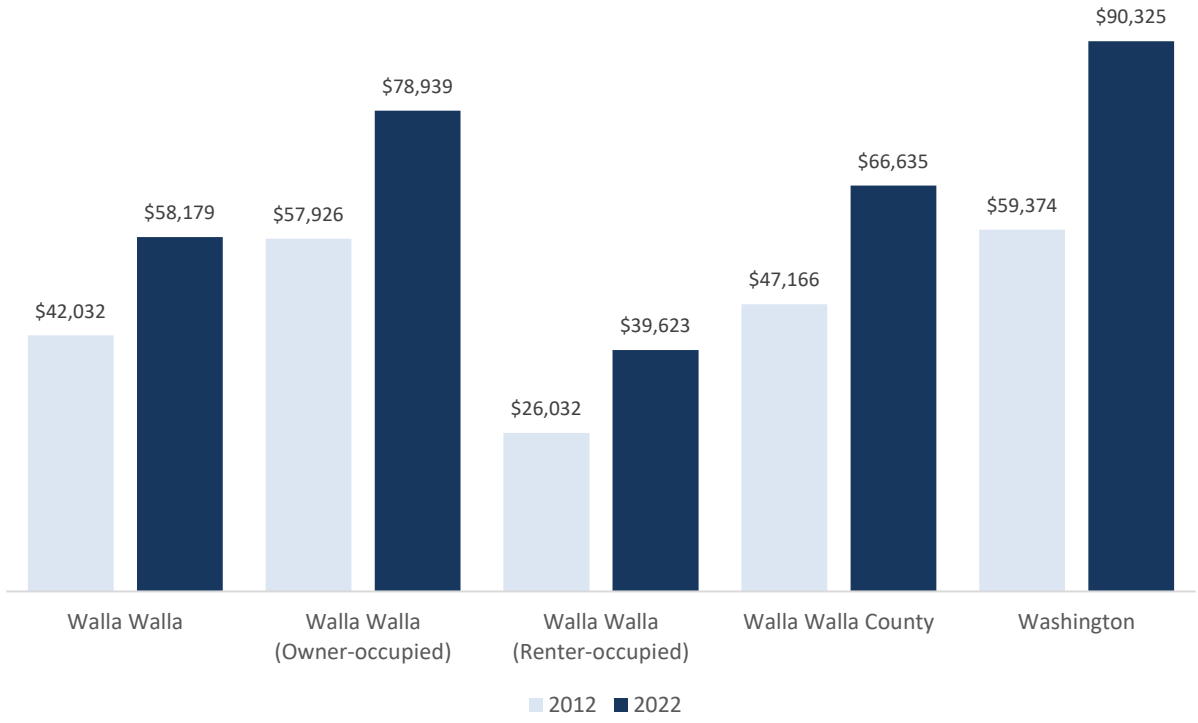


Appendix I Figure 6. Household by Tenure in Walla Walla (with Regional Comparison), 2022

Source: U.S. Census Bureau 2022 American Community Survey 5-Year Estimates, Table S2501

Household Income and Cost Burden

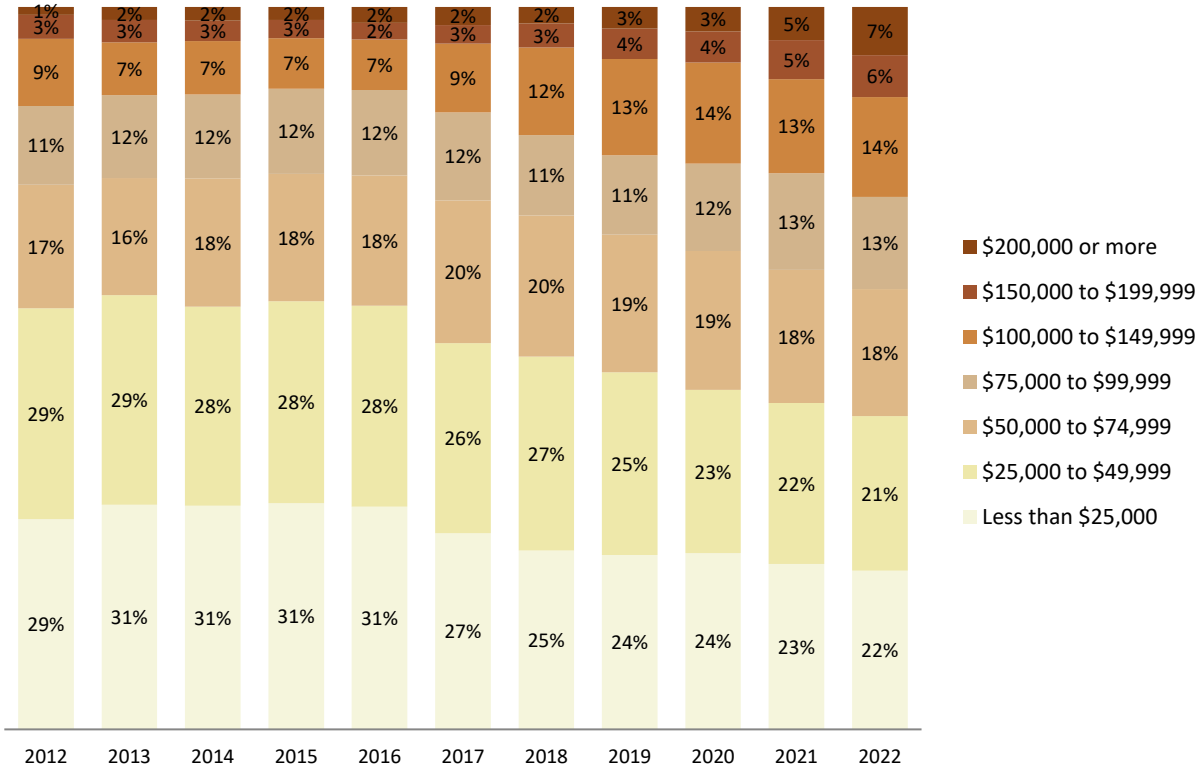
Walla Walla's median household incomes are generally lower than Walla Walla County and Washington State averages. Since 2012, income in Walla Walla has increased by about 38 percent, from $42,032 to $58,179 (inflation-adjusted). This is a slower increase than both Walla Walla County (41 percent) and Washington (52 percent) over the same period. Households who own their homes in Walla Walla make more than twice as much as renter households, as shown below in Figure 7. **Although renter households are often smaller on average than ownership households, the income discrepancy between homeowners and renters indicates the potential for higher displacement risk among renter households.**



Appendix I Figure 7. Median Household Income in Walla Walla with Regional Comparison, 2012 vs. 2022

Source: U.S. Census Bureau 5-Year ACS, Table S2503.

Appendix I Figure 8 shows the change in income levels over the past 10 years. In 2012, 75 percent of Walla Walla's households had income below $75,000; that share dropped to 61 percent of households in 2022. This decline is partially caused by inflation and the overall rise in median income; however, as shown below, **the percentage of households earning more than $150,000 has more than tripled from 4 percent to 13 percent since 2012, indicating a trend of higher income households moving to Walla Walla.**



Appendix I Figure 8. Household Income in Walla Walla by Income Brackets, 2012-2022

Source: U.S Census Bureau 5-Year ACS, Table S2503.

The U.S. Department of Housing and Urban Development (HUD) determines a countywide area median income (AMI) for each county. In 2024, the Walla Walla County AMI was $90,200 for a 4-person household. The HUD AMI is generally higher than the Census-reported median household income (see Appendix I Figure 7 as an example) since AMI is based on the Census-reported median family income, which excludes non-family households (one-person households and multi-person households of unrelated individuals). HUD defines households as "Extremely low income" if they earn 30 percent AMI or less, "very low income" if they earn 30-50 percent AMI, and "low Income" if they earn 50-80 percent AMI.

Table 2 shows these three levels of AMI income limits in Walla Walla County. These figures are used to determine the maximum rent that households at each income level would pay in subsidized housing at the respective income level, based on household size. This metric is used to determine eligibility for subsidized affordable housing.

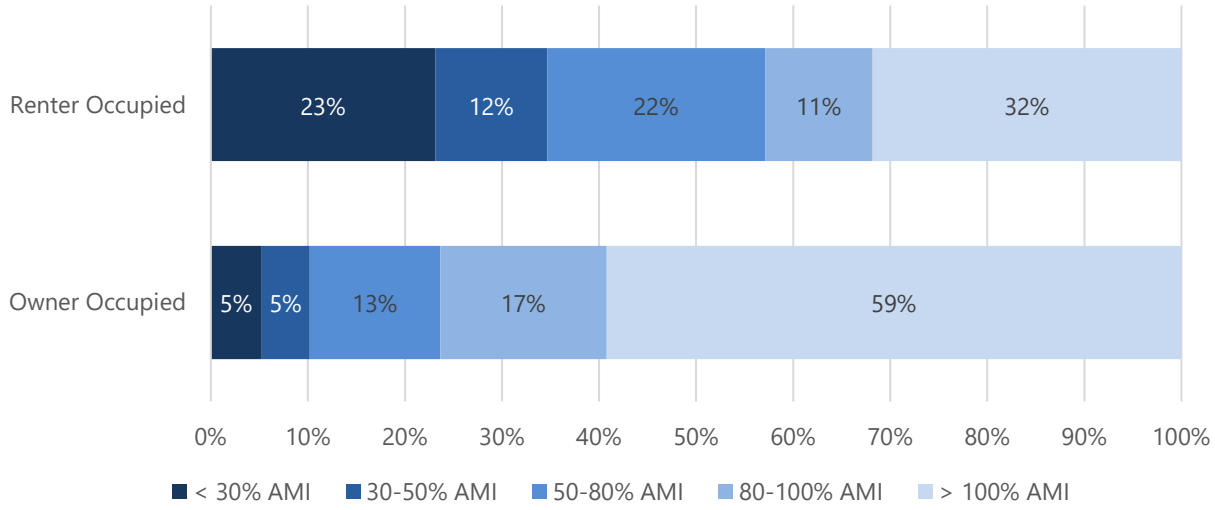
Appendix I Table 2. HUD Income Limits for Walla Walla County, 2024

Persons in Family:	1	2	3	4	5	6	7	8
Extremely Low Income (30% AMI)	$18,950	$21,650	$25,820	$31,200	$36,580	$41,960	$47,340	$52,720
Very Low Income (50% AMI)	$31,600	$36,100	$40,600	$45,100	$48,750	$52,350	$55,950	$59,550
Low Income (80% AMI)	$50,550	$57,750	$64,950	$72,150	$77,950	$83,700	$89,500	$95,250

Source: U.S. Department of Housing and Urban Development (HUD).

While fewer Walla Walla households are considered low-income (households earning less than 80 percent AMI) than 10 years ago, there remains many more low-income renter households than owner households.

Figure 9 shows a breakdown of Walla Walla households by tenure and income, as a percentage of AMI. Compared to estimates shown in the 2018 Comprehensive Plan, the share of low-income households (those making less than 80 percent AMI) has decreased from 49 percent of households to 35 percent of households. However, nearly 57 percent (2,388) of renter households are earning less than 80 percent AMI and could be eligible for subsidized affordable housing compared to 24 percent (1,853) of owner households. In 2018, the latest estimates showed 68 percent of renters and 33 percent of owners earned less than 80 percent AMI. This represents a roughly 10 percentage point decrease in the share of households earning less than 80 percent AMI.

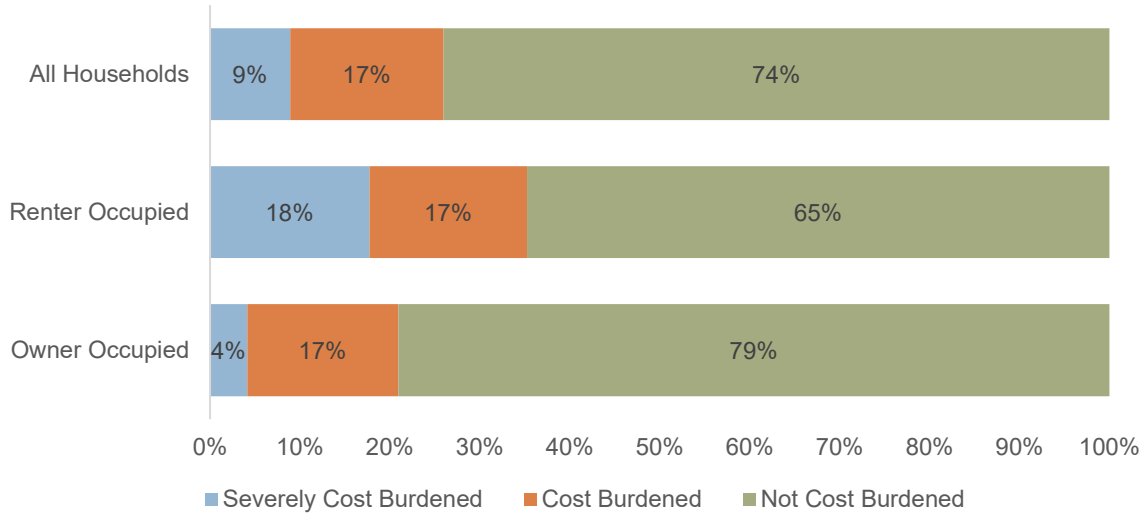


Appendix I Figure 9. Household Income as a Percentage of AMI by Tenure in Walla Walla, 2020

Source: 2016-2020 HUD Comprehensive Housing Affordability Strategy (CHAS).

While the estimated number of cost burdened households has decreased since 2018, Walla Walla renters continue to bear heavier "cost burden" than homeowners, which reflects a need for more affordable rental housing in the city. HUD considers a household to be "cost-burdened" if it spends more than 30 percent of its income on housing, including rent or mortgage and utilities. A household is considered "severely cost-burdened" if it spends more than 50 percent of income on housing.

Figure 10 shows Walla Walla households by cost burden and tenure. Overall, 26 percent of households are cost-burdened, and nine percent of all households are severely cost-burdened. Renters face higher levels of cost burden than owner households, with 35 percent of renter households meeting the cost burden criteria (i.e., spending more than 30 percent of their income on housing) compared to 21 percent of homeowners. This data represents an improvement over 2017, when 49 percent of renters were cost-burdened and 27 percent of owners were cost-burdened. Overall, the share of all households experiencing cost burden declined by 10 percentage points (from 36 percent to 26 percent).

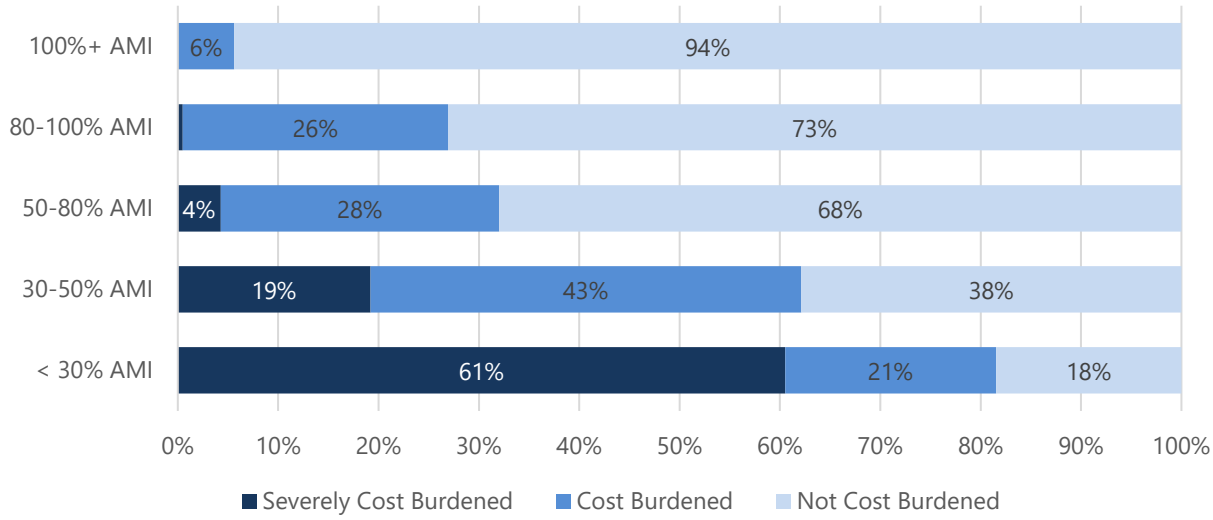


Appendix I Figure 10. Cost Burdened Households by Tenure in Walla Walla, 2020

Source: 2016-2020 HUD Comprehensive Housing Affordability Strategy (CHAS).

Many of Walla Walla's lowest-income households are severely cost burdened, showing the need for more affordable housing most likely in the form of subsidized rental units.

Figure 11 shows that 1,144 (82 percent) of Walla Walla's extremely low-income households (earning 30 percent AMI or below) are cost-burdened, with 74 percent of cost-burdened households in this income bracket spending more than half their income on rent. Among households earning less than 50 percent AMI, 74 percent are cost burdened, and 47 percent of low-income households earning 50 to 80 percent AMI are cost burdened.



Appendix I Figure 11. Cost Burden and Household Income in Walla Walla (All Occupied Units), 2020

Source: 2016-2020 HUD Comprehensive Housing Affordability Strategy (CHAS).

Measures of Economic Hardship – ALICE Framework

The Walla Walla Regional HAP utilized a measure of households experiencing economic hardship called ALICE (Asset Limited, Income Constrained, Employed). Developed by United Way, the framework recognizes shortcomings in measuring economic hardship by utilizing federal poverty statistics and provides a new measure of economically distressed households that reflects more localized costs of living.

ALICE data are calculated for each county across the United States, and considers total cost of household essentials, including housing, childcare, food, transportation, technology, and health care, plus taxes and a 10 percent contingency. More information can be found at Methodology | UnitedForALICE.

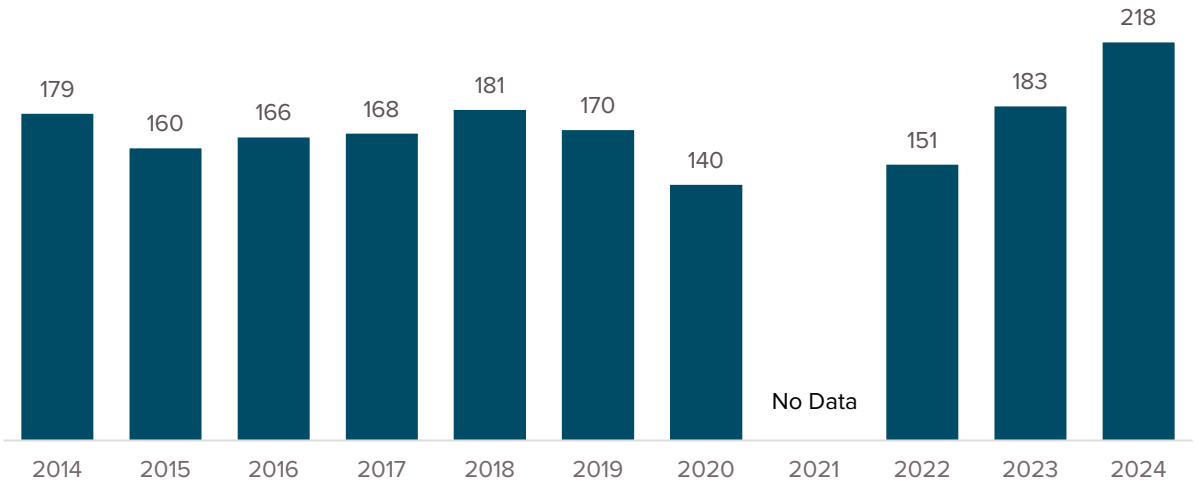
As of 2022, it was estimated that 45 percent of all households in Walla Walla County were either in poverty (13 percent) or in the ALICE category (32 percent), an increase from 42 percent in 2018, as cited in the Regional HAP. In the City of Walla Walla, an estimated 52 percent of households in 2022 were either living below the federal poverty level (17 percent) or in the ALICE category (35 percent), an increase from 49 percent in 2018.

The ALICE data shows an increase in poverty despite HUD showing that the number of cost-burdened households in Walla Walla has been decreasing. This is likely because ALICE includes costs beyond housing, including childcare, food, transportation, and health care. Nationwide, the

costs of these necessities have been increasing significantly since 2020. Although housing prices are stabilizing, households are likely still struggling to afford everyday essentials.

Homeless and Unhoused Population

As of 2024, the annual Point-in-Time Count found that there were 218 homeless residents in Walla Walla County. This is an increase when compared to 2023, when there were an estimated 183 homeless residents in the county. As shown below in Figure 12, after remaining relatively consistent, the number of estimated homeless individuals in the county reached its highest point in the past decade in 2024. Walla Walla County did not conduct a count of residents experiencing unsheltered homelessness in 2021 due to the COVID-19 pandemic. According to the Walla Walla Alliance for the Homeless, there were 221 homeless residents countywide that year.



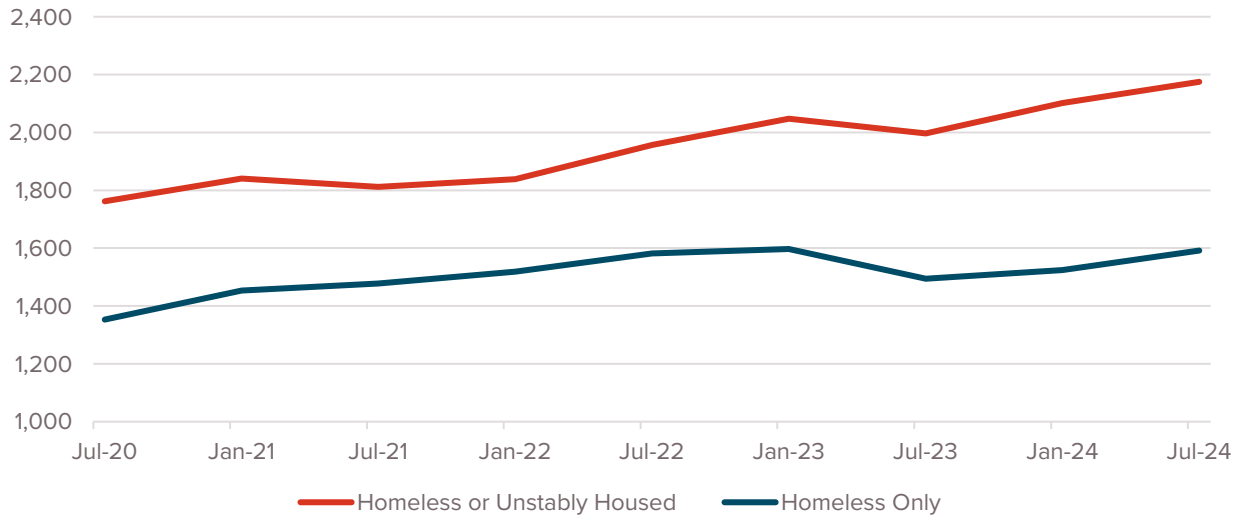
Appendix I Figure 12. Walla Walla County Point-In-Time Homeless Census, 2014-2024

Source: Walla Walla County Annual Point-in-Time Count

The Department of Commerce also reports data on persons who are homeless or unstably housed within its Snapshot of Homelessness in Washington State report. The dataset is derived from several data sources, including Medicaid records, which tracks homelessness when people access medical services, data from numbers of people accessing economic services such as Basic Food and Temporary Assistance for Needy Families (TANF), and data from local homelessness service providers collected by the Department of Commerce. The Snapshot reports two categories of "Homeless or Unstably Housed" and "Homeless Only," which helps to depict both those that are literally homeless, as well as those with intermittent struggles with sustainable housing. The Snapshot definition of these terms is below:

"Homeless or Unstably Housed" refers to all clients or households experiencing any homelessness or housing instability (e.g., they are literally homeless/unsheltered, receiving housing services that indicate housing instability, residing in transitional housing, or couch surfing). "Homeless Only" is a subset of the "Homeless or Unstably Housed" population and includes unsheltered clients/households who lack a fixed nighttime residence, are living outside or in a shelter not fit for human habitation or are living in emergency shelter.

Figure 13 shows a consistent trend over the past five years, like the point-in-time data above, with a gradual increase in persons and households experiencing homelessness or housing instability within the county.



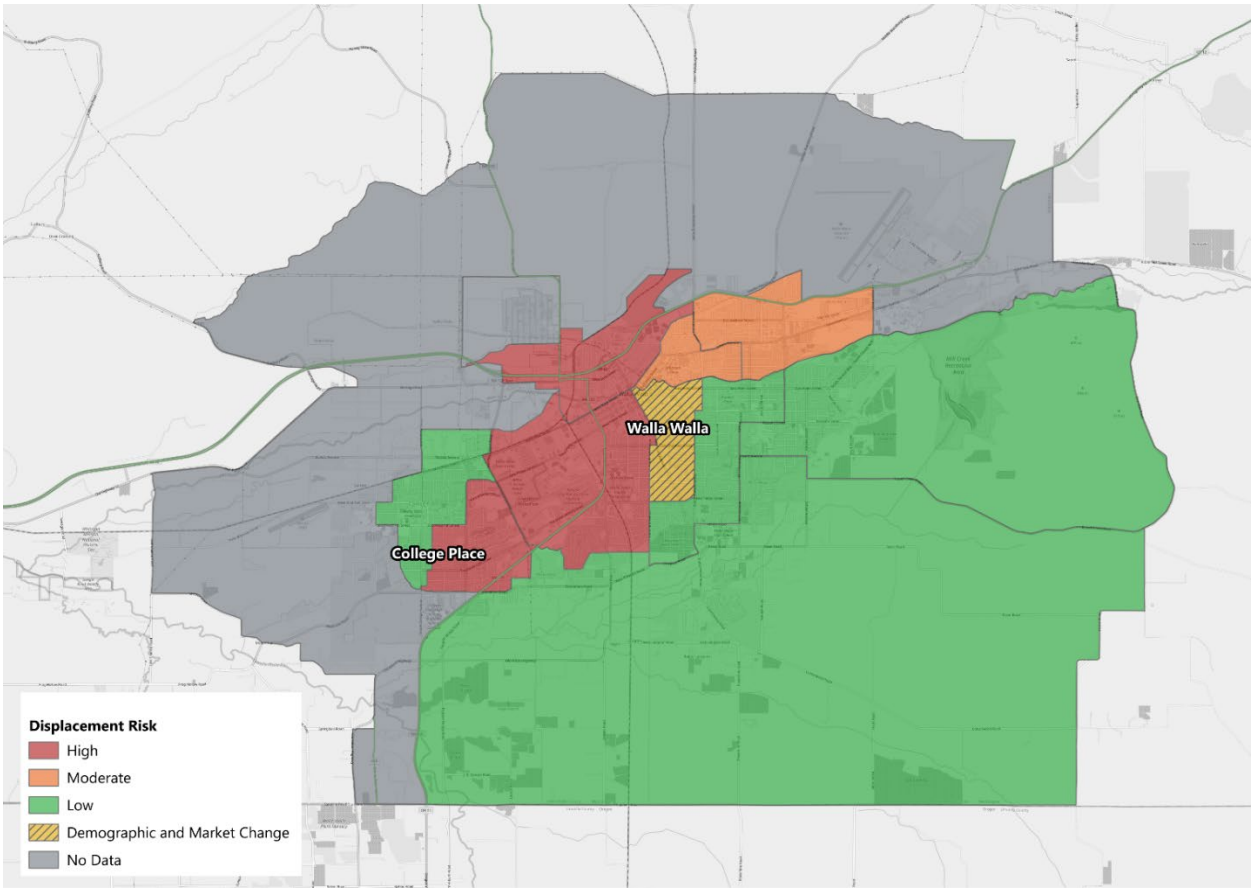
Appendix I Figure 13. Snapshot of Homelessness Counts in Walla Walla County, July 2020-July 2024

Source: Washington Department of Commerce Snapshot of Homelessness in Washington State (2024).

Walla Walla has the highest concentration of displacement risk in the county, with some households already be experiencing displacement. According to the Washington Department of

Commerce's draft Displacement Risk Map, most of the Walla Walla census tracts on the west side of the city, including downtown Walla Walla, face a high risk of displacement. Census tracts on the northeast side of the city face a moderate risk of displacement. These designations represent recently increasing average rents, along with a higher-than average proportion of Black, Indigenous, and people of color (BIPOC), renter, and lower-income households. The neighborhood southeast of downtown is designated as having already experienced "Demographic and Market Change", a measure indicating existing trends across three categories of analysis: a decrease in BIPOC populations and increase in incomes, an increase in rents between 2010 and 2020, and a prevalence of BIPOC, renter, and lower-income households.

As noted by the Department of Commerce, "These findings alone do not confirm displacement or risk of displacement, but act as a starting point for additional analysis and community engagement to determine the scope of displacement or displacement risk, the communities most impacted by displacement or displacement risk and the root causes of that displacement pressure." Walla Walla should continue observing market and social conditions citywide and working with local community-based organizations to identify neighborhoods where residents may be at risk of displacement.



Appendix I Figure 14. Displacement Risk Map for Walla Walla

Source: Washington Department of Commerce Draft Displacement Risk Map.

Workforce Profile

This section describes Walla Walla's workforce and job sectors, jobs-to-housing ratio, and employment trends and projections, which can help inform the city's future housing needs.

Local Workforce Characteristics

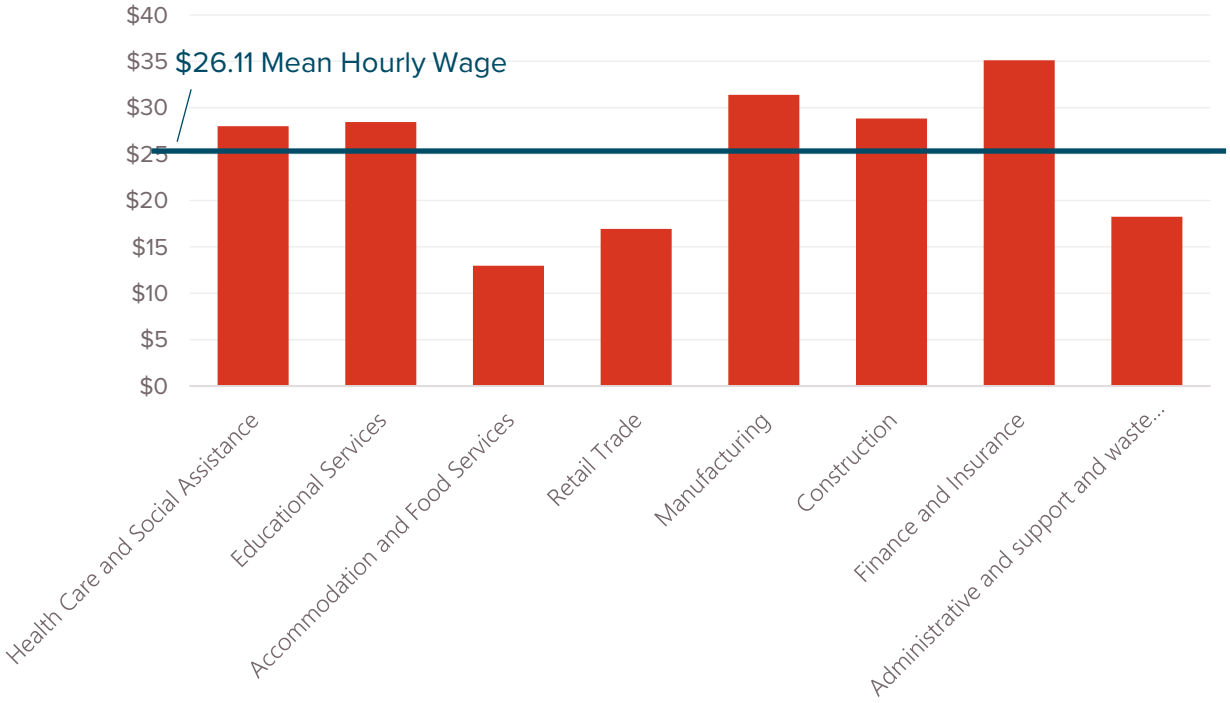
According to the latest U.S. Census Longitudinal Employer-Household Dynamics (LEHD) data, there were 15,754 jobs in Walla Walla in 2022. Figure 14 shows change in employment by job sector since 2012. The top sector in the city is health care and social assistance, which grew by almost 11 percent over the past decade, a total of 386 jobs. Between 2012 and 2022, the educational services sector saw the highest employment gains, adding 797 jobs, while accommodation and food services and public administration added 430 and 379 jobs, respectively. The largest declines in employment occurred in the other services, retail trade, and finance and insurance sectors. The other services sector includes a wide range of jobs, including equipment and machine repair, religious activities, advocacy, dry cleaning, personal care, and pet care services, as well as losses in retail trade and finance and insurance. While health care, education, and public administration jobs tend to provide relatively high wages, accommodation and food services jobs tend to be some of the lowest paid in the local workforce. Growth across these sectors indicates a need for housing affordable to residents at a variety of income levels, including subsidized housing for lower-wage workers.

	2012	2022	Change	% Change
Educational Services	1,105	1,902	797	72%
Accommodation and Food Services	1,385	1,815	430	31%
Health Care and Social Assistance	3,664	4,050	386	11%
Public Administration	1,547	1,926	379	24%
Construction	352	551	199	57%
Arts, Entertainment, and Recreation	197	355	158	80%
Administration & Support, Waste Manage	279	397	118	42%
Wholesale Trade	278	393	115	41%
Agriculture, Forestry, Fishing and Hunting	76	153	77	101%
Manufacturing	839	881	42	5%
Professional, Scientific, and Technical Serv	339	371	32	9%
Utilities	68	86	18	26%
Transportation and Warehousing	133	148	15	11%
Management of Companies and Enterpris	27	41	14	52%
Mining, Quarrying, and Oil and Gas Extrac	1	4	3	300%
Real Estate and Rental and Leasing	181	180	(1)	-1%
Information	263	247	(16)	-6%
Retail Trade	1,620	1,470	(150)	-9%
Finance and Insurance	640	460	(180)	-28%
Other Services (excluding Public Administr	950	324	(626)	-66%
	13,944	**15,754**	**1,810**	

Appendix I Figure 15. Jobs by Sector in Walla Walla, in 2012 vs. 2022

Source: U.S. Census Bureau Longitudinal Employer-Household Dynamics (LEHD) via Census OnTheMap.

The mean hourly wage in Walla Walla County in 2023 was $26.11 (roughly $54,312 in gross annual income). Figure 15 below shows the mean hourly wage for jobs in the top employment sectors in Walla Walla County. The city's top employment sector, health care and social assistance, pays $28.00, which is higher than the county's average; Finance and insurance—the highest-paying sector behind utilities—pays $35.12, though the number of jobs in this sector has declined by 28 percent in the past 10 years.

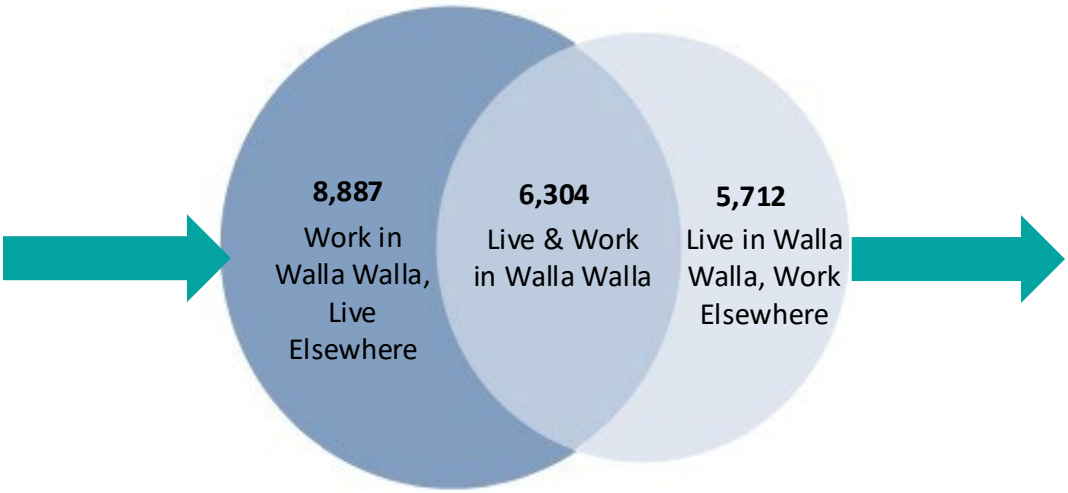


Appendix I Figure 16. Mean Hourly Wage for Jobs in Top Employment Sectors in Wall Walla County, 2023

Source: U.S. Bureau of Labor & Statistics Quarterly Census of Employment and Wages. Note: This table excludes rows with suppressed employment and wages, e.g. "Professional, scientific, and technical services".

Commute Patterns

Figure 16 visualizes commuter inflow and outflow in Walla Walla. The city has about 3,000 more commuters coming in daily for work than it has residents commuting out of the city for work. In Walla Walla, 60 percent of workers in the city also live in the city. Top destinations for commuting include College Place, WA (5 percent), Kennewick (3 percent), and Spokane (3 percent). Smaller shares also work in Pasco, Richmond, and Seattle. College Place is less than a 10-minute drive from Walla Walla. Some of the residents reported as commuting out of the city may be remote employees working from home in Walla Walla but employed in cities that are farther away, like Seattle. For in-commuting, about 15 percent of workers in Walla Walla live in College Place, 6 percent live in Milton-Freewater, OR, and 4 percent live in Kennewick. Smaller shares live elsewhere throughout the county.



Appendix I Figure 17. Commute Patterns in Walla Walla, 2021

Source: U.S. Census Bureau Longitudinal Employer-Household Dynamics (LEHD) via Census OnTheMap

Table 3 shows the regional comparison of the work-home destinations. As described above, the top destination for both Walla Walla's out-commuters and in-commuters after Walla Walla is College Place. Commuting inflow/outflow data is roughly similar at the county level, except in-commuting to Walla Walla County is more distributed to other geographies. Notably, the share of people employed in Walla Walla County who commute from the City of Walla Walla is 30 percent, while the share of people employed in the City of Walla Walla who commute from Walla Walla City is 60 percent. Note that "all other locations" includes unincorporated areas.

Appendix I Table 3. Location of worker residence versus employment, 2021

	Walla Walla Count	Walla Walla Share	Walla Walla County Count	Walla Walla County Share
Places Where Workers are Employed (All Jobs)				
Total	**12,016**		**21,793**	
Walla Walla city, WA	6,304	52%	10,125	46%
College Place city, WA	608	5%	1,342	6%
Kennewick city, WA	356	3%	757	3%
Spokane city, WA	324	3%	576	3%
Pasco city, WA	264	2%	748	3%
Richland city, WA	214	2%	374	2%
Spokane Valley city, WA	171	1%	300	1%
Seattle city, WA	132	1%	241	1%
Milton-Freewater city, OR	126	1%	245	1%
Yakima city, WA	91	1%	-	-
Dayton city, WA	-	-	182	1%
All Other Locations	3,426	29%	6,903	32%
Places Where Workers Live (All Jobs)				
Total	**10,569**		**25,609**	
Walla Walla city, WA	6,304	60%	7,958	31%
College Place city, WA	1,579	15%	2,266	9%

	Walla Walla Count	Walla Walla Share	Walla Walla County Count	Walla Walla County Share
Milton-Freewater city, OR	597	6%	858	3%
Walla Walla East CDP, WA	423	4%	546	2%
Kennewick city, WA	394	4%	1,487	6%
Pasco city, WA	379	4%	2,152	8%
Garrett CDP, WA	311	3%	477	2%
Richland city, WA	259	2%	597	2%
Waitsburg city, WA	165	2%	265	1%
Dayton city, WA	158	1%	-	-
Burbank CDP, WA	-	-	329	1%
All Other Locations	4,622	44%	8,674	34%

Source: U.S. Census Bureau Longitudinal Employer-Household Dynamics (LEHD) via Census OnTheMap

Jobs to Housing Ratio

According to the latest Census data, Walla Walla's employment (12,754) to housing (14,014) ratio is 0.91. A job-to-housing ratio at or near 1.0 suggests that residents have potential employment opportunities without having to commute excessively long distances, which is beneficial for reducing vehicle miles traveled. In addition, employers have a reasonable population base upon which to recruit workers.

Housing Supply

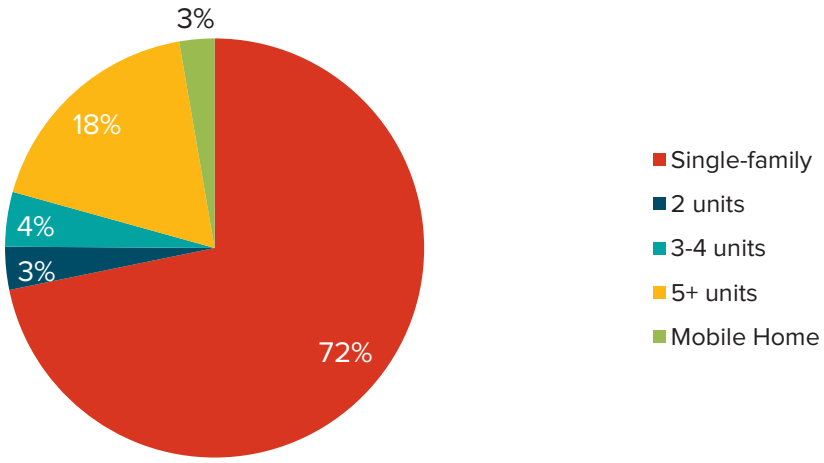
This section inventories Walla Walla's current housing stock and production trends, as well as local housing market data, including rental and sales prices, and housing affordability indicators and trends.

As stated above, the Regional HAP identified a need for the development of more "middle income" housing types, including apartments, duplexes, townhomes, cottages, manufactured homes and accessory dwelling units (ADUs) due to the ability to deliver these housing types at lower price points than more traditional single-family detached and mid-rise housing types. Specifically, the HAP identified demand for an additional 3,710 new dwelling units by 2040 in the Walla Walla UGA, with 1,142 standard lot single-family detached, 889 small lot, cottages or manufactured homes, 556 townhouses/plexes, 816 multifamily units (five or more units per structure), and 297 mobile homes/ADUs.

The analysis shown in this section can be used to identify whether progress has been made in meeting these needs.

General Housing Inventory

Walla Walla has a less diverse housing mix than the state. Walla Walla's housing stock is heavily dominated by single-family homes, with fewer multifamily units. Walla Walla had 14,014 housing units in 2022 according to the ACS. Figure 17 below shows that nearly three-quarters of housing units in the city are in single-unit buildings. About 14 percent of the housing stock is in "Middle Housing" types of between two and nine units. Another 12 percent of units are in multifamily apartments, with most units in buildings of 20 or more units. About 3 percent of Walla Walla's housing stock is in mobile homes. Washington has a higher proportion of multifamily apartment units (18 percent) and a slightly lower proportion of single-family units (71 percent) than Walla Walla. In Walla Walla County, 80 percent of housing is in single-family units, and 8 percent is in multifamily buildings with at least five units.

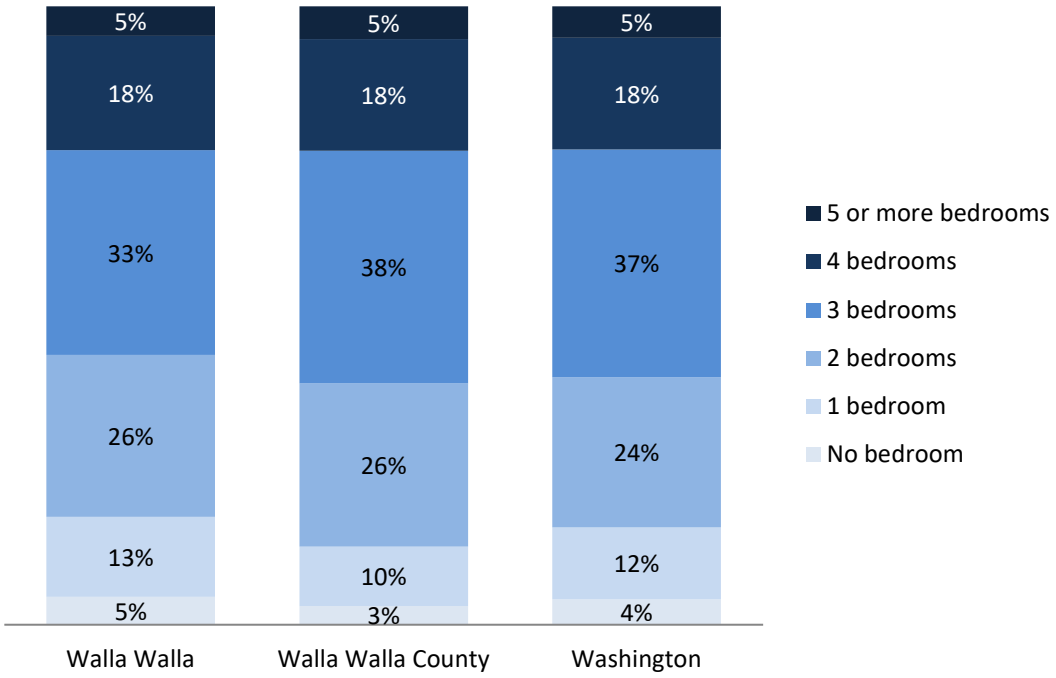


Appendix I Figure 18. Housing Unit Types in Walla Walla, 2022

Source: U.S. Census Bureau 2022 American Community Survey 5-Year Estimates, Table DP04.

Housing Unit Size

The largest segment of Walla Walla's housing stock is three-bedroom units (33 percent), as shown in Figure 18. Over half of the city's housing units have three or more bedrooms, a lower share than the county and state. Instead, Walla Walla has a slightly higher share of one-bedroom and studio units compared to the county and state, largely due to the high share of college-aged residents in Walla Walla. This correlates with the smaller household sizes and larger shares of one-person households discussed above under Households Characteristics.

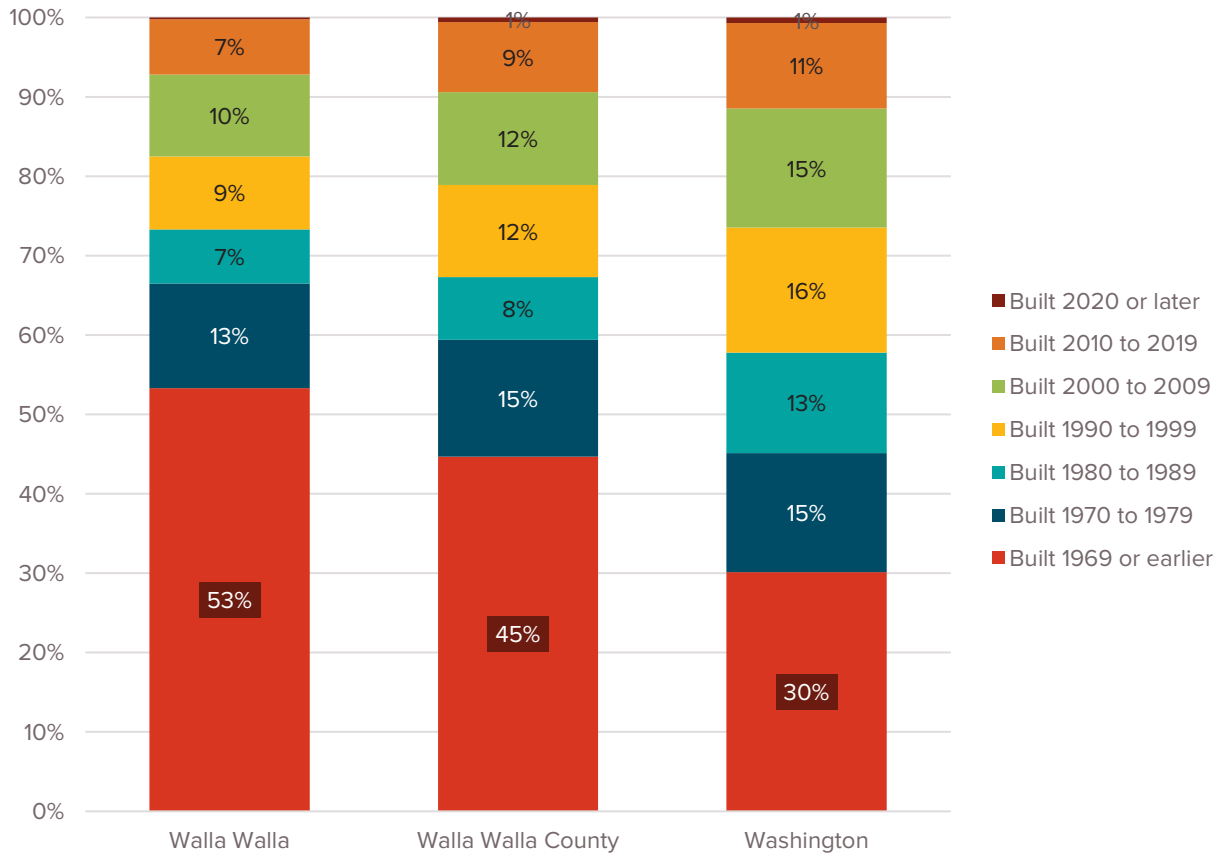


Appendix I Figure 19. Housing Unit by Bedroom Count in Walla Walla with Regional Comparison, 2022

Source: U.S. Census Bureau 2022 American Community Survey 5-Year Estimates, Table DP04

Housing Age

Figure 19 shows the age of existing housing structures by decade built. Walla Walla's housing stock is considerably older than in the county and state, with more than 53 percent of homes built prior to 1970. This suggests that considerable investment will be needed in coming decades to both maintain and reinvest in existing housing stock, as well as build new housing. This data also shows that Walla Walla has seen considerably less investment in new housing since 2010 when compared to the county and state, with less than 1 percent of the overall housing supply built since 2020.

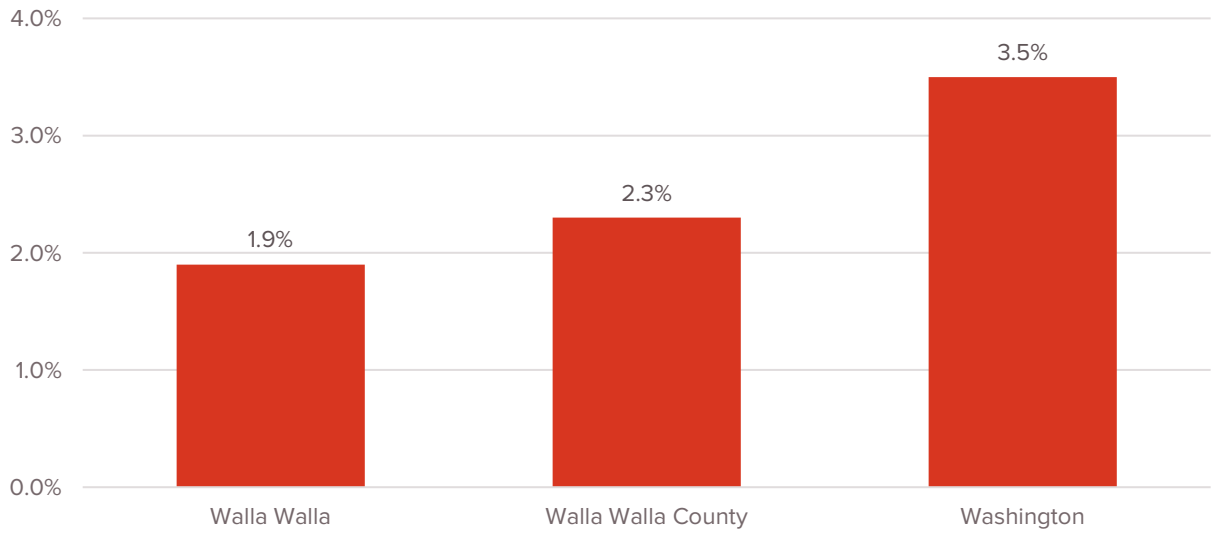


Appendix I Figure 20. Age of Existing Housing Units in Walla Walla, 2022

Source: U.S. Census Bureau 2022 American Community Survey 5-Year Estimates, Table DP04

Overcrowding

Overcrowding is defined by HUD as housing with occupants greater than one per room. While rates of overcrowding are lower in Walla Walla than in the county or state, Figure 18 shows that nearly 2 percent of households in Walla Walla live in overcrowded housing.



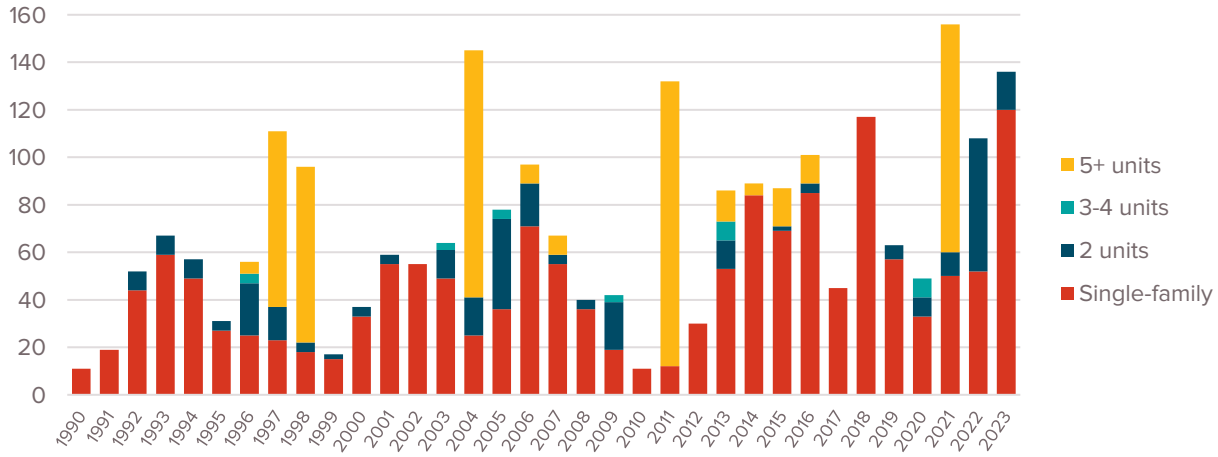
Appendix I Figure 21. Rates of Overcrowding in Walla Walla with Regional Comparison, 2022

Source: U.S. Census 2022 5-Year ACS, Table DP04

Housing Production

Figure 21 below shows housing units permitted since 1990. Since 2018, when the last Comprehensive Plan was published, a total of 629 units has been permitted, with 429 being single-family dwellings, compared to 104 in two- to four-unit structures, and 96 units in structures containing five or more units, all of which were permitted in 2021.

As noted above, the Regional HAP identified a need from 2020 to 2040 within the Walla Walla UGA for 556 townhouse or multiplex units, which correlate with the permits for two- to four-unit structures, as well as 816 multifamily units in structures of five or more units. **According to permit data, 18 percent of the needed middle housing and 12 percent of the needed multifamily has been produced since 2020, indicating significant progress is being made towards meeting the targets identified in the HAP, though a significant amount of new construction will need to continue in the coming years in order to keep up with expected demand.**



Appendix I Figure 22. Housing Unit Permits in Walla Walla, 1990-2023

Source: US Census Building Permits Survey

Subsidized Housing Inventory

The Walla Walla Housing Authority (WWHA) develops, owns, and operates affordable housing as well as providing rental assistance in Walla Walla. **The WWHA owns and manages 613 units and provides rental assistance to an additional 1,174 units.** The completion of Meadow Grove added 50 new one- and two-bedroom units to the city's affordable housing supply. Of the 613 units owned and managed by the WWHA, 128 are targeted at agricultural workers. There is also a nine-unit, 34-bed transitional program for homeless veterans. The target income to qualify for WWHA's programs is 60 percent AMI or below, and there are approximately 1,900 households on the waitlist. **The WWHA's programs have grown significantly since the early 1990s, when they owned 84 units and provided rental assistance to an additional 20.** They expect the number of subsidized units in Walla Walla to continue to grow.

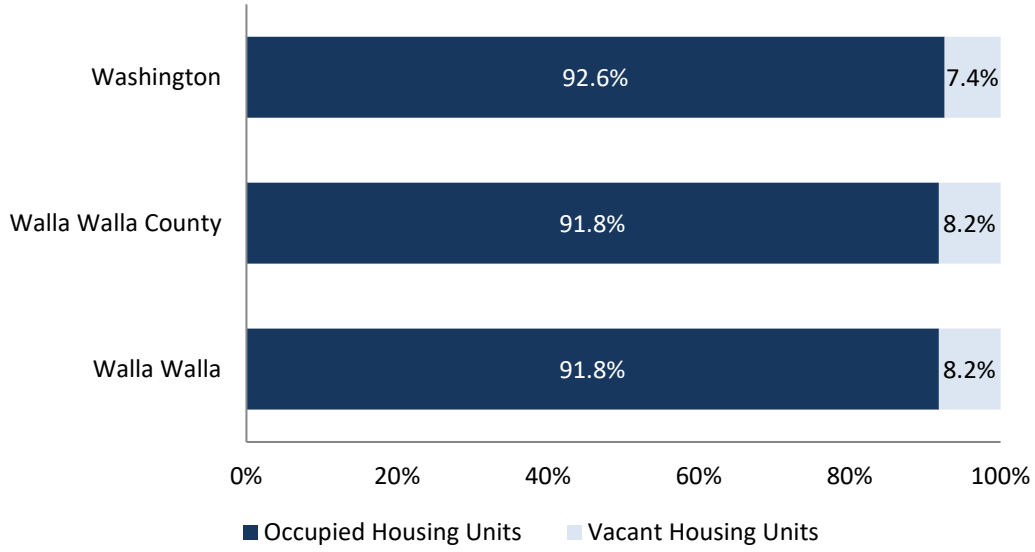


Appendix I Figure 23. Evergreen Commons Affordable Housing in Walla Walla
Source: Walla Walla Housing Authority

Housing Market Conditions

Occupancy

Walla Walla's occupancy rate is in line with the county's and slightly lower than the state's. Figure 23 below shows that in 2022, 91.8 percent of overall units in Walla Walla were occupied, according to the most recent ACS five-year estimates. This rate is the same as the county rate and a touch lower than the state rate. In 2022, 1,149 units were vacant in Walla Walla.



Appendix I Figure 24. Residential Occupancy Rates in Walla Walla with Regional Comparison, 2022

Source: U.S. Census Bureau 2022 5-Year ACS, Table DP04

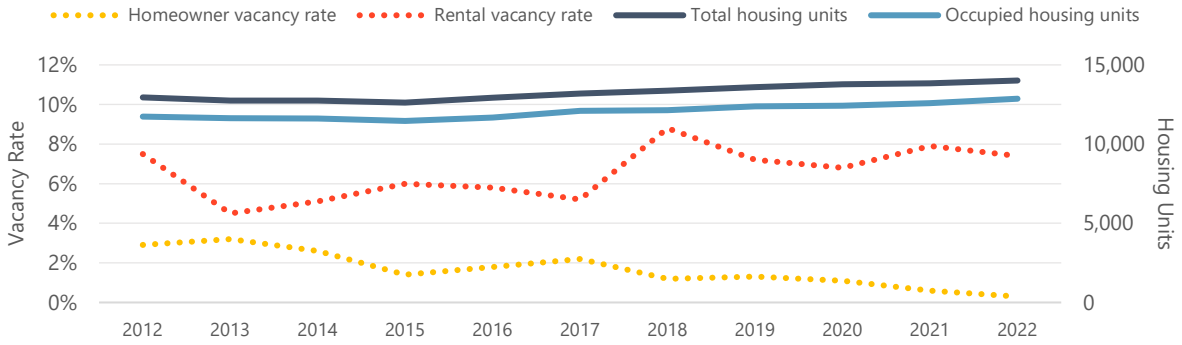
Table 4 shows the breakdown of vacant units by type. In 2022, 35 percent of vacant units were for rent (2.9 percent of all housing units in the city), and 11 percent of vacant units were dedicated for seasonal, recreational, or occasional use (less than 1 percent of all housing units). Washington has a higher share of seasonal use housing than the city and county. As of 2022, the rental vacancy rate is 7.4 percent in the city of Walla Walla and 7.6 percent in Walla Walla County. The homeowner vacancy rate is much lower – 0.3 percent in the city and 0.5 percent in the county. Since the previous Comprehensive Plan, the vacancy rate for rental units has increased by 7.5 percent, likely due to new multifamily construction coming online and going through a lease-up process.

Appendix I Table 4. Vacant Unit Types in Walla Walla with Regional Comparison, 2022

	Walla Walla Units	Walla Walla Share	Walla Walla County Units	Walla Walla County Share	Washington Units	Washington Share
Total Vacant Units	1,149	8.1%	2,054	8.2%	236,971	7.4%
For rent	406	2.9%	638	2.5%	45,935	1.4%
Rented, not occupied	11	0.1%	11	0.04%	12,427	0.4%
For sale only	25	0.2%	71	0.3%	14,761	0.5%
Sold, not occupied	53	0.4%	53	0.2%	11,041	0.3%
For seasonal, recreational, or occasional use	124	0.9%	284	1.1%	84,274	2.6%
For migrant workers	0	0.0%	42	0.2%	1,370	0.04%
Other vacant	530	3.8%	955	3.8%	67,163	2.1%

+-Source: U.S. Census Bureau 5-Year ACS, Table B25004

Walla Walla's rental vacancy rate indicates a relatively healthy market, with rental vacancies increasing as new housing units have been delivered. However, Walla Walla has a tight ownership housing market, reflected in the increased costs of ownership housing, and indicates a need for a wider range of ownership products. Figure 25 shows Census-reported total and occupied unit counts and vacancy rates in Walla Walla over the past decade for both ownership and rental units. Although ownership vacancy rates have declined, rental vacancy rates have gradually increased since 2012, from a low of 4.5 percent in 2013 to 7.4 percent in 2022. This trend indicates that production is likely keeping up with, or exceeding, demand for rentals/apartments in the city. High vacancy rates can make it easier for residents and workers to find housing but provide less incentive for new development. The current vacancy rates for rental housing are above what is considered a "healthy" vacancy rate, which is between 5 percent and 6 percent.



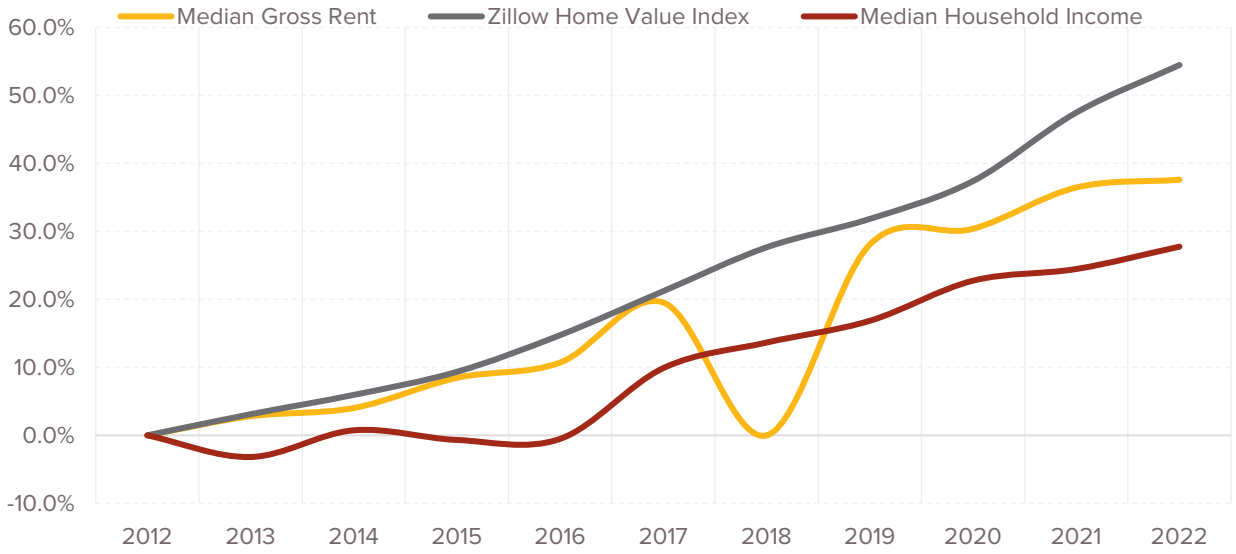
Appendix I Figure 25. Housing Vacancy Rates in Walla Walla, 2012-2022

Source: U.S. Census Bureau 2022 American Community Survey 5-Year Estimates, Table DP04

The relationship between Walla Walla's high vacancy rate and high displacement risk may suggest a combination of high prices, real estate speculation, physical housing stock problems, or other problems preventing the absorption of housing. Despite the city's higher vacancy rate for rental housing, the displacement risk (Map 1) shows that Walla Walla has a high displacement risk in most areas. This may indicate pressure on the ownership market in which higher-income households may be replacing historically lower-income households within the market. Areas with high displacement risk are often places with lower vacancy rates, as demand outpaces supply and lower-income residents are edged out of markets with less supply.

Home Prices

Home prices and median rents have outpaced increases in household incomes since 2012, with home values showing the largest increases. Figure 25 shows the percent change in rents, home values, and household incomes in Walla Walla from 2012-2022. Over this period, median household income increased by 27.8 percent and rents by 37.6 percent. Home values increased at a higher rate of 54.5 percent. Although rents fluctuated in the period between 2016 and 2020, they kept pace with income increases and home values. However, since 2017 home prices have risen at a higher annual rate than both income and rents. Median rents in Walla Walla, according to the 2022 ACS 5-year estimates data, are about $1,109 per month. This is 6 percent higher than Walla Walla County ($1,044), but 30 percent less than the statewide median of $1,592. According to the Zillow Home Value Index, the average home value in Walla Walla was $400,668 as of December 2024, up 1.2 percent over the 2023 average.

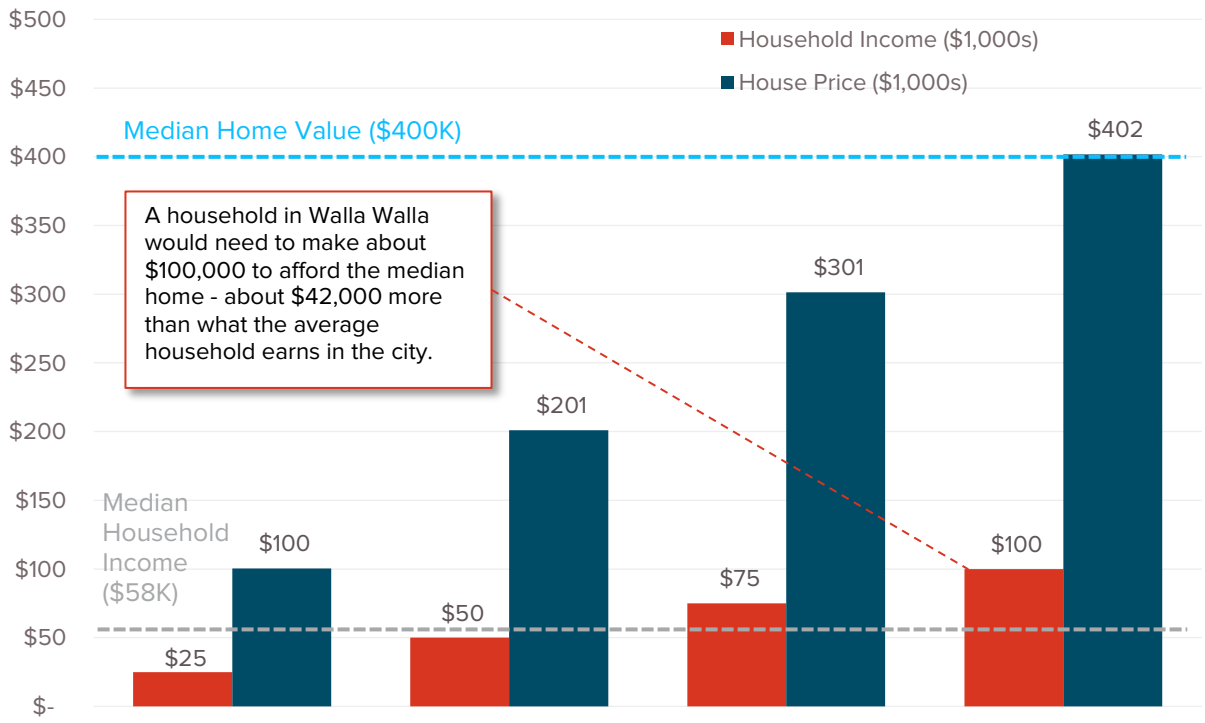


Appendix I Figure 26. Change in Rents, Home Prices, and Income in Walla Walla, 2012-2022

Sources: 2012-2022 American Community Survey 5-Year Estimates, Table S2503; Zillow Home Value Index

Given incomes and prices, home ownership continues to trend further out of reach for Walla Walla households. **Error! Reference source not found.** shows the home price that households at various income levels in Walla Walla could afford. The horizontal dashed lines show the median sales price and median household income in Walla Walla. To have been able to purchase a home at the average home price of $400,668 in 2024, a household would need to make about $100,000 per year, which is about 66 percent higher than the median household income. The median household earning $58,179 could afford to purchase a home costing $233,755, assuming current interest rates, a 20 percent down payment, and a 30-year mortgage. Therefore, there is a gap of about $165,000 between what the average household in Walla Walla could afford and the average prices of homes in the city.

The affordability of ownership housing has been a persistent issue in Walla Walla. According to the 2018 Comprehensive Plan, 48 percent of Walla Walla households earned enough income to afford a median price home in the city at the time—adding the caveat that the share of households with funds to cover the down payment would be likely far lower.

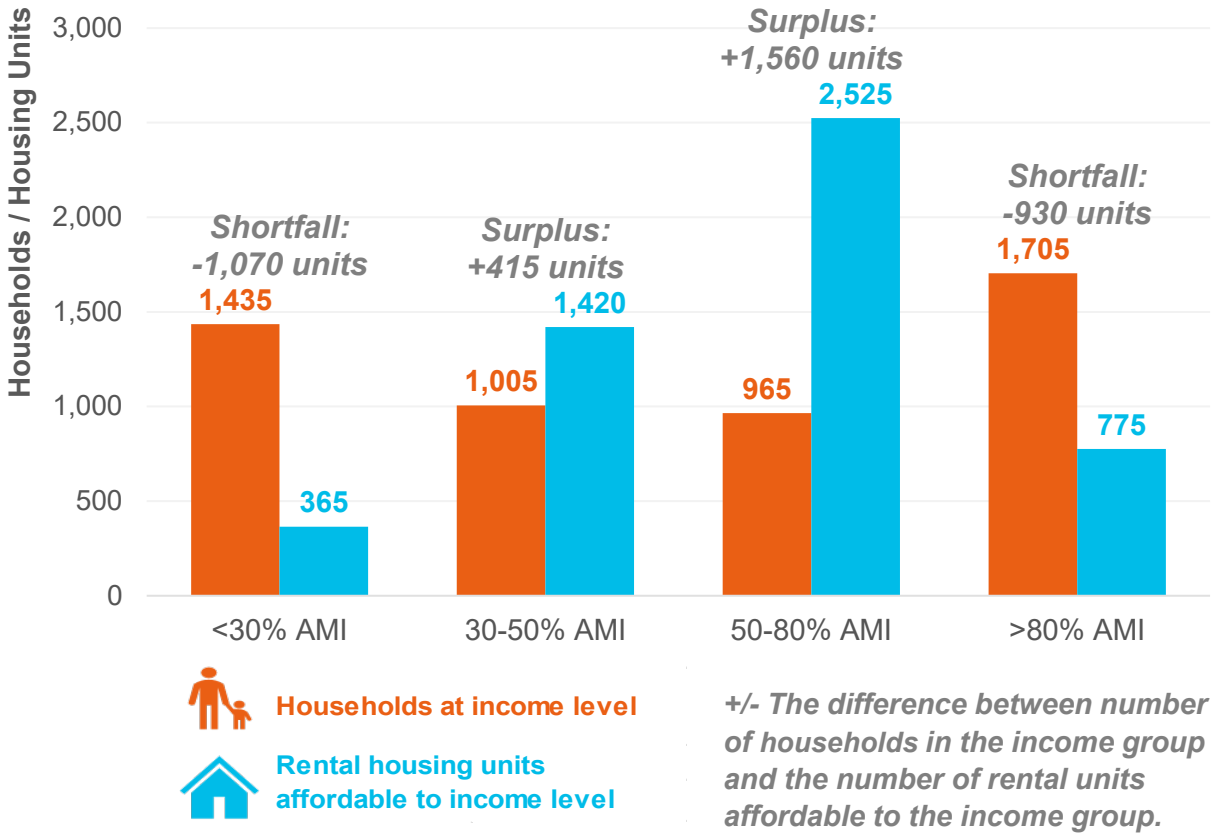


Appendix I Figure 27. Housing Affordability at Various Income Levels in Walla Walla, 2022

Sources: 2022 American Community Survey 5-Year Estimates, Table S2503; Zillow Home Value Index; Freddie Mac; Leland Consulting Group

Gap Analysis

Figure 27 below compares renter households and rental units by income bracket. It shows that overall, the City has just 25 more rental units than renter households. Although there are more rental units affordable to households making between 30 and 80 percent AMI than there are households in that income band, this does not mean that these households are not cost-burdened. The shortages at the high and low end of the market indicate that lower-income households are having to compete with higher-income households for the same units.



Appendix I Figure 28. Renter Households by Income Compared to Rental Units by Affordability in Walla Walla

Source: HUD CHAS Data, 2015-2019.

Land Capacity Analysis

Amendments to the GMA in 2021 resulting from HB1220 now require Washington cities to show sufficient land capacity to accommodate projected needs at all income levels. SCJ Alliance completed an initial land capacity analysis parcel classification for the City of Walla Walla, finding **575.61 acres** of vacant and redevelopable land in the city. Residential/commercial mix and density assumptions were developed by zone based on recent trends and densities of recent, permitted, and proposed development in the City of Walla Walla. In total, the city has capacity for **2,370 new units over the 2020-2046 planning period.**

A review of projects built or permitted since the 2020 baseline as well as proposed/pipeline development shows **2,198 pending housing units** in the City of Walla Walla, which also count towards meeting the city's growth targets. Of these, 1,945 are proposed projects, including both subdivisions and multifamily projects, and the remaining 742 were permitted since 2020 or are currently under construction.

The housing unit land capacity and pending units were **categorized by what income band they can serve,** expressed as a percentage of Countywide Area Median Income (AMI), following Department of Commerce guidance and supplemented by an analysis of housing costs for single-family, duplexes, condos, and rents by unit size in the City of Walla Walla. Recent trends in ADU production as well as capacity for ADUs in lower-density residential zones were also analyzed to forecast **potential new ADU development** over the planning horizon.

This analysis shows that the City of Walla Walla has sufficient capacity to meet its housing needs at all income levels under current zoning, as detailed in the table and chart below. Full results are available in Appendix II. Land Capacity Analysis: Housing by Income Band Employment Methodology and Results.

Appendix I Table 5. The City of Walla Walla Housing Capacity by Income Band, 2020-2046

Income Band	Housing Needs	Aggregated Housing Needs	Pending Units	Remaining Needs	Total Capacity	Surplus/ Deficit
0-30 PSH	428	1,816	639	1,177	1,304	**+127**
0-30 Non PSH	714	1,816	639	1,177	1,304	**+127**
30-50	517	1,816	639	1,177	1,304	**+127**
50-80	157	1,816	639	1,177	1,304	**+127**
80-100	93	209	384	-175	570	**+745**
100-120	116	209	384	-175	570	**+745**
120+	323	323	1,175	-852	948	**+1,800**
Total	**2,348**	**2,348**	**2,198**	**150**	**2,588**	**+2,672**

Key Conclusions & Next Steps

Recent actions taken by the City of Walla Walla include changes to the local zoning code to support the development of middle housing (up to fourplexes) on single lots within residential zones, relaxed road access standards for private lanes serving up to nine dwelling units, permitting multifamily units by right in the Highway Commercial zone, removing owner occupancy requirements for accessory dwelling units, changes to the minimum density in the Multifamily Residential zone, parking changes to align with new state requirements, administrative lot splits, and allowances for up to four units and two ADUs per lot. The City also developed a program for providing water and sewer utility rate discounts to low-income citizens, as well as utilizing Community Development Block Grants to provide funding to property owners for home repair projects.

These actions, as documented in the Walla Walla Regional HAP, were taken to directly address identified housing needs for Walla Walla residents and households. Based on this HNA, Walla Walla has made progress and/or still requires actions in meeting the following housing needs:

- Walla Walla has seen moderate production of both middle housing types (2-4 units in the form of townhomes, duplexes, and other multiplexes) and multifamily housing (5+ unit structures) in recent years, indicating recent actions taken by the City are having an impact. Nevertheless, these housing types remain in demand as more affordable forms of both rental and ownership housing, particularly to bolster the needs of the local workforce.
    - Walla Walla has seen the share of cost-burdened households decrease in recent years, though renter households continue to have a significantly higher likelihood of cost-burden than homeowners. Additionally, households identified as living in poverty, or ALICE (Asset Limited, Income Constrained, Employed), have increased in recent years. This identifies the need for additional affordable housing, particularly in the form of subsidized rental housing, for households making less than 80% of area median income.
- Senior housing, particularly rental housing, will continue to be a need, as Walla Walla's population continues to age. Walla Walla should seek opportunities to support senior housing in the form of smaller units like townhomes, apartments, and ADUs.
- Walla Walla continues to have a smaller share of family households than the county and state. While this may be partially due to the large number of students living in the city, it also likely indicates the lack of affordable homes that serve families. As home prices have continued to increase and outpace wages, the City must remain focused on creating opportunities for both affordable homeownership and rental housing in the form of small-lot detached housing, townhomes, condominiums, and larger apartments.
- Much of Walla Walla's housing stock continues to age, indicating a continuing need for programs to support maintenance to keep the city's housing stock in good condition.

While many of the policies, programs and actions identified in the 2018 Comprehensive Plan, and Regional HAP, have been undertaken by the City of Walla Walla, additional actions that may be taken include the following:

- Expand other fiscal incentives for those who create desired housing types such as waived fees.
- Allowing bonus density increases or other regulatory incentives for any deed-restricted affordable housing development.
    - Promote the development potentially with options that would allow a choice of developing affordable housing on-site, off-site, or through a fee-in-lieu system.
- More zoning for housing which could include new or expanded zoning for multi-family and residential, or new or expanded zoning.
    - Code compliance programs or minimum property management standards that ensure that aging residential neighborhoods remain in good condition.
- Housing assistance programs, such as Community Development Block Grans (CDBG) that help homeowners with low incomes maintain properties, provide weatherization, or remodel housing to accommodate disabilities.
- Enhance and promote programs that supply down payment assistance and application support for a matching grant program for first-time homebuyers.
    - Support the implementation of deed restriction acquisition projects with Connecting Housing to Infrastructure Program (CHIP) funding to incentivize developers to deed restrict their market rate property for resale at a below market rate. This type of program is typically administered by community land trusts (CLT) or similar types of organizations. When a buyer purchases a property at a below market rate price, a deed restriction is created that typically allows for the owner to benefit from some amount of value increase while also ensuring that the property does not revert to market rate at the next sale.
    - Create a rental registration program to track available units in the City and rental costs, to improve access to rental information.

Expedite permitting for simple building permit applications

- Develop pre-approved housing plans for accessory dwelling units, to expedite permitting and reduce building permit costs.
- Development of a Community First Choice charge waiver/ reduction program.
- Review current vacant City-owned land for surplus and possible development of low and very low-income housing development.
- Traffic Impact Fees – proportionate impact based on housing type.
- Continue to support the work of the Ad Hoc Housing Committee.



Appendix II. Land Capacity Analysis: Housing by Income Band Employment Methodology and Results

January 15, 2026

Background

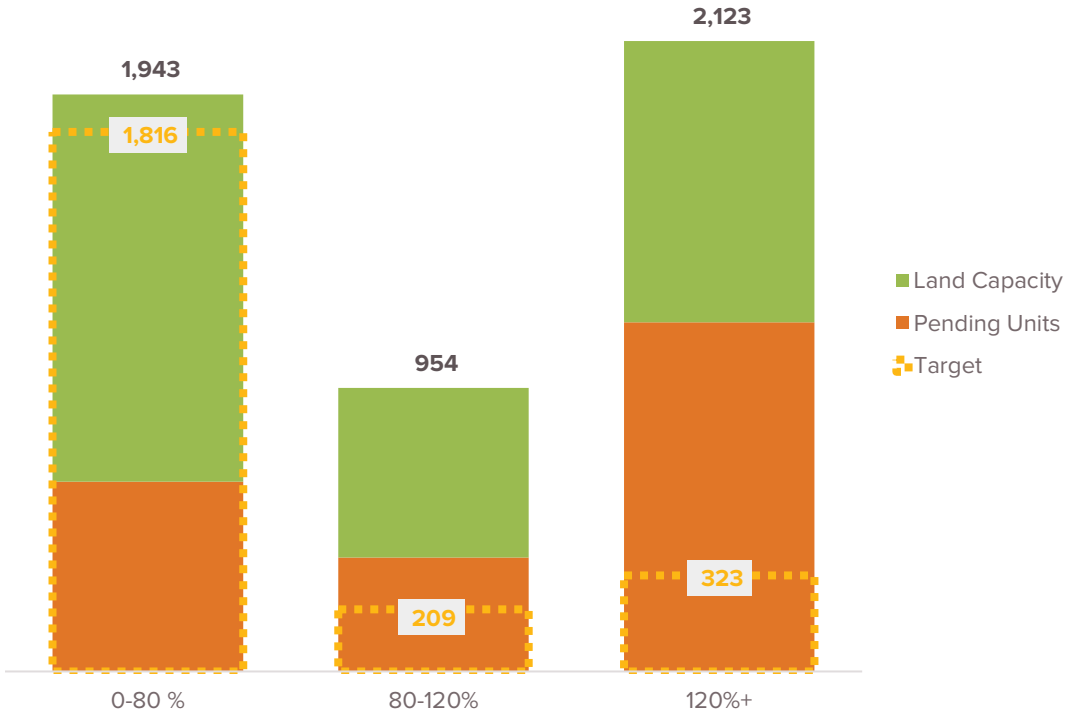
As part of the City of Walla Walla's 2046 Comprehensive Plan update, Leland Consulting Group (Leland) was retained as part of a consultant team led by SCJ Alliance to complete an analysis of land capacity for the City of Walla Walla by income band as required by RCW 36.70A.070(2)(c) This memo outlines the methodology and results of this analysis, using the process outlined in the Washington Department of Commerce's August 2023 guidebook "Guidance for Updating Your Housing Element."

Executive Summary

- Amendments to the GMA in 2021 resulting from HB1220 now require Washington cities to show sufficient land capacity to accommodate projected needs at all income levels.
- SCJ Alliance completed an initial land capacity analysis parcel classification for the City of Walla Walla, finding **575.61 acres** of vacant and redevelopable land in the city.
- Residential/commercial mix and density assumptions were developed by zone based on recent trends and densities of recent, permitted, and proposed development in the City of Walla Walla. In total, the city has capacity for **2,370 new units over the 2020-2046 planning period.**
- A review of projects built or permitted since the 2020 baseline as well as proposed/pipeline development shows **2,198 pending housing units** in the City of Walla Walla, which also count towards meeting the city's growth targets. Of these, 1,945 are proposed projects, including both subdivisions and multifamily projects, and the remaining 742 were permitted since 2020 or are currently under construction.
- The housing unit land capacity and pending units were **categorized by what income band they can serve,** expressed as a percentage of Countywide Area Median Income (AMI), following Department of Commerce guidance and supplemented by an analysis of housing costs for single-family, duplexes, condos, and rents by unit size in the City of Walla Walla.
- Recent trends in ADU production as well as capacity for ADUs in lower-density residential zones were also analyzed to forecast **potential new ADU development** over the planning horizon.
- This analysis shows that the City of Walla Walla has sufficient capacity to meet its housing needs at all income levels under current zoning, as detailed in the table and following chart:

Appendix II Table 1. The City of Walla Walla Housing Capacity by Income Band, 2020-2046

Income Band	Housing Needs	Aggregated Housing Needs	Pending Units	Remaining Needs	Total Capacity	Surplus/ Deficit
0-30 PSH	428	1,816	639	1,177	1,304	+127
0-30 Non PSH	714	1,816	639	1,177	1,304	+127
30-50	517	1,816	639	1,177	1,304	+127
50-80	157	1,816	639	1,177	1,304	+127
80-100	93	209	384	-175	570	+745
100-120	116	209	384	-175	570	+745
120+	323	323	1,175	-852	948	+1,800
Total	2,348	2,348	2,198	150	2,588	+2,672



Appendix II Figure 1. The City of Walla Walla Aggregated Income Band Land Capacity Analysis Results, 2020-2045

Land Capacity Analysis by Income Band

Housing Targets by Income Band

Amendments to the Growth Management Act under House Bill 1220 passed in 2021 require jurisdictions to analyze their estimated housing capacity by household income level. Using future county-level housing targets from Commerce, Walla Walla County determined the units to be accommodated by the City of Walla Walla versus unincorporated areas, categorized by what income band the housing units can serve, expressed as a percentage of the HUD Area Median Income (AMI). For reference, the 2025 AMI for Walla Walla County is $97,900 for a household size of four persons per family. The AMI is determined by the U.S. Department of Housing and Urban Development (HUD), and is generally higher than the Census-reported Median Household income for a given city, since it is a countywide metric and based on family income, which excludes some households. The HUD AMI is used to determine eligibility and income limits for subsidized affordable housing units. The City of Walla Walla must demonstrate sufficient land capacity for the number of units allocated for households at all income bands.

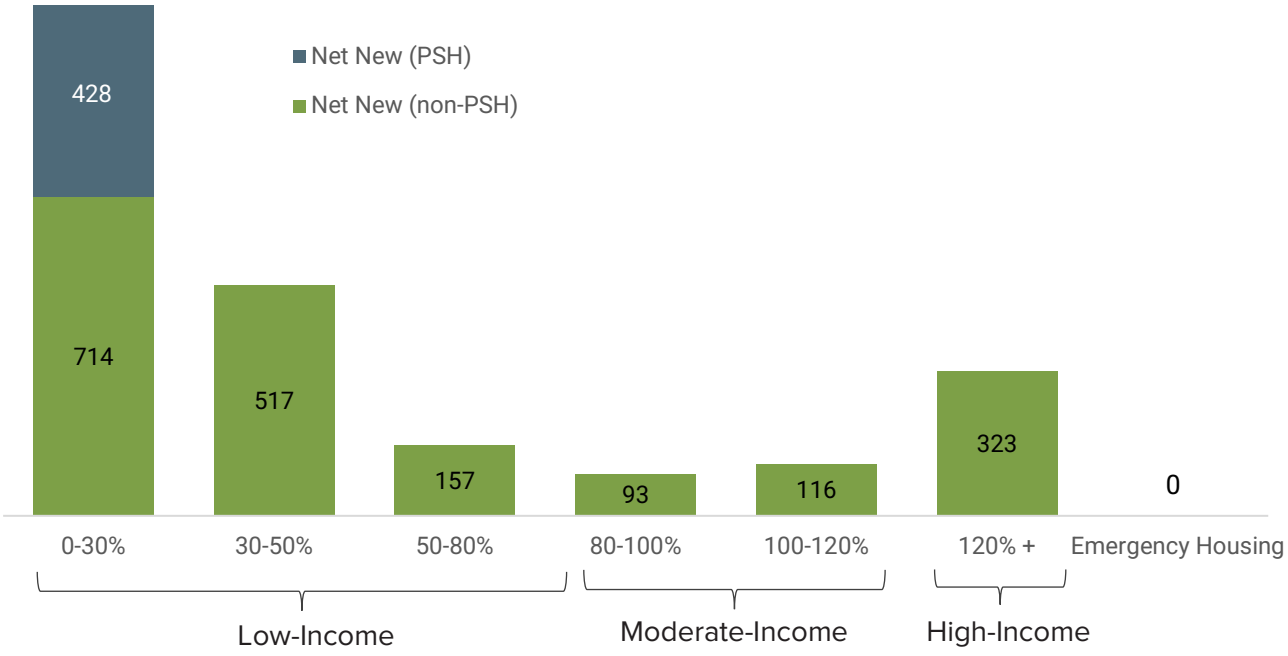
In conjunction with the Cities, Walla Walla County selected a 2046 population target of 73,112, between the OFM medium and high range. This represents a net increase of 10,528 residents over the 2020-2046 period. The County allocated population and housing targets to each city. The City of Walla Walla's allocation is for 5,824 new residents and 2,348 new housing units for the 2020-2046 planning period. The breakdown of these housing units by income band as a percentage of AMI, including 0-30% AMI permanent supportive housing (PSH), defined in the Department of Commerce guidebook as "subsidized, leased housing for people who are experiencing homelessness or are at risk of homelessness and living with a disabling condition," is shown below in Appendix II Figure 2.

Additionally, each jurisdiction receives a housing target for emergency housing, defined as "temporary accommodations for households who are experiencing homelessness or are at imminent risk of becoming homeless." Walla Walla County has set the City of Walla Walla's target for Emergency Housing at zero, since the County already has sufficient capacity for projected Emergency Housing needs. See p. 53 for more details.

Income Categories

This analysis uses three main income categories:

Low-Income *(Households earning under 80% AMI)*
Moderate-Income *(Households earning 80-120% AMI)*
High-Income *(Households earning more than 120% AMI)*

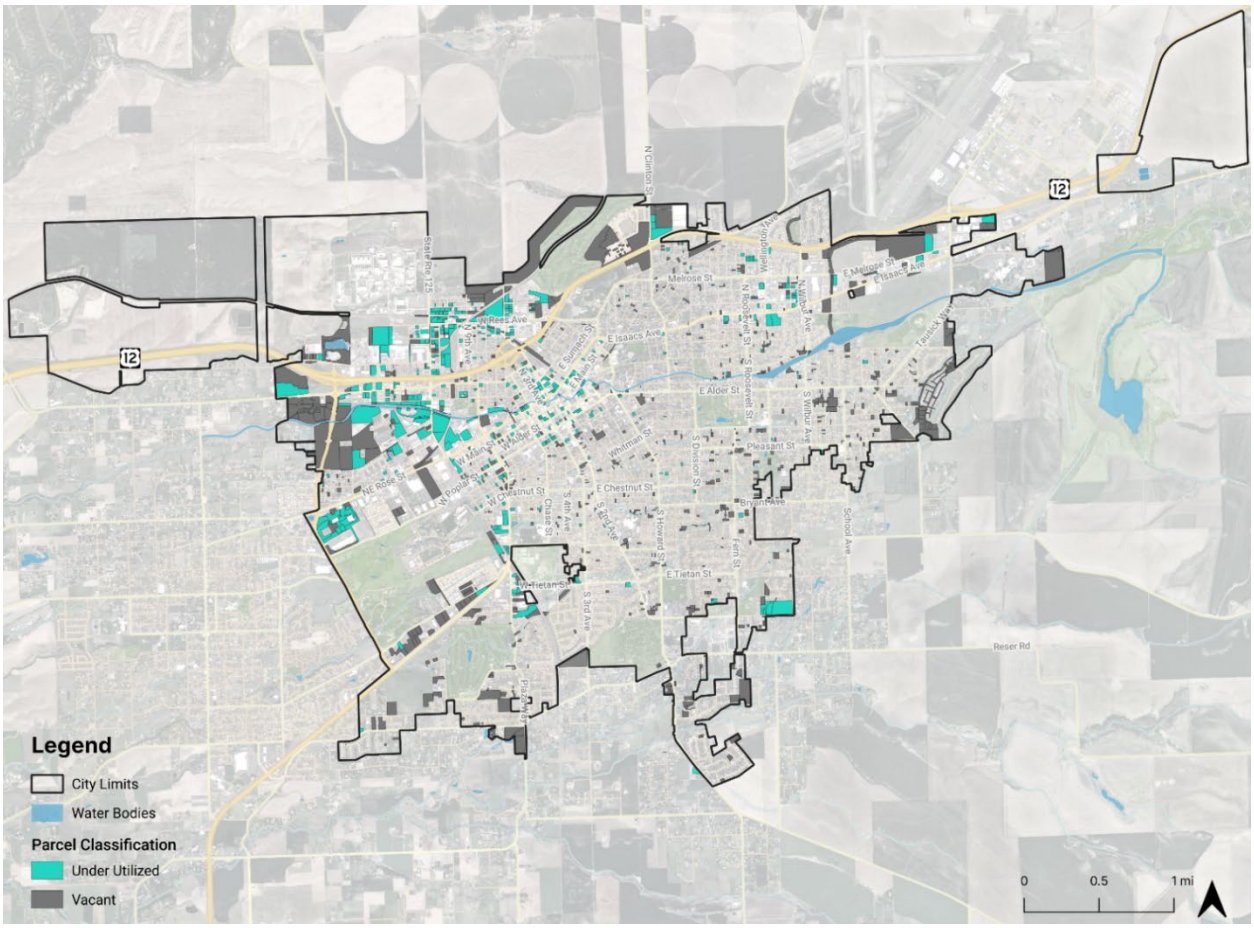


Appendix II Figure 2. The City of Walla Walla Housing Unit Targets by Income Band, 2020-2046

Source: Walla Walla County

Potentially Developable Acreage

SCJ Alliance conducted an overall Land Capacity Analysis for the City of Walla Walla for the 2020-2046 planning horizon which produced the total vacant and redevelopable acreage by zone used in this income band analysis. This analysis classified parcels as vacant or under-utilized, excluded parcels that were fully developed or unsuitable for development as well as parcel acreage encumbered by critical areas. The parcel classifications used in this analysis are shown in the map below in Appendix II Figure 3.



Appendix II Figure 3. The City of Walla Walla Land Capacity Analysis Parcel Classifications

Source: SCJ Alliance

After parcel classification and removal of critical areas, further deductions were applied to account for infrastructure gaps and a market factor representing a portion of land that will remain unavailable during the planning period due to the market and individual property owner choice. The net vacant, under-utilized, and partially utilized acreage by zone are shown below in Appendix II Table 2.

Appendix II Table 2. Total Developable Acreage in the City of Walla Walla by Zone

Zone	Description	Net Developable Vacant Acres	Net Developable Underutilized Acres	Total Net Developable Acres
CC	Central Commercial	1.7	7.7	9.4
CH	Highway Commercial	95.2	36.7	131.9
IH	Heavy Industrial	40.4	52.9	93.2
IL	Light Industrial / Commercial	29.1	24.1	53.2
PR	Public Reserve	33.4	2.5	35.9
RN	Neighborhood Residential	193.4	15.1	208.6
RM	Multi-Family Residential	12.9	1.1	14.1
UPC	Urban Planned Community	26.3	2.9	29.2

Source: SCJ Alliance

Residential/Commercial Split

The next step in the analysis was to develop assumptions around how much of each zone acreage would develop as commercial or residential uses. Residential zones are assumed to develop with fully residential uses. In commercial and mixed-use zones, real estate data from CoStar, a national data provider, as well as City parcel and permit data were analyzed to determine the share of development in each zone over the past decade which was commercial or residential (by parcel acreage). In the past 10 years, approximately 25% of the acreage developed in the CH zone has been multifamily. In CC, CoStar reports that the only commercial development since 2015 was the Lodge Apartments. However, County Assessor data shows that some restaurants were also built in that zone over the past decade. Since it is a mixed-use zone with a variety of allowed uses and a commercial focus, and most existing development in the zone is non-residential, the same 25% assumption was used as in CH. The table below in Appendix II Table 3 shows the Residential/Commercial split used in this analysis.

Appendix II Table 3. Residential/Commercial Split for the City of Walla Walla LCA

Zone	Description	Assumed % Residential for LCA	Assumed % Commercial for LCA
CC	Central Commercial	25%	75%
CH	Highway Commercial	25%	75%
IH	Heavy Industrial	0%	0%
IL	Light Industrial / Commercial	0%	0%
PR	Public Reserve	5%	95%
RN	Neighborhood Residential	100%	0%
RM	Multi-Family Residential	100%	0%

Housing Density Assumptions

Finally, density assumptions for each zone were developed to convert the resulting residential and commercial acreage into potential housing unit capacity. These assumptions were based on both allowed zoning in the City of Walla Walla's code as well as recent trends and examples of recent development in the city:

- In the CC zone, density was based on the recent Lodge Apartments.
- In the CH zone, density was based on an average of three projects built since 2007: Wellington Arms, Desoto, and Affinity.
- In the RN zone, density was based on achieved density of about 5 units per acre seen over the past decade, plus an additional assumption that 10 percent of housing in the zone could be duplexes, following an analysis of recent middle housing trends in the city discussed further below and shown in Appendix II Figure 5. This resulted in an average density of 5.5 units per acre (i.e. assuming that 10 percent of lots would develop at 10 units per acre).
- Public Reserve allows some single-family housing, so a similar density to RN was used, but without the middle housing assumptions.
- In the RM zone, an average of existing and recently completed apartments (Cottage at Sunset Lodge, Kenwood) was used.

The resulting assumed densities for housing on vacant and underutilized parcels in each zone are shown below:

Appendix II Table 4. Housing Density Assumptions for the City of Walla Walla LCA

Zone	Description	Assumed Density for LCA (du/ac)	Notes
CC	Central Commercial	75.0	Based on The Lodge Apartments
CH	Highway Commercial	30.0	Based on an average of Wellington Arms, Desoto, Affinity (all built since 2007)
PR	Public Reserve	5.0	
RN	Neighborhood Residential	5.5	Based on achieved density of new single-family development over the past 5 years (5 du/ac) + 10% duplex assumption as detailed above.
RM	Multi-Family Residential	20.0	Based on recent apartments (Cottage at Sunset Lodge, Kenwood)

Housing Unit Capacity on Vacant and Underutilized Parcels

The table below shows the housing unit capacity by zone on vacant and underutilized parcels, derived from the total acreage of these parcels as detailed previously, adjusted by the residential/commercial split, then multiplied by the assumed densities shown above, and finally adjusted to account for existing units that would be lost to redevelopment. On vacant and underutilized parcels, the City of Walla Walla has land capacity for 2,370 new units over the 2020-2046 planning period. Note that this LCA also takes into account projects built since 2020 and planned future developments, including a number of large proposed projects in the UPC zone. These "pending" units are discussed further below. The pending units are then combined with the land capacity on vacant and underutilized parcels shown in Appendix II Table 5to derive the City of Walla Walla's total capacity for this LCA shown in Appendix II Table 11.

Appendix II Table 5. Housing Unit Capacity on Vacant and Underutilized parcels in the City of Walla Walla by Zone

Zone	Description	Net Unit Capacity
CC	Central Commercial	**176**
CH	Highway Commercial	**989**
IH	Heavy Industrial	**0**
IL	Light Industrial / Commercial	**0**
PR	Public Reserve	**9**
RN	Neighborhood Residential	**1,147**
RM	Multi-Family Residential	**282**

Housing Unit Capacity by Income Band

The next step in this analysis is to break down the land capacity for future units into income bands that those units could serve. Following Department of Commerce guidance, this is accomplished by grouping zones into zone categories based on the housing types that are allowed and then grouping those categories by the lowest potential income level that could be served by the housing types in that zone category. The table below in Appendix II Figure 4 shows the Department of Commerce's guidance on the relationship of housing types to income levels and land capacity. These "moderate-cost" income band classifications are recommended for communities outside the Puget Sound region.

Note that the Commerce table shown below in Appendix II Figure 4 includes columns for both assumed income bands that can be served by market-rate development and assumed income bands that can be served by subsidized development (i.e. income-restricted low-income housing funded through the Low Income Housing Tax Credit or Multifamily Tax Exemption, etc.). Following Commerce guidance, zones are categorized based on the lowest *potential* income that can be served, including by subsidized development, in the zone. This does not imply that the entire zone will be built out with subsidized or deeply subsidized units, but it does indicate that the zone *allows* those types of units to be built without undue regulatory barriers, as required by HB1220. Commerce guidance and HB1220 also indicate that jurisdictions should document available sources of subsidy that may be used over the planning horizon in order for the capacity for lower income units, particularly under 50 percent AMI, to be realized. This is found in the "Adequate Provisions" analysis in **Error! Reference source not found.**.

Zone category	Typical housing types allowed	Lowest potential income level served		Assumed affordability level for capacity analysis
		Market rate	With subsidies and/or incentives	
Low Density	Detached single family homes	Higher income (>120% AMI)	Not typically feasible at scale*	Higher income (>120% AMI)
Moderate Density	Townhomes, duplex, triplex, quadplex	Moderate income (>80-120% AMI)	Not typically feasible at scale*	Moderate income (>80-120% AMI)
Low-Rise Multifamily	Walk-up apartments, condominiums (2-3-floors)	Low income (>50-80% AMI)	Extremely low and Very low income (0-50% AMI)	Low income (0-80% AMI) and PSH
Mid-Rise Multifamily	Apartments, condominiums	Low income (>50-80% AMI)	Extremely low and Very low income (0-50% AMI)	Low income (0-80% AMI) and PSH
ADUs (all zones)	Accessory Dwelling Units on developed residential lots	Low income (>50-80% AMI)	N/A	Low income (>50-80% AMI) – Group with Low-Rise and/or Mid-Rise Multifamily

Appendix II Figure 4. Department of Commerce Guidance on Income Band Classification (Moderate-Cost Communities)

Source: Washington Department of Commerce "Guidance for Updating Your Housing Element" (2023)

To corroborate the income band classifications shown above for *market rate* units, CoStar data on rents and Redfin data on home sales was analyzed and compared to Walla Walla County's AMI. Appendix II Table 6 shows sales prices for single-family and middle housing in the City of Walla Walla, for all sales regardless of age of housing unit as well as for sales of recently built

units. Newly built single-family homes are serving households earning 120 percent AMI and higher, and newly built duplexes are serving households earning between 100-120 percent AMI, confirming the Commerce assumptions above for those housing types. Note that median sales prices indicate that some single-family homes are serving moderate-income households earning less than 120 percent AMI, and some condos and townhomes are affordable to households earning slightly below 80 percent AMI, but since the LCA is focused mostly on new housing production, the income band assumptions based on homes built since 2020 were used.

Appendix II Table 6. Market Sales Prices of Single-Family and Middle Housing in the City of Walla Walla

	Sale Price	Affordable to AMI %
Single-Family		
Median 2025 YTD Sales Price (All Single-Family Homes)	$437,668	111%
Average Price of 204 Homes Built and Sold Since 2020	$504,846	128%
Middle Housing		
Median 2025 YTD Sale Price (All Condos/Townhomes)	$297,375	76%
Average Price of 3 Duplexes Built and Sold Since 2020	$410,000	104%

Source: Redfin, Leland Consulting Group, HUD
Note: Assumes 20% down payment, 6.5% interest rate, 30-year mortgage, 0.9% property tax rate, and $5/$1,000 insurance rate.

Appendix II Table 7 shows market rents for all multifamily apartments in the City of Walla Walla and for recently developed apartments, by unit size. It then shows the corresponding percentage of AMI that households of various sizes would need to afford the rent, based on HUD income limits by household size. Overall, most renters earning 80 percent AMI would be able to afford an apartment in the city at an appropriate size for their household. Some smaller households at 80 percent AMI or below may struggle to afford to rent an apartment in recently built projects. This data only captures rents in multifamily buildings reported by CoStar. For comparison, data from the Washington Center for Real Estate Research reports an average rent citywide of **$1,277,** which also includes rentals of single-family units. These rents would be affordable to **all household sizes at 80 percent AMI or below.**

Overall, this data suggests that the majority of renters in the City of Walla Walla, particularly in households of two people or more, can afford a unit without being cost-burdened if their incomes are at 80 percent of the AMI. However, because some recent construction is renting for higher rates, particularly for smaller units, the LCA assumes that 75 percent of market-rate capacity in multifamily zones can serve households earning 80 percent AMI and below, and 25 percent may serve households in the 80-120 percent AMI bracket.

Appendix II Table 7. Market Multifamily Rents in the City of Walla Walla, September 2025

	Average Monthly Rent	% of AMI Needed for 1-Person Household	% of AMI Needed for 2-Person Household	% of AMI Needed for 3-Person Household
HUD Income Limit		$68,600	$78,400	$88,200
Average Rent per Studio Unit (all)	$1,031	60%	53%	47%
Average Rent per Studio Unit (Built Since 2020)	$1,494	87%	76%	68%
Average Rent per 1-Bedroom Unit (all)	$1,217	71%	62%	55%
Average Rent per 1-Bedroom Unit (Built Since 2020)	$1,522	89%	78%	69%
Average Rent per 2-Bedroom Unit (all)	$1,570	92%	80%	71%
Average Rent per 2-Bedroom Unit (Built Since 2020)	$1,685	98%	86%	76%
Average Rent per 3-Bedroom Unit (all)	$1,648	96%	84%	75%
Average Rent per 3-Bedroom Unit (Built Since 2020)	$1,953	114%	100%	89%

Source: CoStar, HUD Income Limits, Washington State Housing Finance Commission, Leland Consulting Group
Note: Assumes households can spend 30 percent of their income on rent/housing costs without being cost-burdened.

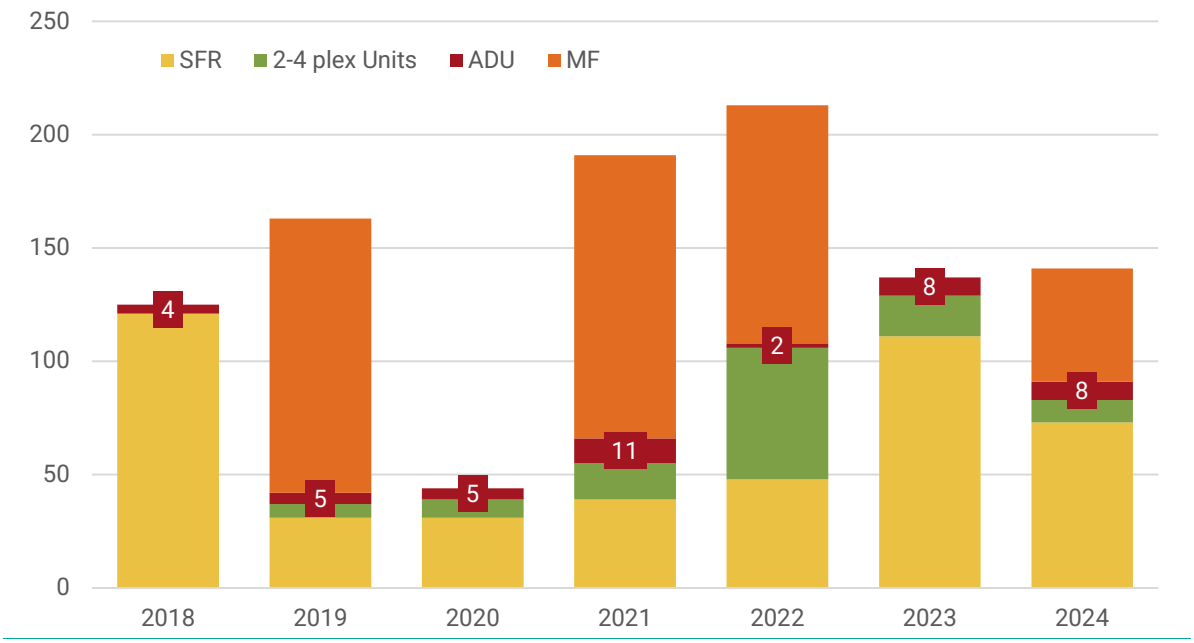
Based on this cost analysis and the types of housing allowed in each of the City of Walla Walla's zoning districts, the table below shows the income-band classifications for each zone in the city. Note that the CC, CH, and RM zones are split between the 0-80 percent AMI and 80-120 percent AMI brackets, as described above, and the RN is mostly assumed to serve 120 percent AMI and higher, but 10 percent of the capacity in this zone is allocated to the 80-120 percent AMI category since it is assigned to duplex capacity as described above on p.46, and duplexes are assumed to serve moderate-income households as detailed above in Appendix II Table 6.

Appendix II Table 8. Capacity and Affordability Levels by Zone for the City of Walla Walla LCA

Zone	Zone Description	Net Unit Capacity	Assumed Affordability Level for Capacity Analysis	Notes
CC	Central Commercial	132	0-80%	75% of zone capacity to 0-80% based on apartment rent data
CC	Central Commercial	44	80-120%	25% of zone capacity to 80-120% based on apartment rent data
CH	Highway Commercial	742	0-80%	75% of zone capacity to 0-80% based on apartment rent data
CH	Highway Commercial	247	80-120%	25% of zone capacity to 80-120% based on apartment rent data
IH	Heavy Industrial	0		
IL	Light Industrial / Commercial	0		
PR	Public Reserve	9	120% +	
RN	Neighborhood Residential	939	120% +	90% of zone capacity to 120+% for assumed single-family capacity
RN	Neighborhood Residential	209	80-120%	10% of zone capacity to 80-120% for assumed duplex capacity
RM	Multi-Family Residential	211	0-80%	75% of zone capacity to 0-80% based on apartment rent data
	Multi-Family Residential	70	80-120%	25% of zone capacity to 80-120% based on apartment rent data
UPC		0	120% +	
	TOTAL	**2,370**		

ADU Capacity

Recent state legislation requires the City of Walla Walla to allow two ADUs, attached or detached, on every low-density residential lot. To calculate ADU capacity for the purposes of this LCA, following Commerce guidance, the total number of parcels zoned for low-density residential was used as a base count of potential parcels where an ADU could be developed. The RN zone is the City of Walla Walla's low-density residential zone, which contains a total of 9,909 parcels. Taking a conservative estimate that 2 percent of parcels in the zone might see an ADU developed over the planning horizon, and that 10 percent of that 2 percent might see two ADUs as a result of recent legislation, results in an ADU capacity of 218 units over the planning period. This would equate to about 11 ADUs produced per year, which is in line with recent trends shown below in Appendix II Figure 5. In 2021, 11 ADUs were built, and the average over the past five years is 6.8 ADUs per year. Additionally, Commerce guidance suggests that ADUs should not count towards more than 10 percent of total housing capacity. In this case, 218 ADUs would represent 8 percent of the City of Walla Walla's total capacity, not exceeding the 10 percent threshold.



Appendix II Figure 5. Housing Units Built in the City of Walla Walla, 2018-2024

Source: City of Walla Walla

Total Land and ADU Capacity by Income Band

Finally, the capacity by zone is totaled based on the zone category and affordability level corresponding to the housing types allowed. At this point, ADU capacity is also added, and assigned to the 0-80 percent income band per Commerce guidance. The table below shows total land capacity in the City of Walla Walla by income band on vacant and underutilized parcels. In the next step, units built since 2020 or in the development pipeline will be classified by income band and added to the totals.

Appendix II Table 9. Total Additional Unit Capacity by Income Band in the City of Walla Walla, 2020-2046

Zone Category	Assumed Affordability Level for Capacity Analysis	Housing Types Allowed	Additional Unit Capacity
Low Density	120% +	Detached single-family homes	948
Moderate Density	80-120%	Townhomes, duplex, triplex, quadplex	512
Low-Rise	0-80%	Walk-up apartments, condominiums (2-3 stories)	911
Mid-Rise	0-80%	Apartments, condominiums	0
ADUs	0-80%	Accessory Dwelling Units	198
		TOTAL	**2,588**

Pending Units

The City of Walla Walla's housing targets are based on a 2020 baseline. Therefore, development since 2020 should be counted toward the city's housing targets, per Commerce guidance. Additionally, parcels with proposed or planned development were excluded from consideration in the parcel classification process conducted by SCJ. Per Commerce guidance, the planned and proposed development should also count towards the city's targets. Together, planned and proposed development and units built or permitted since 2020 are called "Pending" units for the purposes of this LCA. The table below shows pending units in the City of Walla Walla.

These units are classified by income band using the same methodology as used for the overall land capacity analysis – multifamily units are split with 75 percent of units going to the 0-80 percent AMI category and the remaining 25 percent (representing smaller units that may not be affordable to one-person households earning 80 percent AMI) going towards the 80-120 percent category. Additionally, several projects including Meadow Grove, Peyton Lane, and MC Gateway, are known affordable housing projects targeting households earning less than 80 percent AMI. Therefore, these projects are categorized accordingly in the table below.

Appendix II Table 10. Pending Units in the City of Walla Walla for LCA

Year	Project / Info	Single Family Units	Townhome Units	ADUs	Duplexes	Multifamily (0-80% AMI)	Multifamily (80-120% AMI)
2020	Permitted Units	31		5	2	3	1
2021	Permitted Units	39	4	11	8	94	31
2022	Permitted Units	48		2	29	79	26
2023	Permitted Units	110		8	9		
2024	Permitted Units	75	1	8	5	3	1
2025	Permitted Units	48		3	1		
Under Construction	Meadow Grove					50	
Under Construction	Peyton Lane					7	
Proposed	BMAC Tiny Homes				8		
Proposed	Equinox	119					
Proposed	Pinnacle	35					
Proposed	Waterford					48	16
Proposed	Equinox Commercial						
Proposed	MC Gateway	670					
Proposed	McFeely's Building					15	5
Proposed	Bouchon Area - Palindrome		75			56	19
Proposed	Myra Road - Palindrome		60			248	83
Total		**1,175**	**140**	**37**	**62**	**602**	**182**
Assumed Income Band (% of AMI)		*120% +*	*80-120%*	*0-80%*	*80-120%*	*0-80%*	*80-120%*

Source: City of Walla Walla

Total Capacity by Income Band

The table below shows the total housing unit capacity by income band for The City of Walla Walla for the 2020-2046 planning period, including pending units. As shown in Appendix II Table 11 the city has sufficient capacity to accommodate its housing allocation at all income levels.

Appendix II Table 11. City of Walla Walla Housing Capacity by Income Band, 2020-2046

Income Band	Housing Needs	Aggregated Housing Needs	Pending Units	Remaining Needs	Total Capacity	Surplus/ Deficit
0-30 PSH	428	1,816	639	1,177	1,304	**127**
0-30 Non PSH	714	1,816	639	1,177	1,304	**127**
30-50	517	1,816	639	1,177	1,304	**127**
50-80	157	1,816	639	1,177	1,304	**127**
80-100	93	209	384	-175	570	**745**
100-120	116	209	384	-175	570	**745**
120+	323	323	1,175	-852	948	**1,800**
Total	**2,348**	**2,348**	**2,198**	**150**	**2,588**	**2,672**

Emergency Housing

In addition to permanent housing, jurisdictions are required to show sufficient land capacity to accommodate their allocation of Emergency Housing and Emergency Shelter under RCW 36.70A.070(2)(c). However, Commerce's Housing for All Planning Tool (HAPT) indicates that Walla Walla County already has a sufficient capacity of Emergency Housing and Emergency Shelter to accommodate the projected need during the 2020-2046 planning horizon, as shown below. Therefore, an Emergency Housing Land Capacity Analysis for the City of Walla Walla is not required.

Affordability Level (% of AMI)	Housing Needed to Eliminate Existing Renter Cost Burden	Housing Needed for Existing Homeless Population	Housing Need for Cost Burdened + Homeless	Pct. of Households by Income Level (2018)	Remaining Housing Need to Address Household Growth***	Projected Future Net New Permanent Supportive Housing (PSH) Need	Total Net New Housing Need 2020-2046
0-30%	1,629	247	1,876	11.0%	170		2,046
0-30% (Not PSH)							*1,279*
PSH						*767*	*767*
>30%-50%	740	27	767	10.4%	161		928
>50-80%	43	-	43	15.8%	245		288
>80-100%	7	-	7	10.4%	162		169
>100-120%	58	-	58	9.9%	154		212
>120%	-	-	-	42.4%	656		656
Total	**2,477**	**274**	**2,751**	100.0%	**1,548**		**4,299**
Projected Emergency Housing Net Need: 2020-2046							-

Appendix II Figure 6. Detail from Walla Walla County Housing for All Planning Tool (HAPT) Showing No New Emergency Housing Needed Countywide 2020-2046

Source: Washington Department of Commerce, Walla Walla County

Employment Capacity

To calculate employment capacity, the acreage of vacant and underutilized parcels in commercial zones, and the share of acreage of vacant and underutilized parcels in mixed-use zones allocated to commercial uses (after removing the share of acreage allocated to residential uses, as shown above in Appendix II Table 3) was used. Next, density assumptions for commercial development were developed, based on Floor Area Ratio (FAR) of recent development (since 2015) in commercial and industrial zones based on CoStar data. Assumptions of square foot of building area per employee were developed based on the U.S. Energy Information

Administration's Commercial Buildings Energy Consumption Survey, which includes metrics on square feet per worker by building activity. The table below shows share of commercial acreage, total developable commercial acres, assumed FAR, and assumed Square Feet per Job, which are then used to calculate an assumed job density in jobs per acre.

Appendix II Table 12. Net Developable Commercial Acreage in the City of Walla Walla, 2020-2046

Zone	Description	% Commercial	Net Commercial Developable Vacant/ Underutilized Acres	Assumed FAR	Assumed Square Feet per Job	Assumed Job Density for LCA (Jobs/Acre)
CC	Central Commercial	75%	7.1	0.5	600	36.3
CH	Highway Commercial	75%	98.9	0.4	600	29.0
IH	Heavy Industrial	100%	93.2	0.3	1500	8.7
IL	Light Industrial / Commercial	100%	53.2	0.3	1500	8.7

Applying the densities shown above to the vacant and underutilized commercial acreage by zone results in an employment land capacity of 4,405 jobs over the planning horizon, split by zone as shown below:

Appendix II Table 13. The City of Walla Walla Employment Land Capacity by Zone, 20202-2046

Zone	Description	Net Job Capacity
CC	Central Commercial	**256**
CH	Highway Commercial	**2,873**
IH	Heavy Industrial	**812**
IL	Light Industrial / Commercial	**464**
	TOTAL	**4,405**

In addition, two proposed developments – MC Gateway and Equinox, contain 80,000 and 87,120 square feet of proposed commercial development, respectively. Additionally, communication with the developer indicated that the proposed project at Myra Road is expected to generate 904 jobs. Together, this totals 1,183 pending jobs over the planning period. When added to the land capacity for 4,405 jobs, this results in a grand total capacity of 5,588 jobs, which represents a significant surplus over the City of Walla Walla's target of 2,348 jobs, as shown below.

Appendix II Table 14. The City of Walla Walla Employment Capacity, 2020-2045

Employment Land Capacity	Pending Jobs	Total Employment Capacity	Target	Surplus
4,405	1,183	5,588	2,348	**3,240**

Conclusion

As shown above in Appendix II Table 11, the City of Walla Walla has sufficient capacity to meet its housing units at each income band, as required by the GMA, given reasonable assumptions of future density, commercial/residential split, and accounting for a variety of income bands and housing types to be potentially accommodated in most zones that allow housing. As shown in Appendix II Table 14, the City also has sufficient capacity to meet its employment targets.

As discussed in detail in "Housing Unit Capacity by Income Band" beginning on p. 48, these results demonstrate capacity for housing at all income bands, but zoned land capacity does not guarantee that all units will be built at the income levels shown below. The "Adequate Provisions" section in Appendix III. Adequate Provisions Analysis continues this analysis by documenting Walla Walla's existing affordable housing, recent affordable housing production trends, and pipeline affordable housing projects. The Adequate Provisions analysis also discusses the quantity of subsidy which would be required to meet Walla Walla's subsidized housing targets and documents the available and potential sources of that funding.

Appendix III. Adequate Provisions Analysis

October 15, 2025

Introduction

RCW 36.70A.070(2)(d) requires jurisdictions planning under the GMA to include in their comprehensive plan a housing element that "[m]akes adequate provisions for existing and projected needs of all economic segments of the community, including:

a) Incorporating consideration for low, very low, extremely low, and moderate-income households;

b) Documenting programs and actions needed to achieve housing availability including gaps in local funding, barriers such as development regulations, and other limitations;

c) Consideration of housing locations in relation to employment location; and

d) Consideration of the role of accessory dwelling units in meeting housing needs."

This section begins with Commerce's Adequate Provisions checklists which document potential barriers to housing production, and continues with an analysis of Walla Walla's existing subsidized housing inventory, pipeline for subsidized housing units and preservation of naturally occurring affordable housing, a discussion of housing vouchers, a gap analysis of potential funding levels needed to develop the quantity of affordable units needed to meet housing targets, and a list of potential sources of funding for those subsidized units over the planning horizon.

Barrier Review Checklists

In their August 2024 Guidance for Updating Your Housing Element (also known as "Book 2"), the Department of Commerce developed checklists for jurisdictions to evaluate regulatory, process, financial, and land constraints to the development of affordable housing. These checklists for moderate-density housing, low- and mid-rise housing, PSH and emergency housing, and ADUs follow:

Appendix III Exhibit 1. Moderate Density Housing Barrier Review Checklist

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
DEVELOPMENT REGULATIONS			
Unclear development regulations	No	Development regulations are clear and publicly accessible.	
Prohibiting some moderate density housing types, such as: • Duplexes • Triplexes • Four/five/six-plexes • Townhomes • Cottage housing • Live-work units • Manufactured home parks	No	Duplexes, triplexes, fourplexes, cottage housing, and townhomes are all allowed in the RN and RM zones. Manufactured home parks are permitted in these zones as well as the MHC zone.	
High minimum lot sizes	No	There are no minimum lot sizes in the RN and RM zones.	
Low maximum densities or low maximum FAR	No	The minimum density in the RN zone is 4 dwelling units per acre. This density is sufficient for accommodating the moderate density housing types the zone's description indicates are desired.	.
Low maximum building heights	No	The maximum building height is 35 feet (approximately three stories) in the RN zone and 60 feet (approximately 5 stories) in the RM zone.	
Large setback requirements	No	Front and rear setbacks are 20 feet in the RN district. The RM district has 15-foot front setbacks and 10-foot rear setbacks. Both districts have 5-foot side setbacks.	

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
High off-street parking requirements	No	The recently updated development code incudes an exemption for residences under 1,200 square feet and no parking required for affordable housing, senior housing/congregate care or transitional housing. 1 space is required for SFR and.5 spaces per units is required for multifamily units. For all other housing types in the RN zone 1 space per unit, except for .5 spaces for units on lots less than 6,000 square feet. Tandem Parking calculation was recently updated to be counted at a rate of 1 space for every 20 linear feet. Residential parking stall widths were recently reduced from 9.0 to 8.0 feet, parallel to aisle at 90-degree angle.	
High impervious coverage limits	No	The maximum lot coverage is 50% in the RN zone and 65% in the RM zone.	
Lack of alignment between building codes and development codes	No	There does not appear to be a lack of alignment between building and development codes.	
Other (for example: complex design standards, tree retention regulations, historic preservation requirements)	No	There are no additional requirements that are challenging to development feasibility.	
PROCESS OBSTACLES			
Conditional use permit process	No	A conditional use permit is not required for moderate density housing in the RN zone.	
Design review	No	Design review is not required for moderate density housing in the RN zone.	

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
Lack of clear and accessible information about process and fees1	No	Information about process and fees is clear and publicly available.	
Permit fees, impact fees and utility connection fees	No	Permit fees are not significantly higher than comparable jurisdictions.	
Processing times and staffing challenges	No	In August of 2025 the City converted from a Paper to Digital permit tracking system using Tyler's EPL and all staffing positions are filled throughout the Department with two full-time inspectors/plans examiners, one Building Official, two permit technicians, one permit coordinator, two senior planners and one code enforcement officer.	
SEPA process	No	SEPA process is explained clearly within the code.	
LIMITED LAND AVAILABILITY AND ENVIRONMENTAL CONSTRAINTS			
Lack of large parcels for infill development	No	Walla Walla's Land Capacity Analysis found sufficient capacity to accommodate needed housing units at all income levels and housing types.	
Environmental constraints	No	The city has very few critical areas overall, and the Land Capacity Analysis found that critical areas do not significantly affect developable acreage.	

[1] For example: guidance resources are unclear or difficult to find, no digital permit tracking system, staff do not provide fee estimates or permitting time estimates are unavailable or inaccurate.

Appendix III Exhibit 2. Low-Rise or Mid-Rise Housing Barrier Review Checklist

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
DEVELOPMENT REGULATIONS			
Unclear development regulations	No	Development regulations are clear and publicly accessible.	
High minimum lot sizes	No	There are no minimum lot sizes in the RN and RM zones.	
Low maximum densities or low maximum FAR	No	The minimum density in the RM zone is 20 dwelling units per acre; the maximum density is 75 dwelling units per acre.	
Low maximum building heights	No	The maximum building height in the RM zone is 60 feet (approximately 5 stories)	
Large setback requirements	No	The RM zone has 15-foot front setbacks, 5-foot side setbacks, and 5-foot rear setbacks.	
High off-street parking requirements	No	The recently updated development code includes an exemption for residences under 1,200 square feet and no parking required for affordable housing, senior housing/congregate care or transitional housing. 1 space is required for SFR and.5 spaces per units is required for multifamily units. For all other housing types in the RN zone 1 space per unit, except for .5 spaces for units on lots less than 6,000 square feet.	
High impervious coverage limits	No	The max lot coverage is 65%.	

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
Lack of alignment between building and development codes	No	There does not appear to be a lack of alignment between building and development codes.	
Other (for example: ground floor retail requirements, open space requirements, complex design standards, tree retention regulations, historic preservation requirements)	No	There are no additional requirements impacting development feasibility in these zones.	
PROCESS OBSTACLES			
Conditional use permit process	No	A conditional use permit is not required for multifamily housing in the RM zone.	
Design review	No	Design review is not required for multifamily housing in the RM zone.	
Lack of clear and accessible information about process and fees	No	Information about process and fees is clear and publicly available.	
Permit fees, impact fees and utility connection fees	No	Permit fees are not significantly higher than comparable jurisdictions.	

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
Process times and staffing challenges	No.	The City in August of 2025 converted from a Paper to Digital permit system using Tyler's EPL and all staffing positions are filled throughout the Department with 2 full-time inspectors/plans examiners, a Building Official, 2 permit technicians, 1 permit coordinator, 2 senior planners and 1 code enforcement officer.	
SEPA process	No	SEPA process is explained clearly within the code.	
LIMITED LAND AVAILABILITY AND ENVIRONMENTAL CONSTRAINTS			
Lack of large parcels for infill development	No	Walla Walla's Land Capacity Analysis found sufficient capacity to accommodate needed housing units at all income levels and housing types.	
Environmental constraints	No	The city has very few critical areas overall, and the Land Capacity Analysis found that critical areas do not significantly affect developable acreage.	

Appendix III Exhibit 3. Supplementary Barrier Review Checklist for PSH and Emergency Housing

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
DEVELOPMENT REGULATIONS			
Spacing requirements (for example, minimum distance from parks, schools or other emergency/PSH housing facilities)2	No	There are no specifically outlined space requirements for PSH/emergency housing.	
Parking requirements	No	The development code was recently updated to include a new parking exemption Section, WWMC 20.127.007. No parking required for affordable hedrf2qwqousing, senior housing/congregate care or transitional housing.	
On-site recreation and open space requirements	No	There are no specific open space requirements for emergency/PSH	
Restrictions on support spaces, such as office space, within a transitional or PSH building in a residential zone	No	Emergency/PSH is allowed by right in commercial zones, such as CC and CH. These zones allow for complementary services.	
Arbitrary limits on number of occupants (in conflict with RCW 35A.21.314)	No	There are no limits on the number of occupants.	

[2] Note that RCW 35A.21.430 expressly states requirements on occupancy, spacing, and intensity of use may not prevent the siting of a sufficient number of permanent supportive housing, transitional housing, indoor emergency housing or indoor emergency shelters necessary to accommodate each code city's projected need for such housing and shelter under RCW 36.70A.070(2)(a)(ii). The restrictions on these uses must be to protect public health and safety.

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
Requirements for PSH or emergency housing that are different than the requirements imposed on housing developments generally (in conflict with RCW 36.130.020)	Yes	A conditional use permit is required for emergency/PSH in the RN and RM zones.	Consider allowing Level I or Level II review of emergency/PSH in these zones.
Other restrictions specific to emergency shelters, emergency housing, transitional housing and permanent supportive housing	No	There are no additional restrictions impacting the development of emergency/PSH.	

Appendix III Exhibit 4. Accessory Dwelling Unit Barrier Review Checklist

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
DEVELOPMENT REGULATIONS			
Consistent with HB 1337 (2023) • **Must allow two ADUs on each lot in urban growth areas;** • **May not require the owner to occupy the property, and may not prohibit sale as independent units, but may restrict the use of ADUs as short term rentals;** • **Must allow an ADU of at least 1,000 square feet;** • **Must set parking requirements based on distance from transit and lot size;** • **May not charge more than 50% of the impact fees charged for the principal unit;** • **Must permit ADUs in structures detached from the principal unit;** • **May not restrict roof heights of ADUs to less than 24 feet, unless that limitation applies to the principal unit;** • **May not impose setback requirements, yard coverage limits, tree retention mandates, restrictions on entry door locations, aesthetic requirements, or requirements**	No	Two ADUs are allowed per lot in residential zones pursuant to HB 1337. Accessory dwelling units may be attached or detached from a permitted residential unit. The setbacks for an ADU shall be a minimum of 5 feet from the side property line, 5 feet from the rear property line, and up to, but not within, the required front yard. No alleys are plowed.	

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
for design review for ADUs that are more restrictive than those for principal units; • Must allow an ADUs on any lot that meets the minimum lot size required for the principal unit; • Must allow detached ADUs to be sited at a lot line if the lot line abuts a public alley, unless the city or county routinely plows snow on the public alley; • Must allow conversions from existing structures, even if they violate current code requirements for setbacks or lot coverage; and • May not require public street improvements as a condition of permitting ADUs.			
Unclear development regulations	No	Development regulations for ADUs are clear.	
Large setback requirements	No	A five-foot rear setback is not overly large, and aligned with the requirements of HB 1337 as the city does not plow alleys	
Off-street parking requirements	No.	No off-street parking required for ADUs.	
Other (for example: burdensome design standards, tree retention regulations, historic preservation	No	There are no additional standards impacting the development of ADUs.	

	Is this barrier likely to affect housing production? (yes or no)	Why or why not? Provide evidence.	Actions needed to address barrier.
requirements, open space requirements, etc.)			
PROCESS OBSTACLES			
Lack of clear and accessible information about process and fees	No	Fee and process information is available publicly.	
Permit fees, impact fees and utility connection fees that are not proportionate to impact	No	The ADU impact fees in Walla Walla are not more than 50% of those for single family homes.	
Processing times and staffing challenges		The City in August of 2025 converted from a Paper to Digital permit system using Tyler's EPL and all staffing positions are filled throughout the Department with two full-time inspectors/plans examiners, one Building Official, two permit technicians, one permit coordinator, two senior planners and one code enforcement officer.	

Appendix III Exhibit 5. Checklist for Local Option Tools for Addressing Affordable Housing Funding Gaps

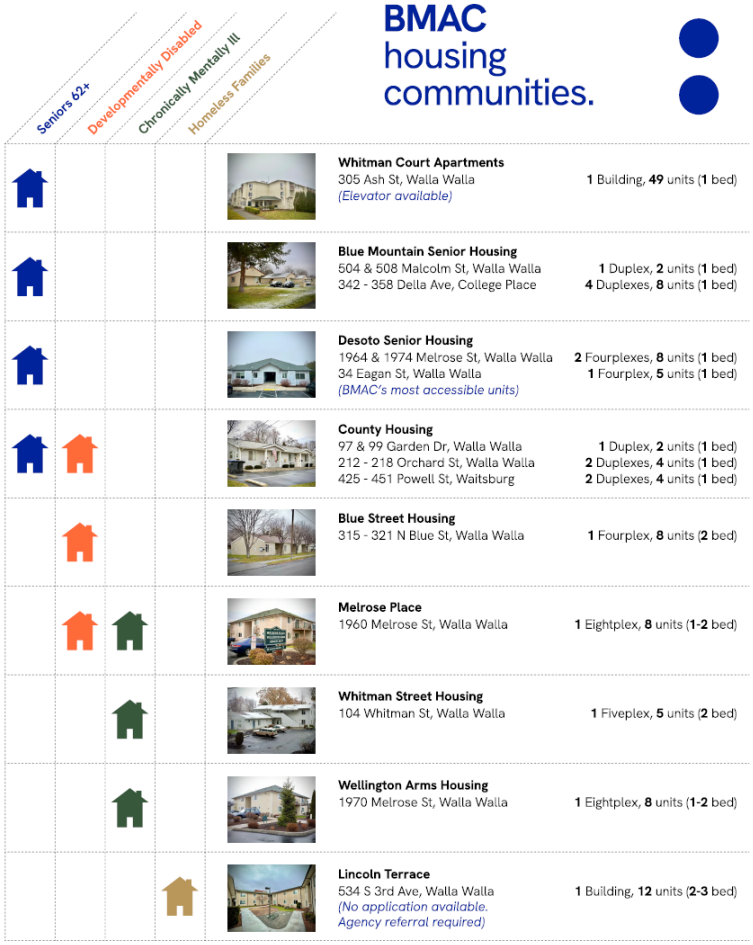
Local option tools for addressing affordable housing funding gaps*	Implementation status	Plans for implementation
Housing and related services sales tax (RCW 82.14.530)		
Affordable housing property tax levy (RCW 84.52.105)		
REET 2 (RCW 82.46.035) – GMA jurisdictions only and only available through 2025		
Affordable Housing Sales Tax Credit (RCW 82.14.540) – was only available to jurisdictions through July 2020		
Lodging Tax (RCW 67.28.150 and RCW 67.28.160) to repay general obligation bonds or revenue bonds	3.15.060 Lodging tax fund.	
Mental Illness and Drug Dependency Tax (RCW 82.14.460) – jurisdictions with a population over 30,000		
Donating surplus public lands for affordable housing projects (RCW 39.33.015)	An RFP was issued in February 2026 for a site at 280 W. Sumach St. The site is 0.33 acres and has water and sewer available.	Applications for a proposal to develop the site were reviewed, and the Council selected a proposal in August 2026.
Impact fee waivers for affordable housing projects (RCW 82.02.060)	City currently provides letters indicating that they will waive fees for affordable projects applying for CHIP funding.	City is considering codifying these fee waivers in an ordinance.
Application fee waivers or other benefits for affordable housing projects (RCW 36.70A.540)		
Multifamily Tax Exemption (MFTE) with affordable housing requirement (RCW 84.14)	Chapter 2.28 MULTIFAMILY HOUSING TAX INCENTIVES	
General funds (including levy lid lifts to increase funds available)		

Subsidized Housing Inventory

Walla Walla has a substantial inventory of subsidized housing, primarily owned and operated by the Walla Walla Housing Authority (WWHA). The Housing Authority owns and manages 613 units, and provides rental assistance to another 1,174. An additional 50 units (Meadow Grove) came online in Fall of 2025. The WWHA reports that there are approximately 1,900 households on their wait lists, and that their wait list is consistently larger than 1,500 households. Their target income for qualifying for their programs is below 60% AMI.

Of the 613 units owned and managed by the WWHA, 128 units are targeted to agricultural workers. Additionally, there is one transitional program targeting homeless veterans which has nine units totaling 34 beds. The WWHA indicated that since the early 1990s, their programs has grown from 84 owned units with 20 rental assistance slots, into the numbers reported above. This equates to approximately 15 new subsidized units per year, on average.

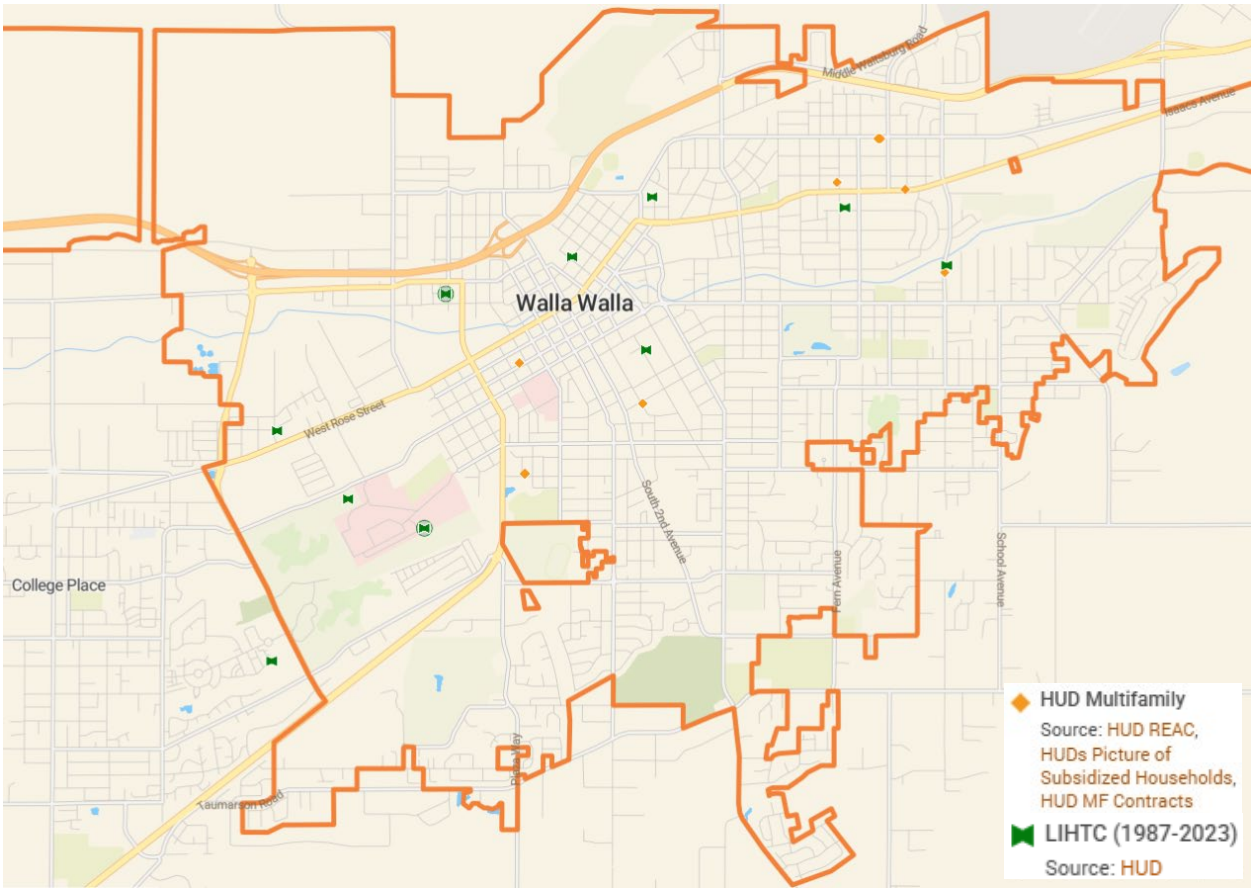
In addition to WWHA, the Blue Mountain Action Council (BMAC) provides a variety of services to low-income Walla Walla residents, including housing serving seniors, developmentally disabled residents, chronically mentally ill residents, and shelters serving homeless families. The sheet below details BMAC's largest projects in Walla Walla. BMAC reports that they also have several other smaller locations serving these categories as well.



Appendix III Figure 1. Blue Mountain Action Council Major Housing Sites in Walla Walla

Source: Blue Mountain Action Council

The map below shows locations of subsidized housing in Walla Walla developed using various HUD funding sources (in orange) and the Low Income Housing Tax Credit (in green).



Appendix III Figure 2. Subsidized Housing Locations in Walla Walla

Source: PolicyMap

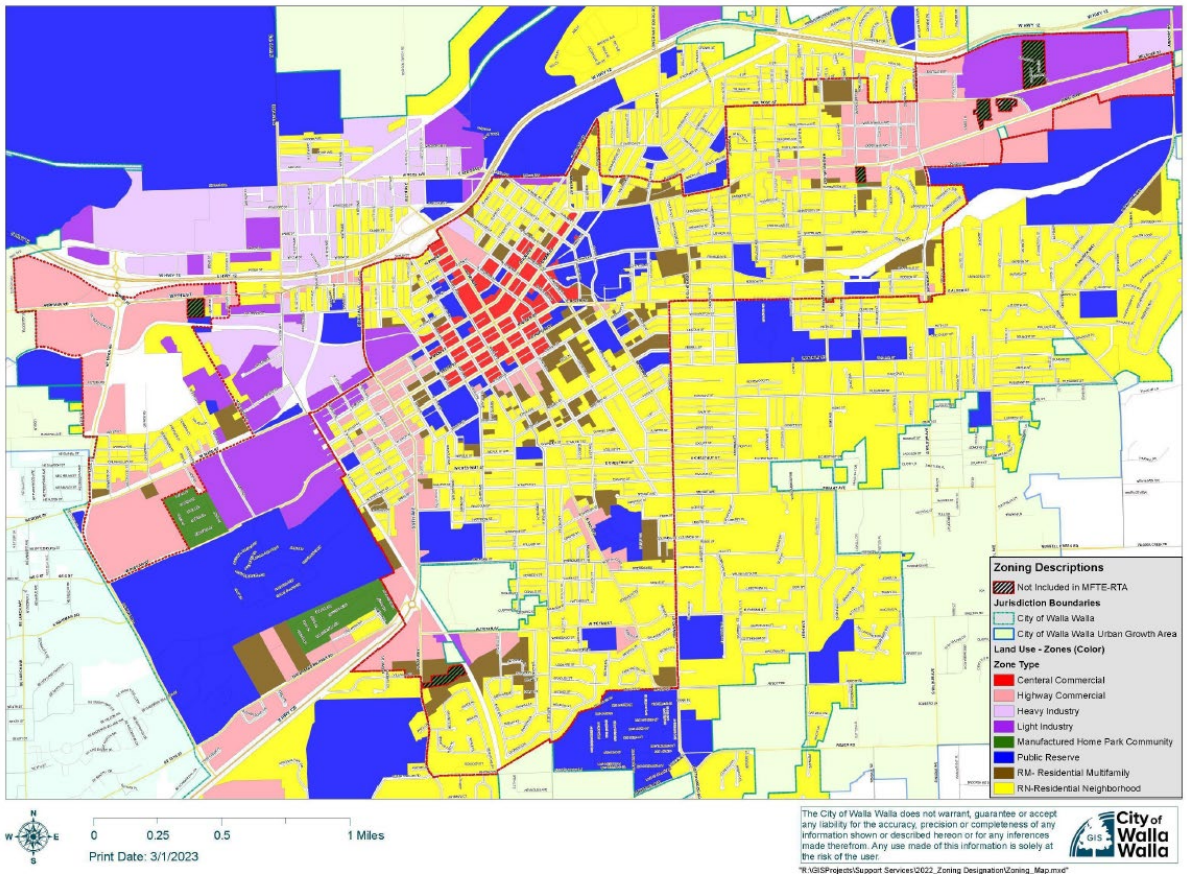
Subsidized Housing Pipeline

In addition to the existing subsidized units detailed above, there are plans for several more developments in the near future, including:

- 48 units at Wilbur Avenue (across from the fire station), proposed by the WWHA, to include:
  - 12 units at 0-30% AMI
  - 24 units at 40-50% AMI
  - 12 units at 60% AMI
- Eight tiny home units proposed by BMAC at 714 Carrie Ave., serving 80-120% AMI.

Additionally, note that the WWHA has a significant track record of developing affordable housing in the city, on average 15 units a year since the 1990s, as discussed above.

The City of Walla Walla also has a Multifamily Tax Exemption (MFTE) program, which was recently updated in 2021. This program offers a tax exemption to residential multifamily developments in the targeted area, shown outlined in red on the map below. MFTE projects must commit to providing 25 percent of units in their projects at rents or sale prices affordable to low-income households and complying with HUD's Fair Market Rent (FMR) thresholds for Walla Walla County for twelve years, with the possibility of extension. Therefore, any new multifamily development in the targeted area will also generate additional subsidized units over the planning horizon.



Appendix III Figure 3. MFTE Residential Targeted Area in Walla Walla

Source: City of Walla Walla

Housing Assistance / Vouchers

The Walla Walla Housing Authority (WWHA) operates housing assistance programs which provide vouchers to eligible households and rental assistance at specific locations as follows:

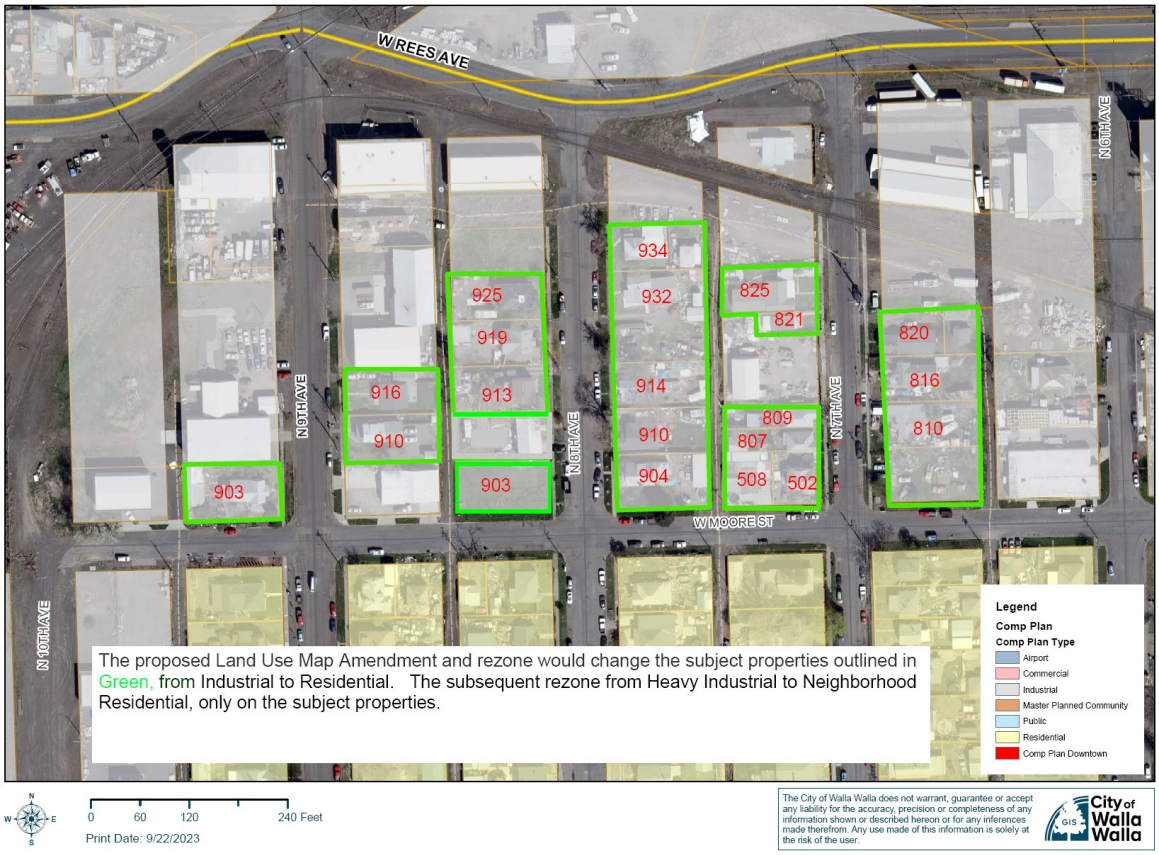
- The Housing Choice Voucher Rental Assistance Program provides vouchers to eligible households funded through the U.S. Department of Housing and Urban Development. The wait list in Walla Walla is currently closed per the WWHA website.
- The Project-Based Voucher program offers rental assistance at specific housing locations around the city, including Belmont Apartments, Emerald Family Properties, Evergreen Commons, Marjorie Terrace, and Rosehaven Cottages. Full details of all sites are available at wallawallaha.org/rental-assistance.

- The HUD-VASH program combines the U.S. Department of Housing and Urban Development's (HUD) Housing Choice Voucher program for homeless veterans with case management and clinical services provided by the Veterans Medical Administration Center (VMAC) located in Walla Walla.
- The HOME Tenant-Based Rental Assistance (TBRA) program utilizes federal funds to support communities by providing utility, deposit, and ongoing rental assistance. The Washington State Department of Commerce funds the TBRA program and those monies are contracted to local providers. Eligible households are referred to TBRA through the local Coordinated Entry System.

In total, the WWHA provides rental assistance to 1,174 households. The WWHA reports that there are approximately 1,900 households currently on their wait lists.

Preservation of Naturally Occurring Affordable Housing

Recently, a comprehensive plan amendment has been proposed to convert the parcels shown below in green from heavy industrial to single-family residential. These parcels have pre-existing nonconforming residential uses, and contain housing which serves lower-income residents. The rezoning of these parcels is intended to prevent displacement of these residents and loss of this existing naturally occurring affordable housing. This single-family zoning is not reducing housing capacity, since housing is not allowed in the industrial zones, and the same potential for ADUs or middle housing anywhere else in the city under new regulations will also apply to these parcels.



Appendix III Figure 4. Proposed Rezone Parcels North of Moore Street

Source: City of Walla Walla

Surplus City-Owned Property

As allowed by RCW 39.33.015, the Walla Walla City Council may dispose of surplus publicly owned property for affordable housing development. In 2026, the city issued an RFP to solicit developers or teams for development of a site at 280 W. Sumach St. The City completed its RFP and Council selected a proposal for development. The site is 0.33 acres and has water and sewer available. The site is zoned PR, and multifamily dwellings and townhomes are allowed on the site. The city is seeking housing that can serve households earning 80 percent of the Area Median Income or below, for a minimum term of 30 years, with scoring bonuses for senior, family, and special needs housing.

Affordable Housing Funding Gap

The Department of Commerce suggests analyzing the potential funding gap that would be needed to fund the quantity of subsidized housing needed to meet the jurisdiction's targets at lower income bands. As noted previously, about 15 subsidized units per year have been built in the city since the 1990s. Given a continuation of this rate of production, this would equate to 392 units over the 2020-2046 planning horizon. Based on Walla Walla's housing targets, and removing pending units, there would be a gap of 784 housing units needed to serve Walla Walla's target. Given Commerce's estimation of $316,272 (as of 2023) needed to construct a subsidized unit in Walla Walla County, this would equate to a need for **$247.9 million** in additional subsidized housing funding, or **$9.5 million per year** (not adjusted for inflation).

Sources of Affordable Housing

Commerce guidance directs cities to document likely potential sources of funding to help address the gap needed to develop the amount of housing needed to meet the targets, detailed above. The following are existing and potential sources of affordable housing funding in Walla Walla over the 20-year planning horizon:

- **Lodging Tax –** As authorized by RCW 67.28.150 and RCW 67.28.160, Walla Walla has established a "Lodging Tax Fund" detailed in WWMC 3.15.060. These funds, which are generated by a special excise tax on lodging, can be used for tourism-related purposes, general obligation bonds for tourism, or any other uses authorized by RCW 67.28, which includes affordable workforce housing.
- **Multifamily Tax Exemption –** As authorized by RCW 84.14, and as detailed above under "Subsidized Housing Pipeline," starting on p. 73, Walla Walla has a Multifamily Tax Exemption program which provides 25 percent of new units affordable to lower-income households in multifamily developments which take advantage of the program.
- **Housing Trust Fund and HOME Funds –** The Department of Commerce provides state and federal funding for affordable housing construction and preservation through these programs, which targets low-income and special needs populations and are open to local governments, tribes, and nonprofits.
    - commerce.wa.gov/building-infrastructure/housing/housing-trust-fund/
    - commerce.wa.gov/building-infrastructure/housing/housing-trust-fund/home-program/
- **Low-Income Housing Tax Credit (LIHTC) –** This program, administered by the Washington State Housing Finance Commission (WSHFC) allocates federal income tax credits to developers for the construction and rehabilitation of affordable housing. As shown above in **Error! Reference source not found.**, there are several affordable housing projects in Walla Walla funded using this program, and nonprofit developers are expected to continue to take advantage of this financing option, the most common method of financing affordable housing nationwide.
- **Fee Waivers –** The City anticipates that the 2026 annual code amendments will include an exemption for utility connections: a program to waive applicable capital facility charges (e.g. utility connection fee) and permit fees for the affordable units contingent on receiving of CHIP grant funds for the sewer utility work. A transportation impact fee program is currently under development and could include waivers for certain projects, such as affordable housing,
- **Housing Development Fund –** Walla Walla has adopted a "housing development fund," as codified in WWMC 3.15.140 into which shall be paid funds to be used for the purpose of low income housing development, as authorized by RCW 35.21.685 and RCW 35A.33.150.
- **Connecting Housing to Infrastructure Program (CHIP) –** Created in 2021, this State program helps local governments encourage the creation of affordable housing by reducing the cost of infrastructure associated with development. The program can

reimburse water, sewer, and stormwater extensions and connections as well as regional stormwater systems and upgrades. It can also reimburse System Development Charges (SDCs) that the city waives for affordable housing. Walla Walla has not codified fee waivers for affordable housing in its municipal code. However, the city is providing letters to developers applying for CHIP funding indicating that they will waive these fees for affordable projects.

In addition, city staff have indicated that the city is planning to consider the use of additional surplus land to be donated or provided at a discount for the purposes of developing affordable housing, as well as the creation of a Real Estate Excise Tax 2 (REET 2) which can be imposed at 0.25% to be used for capital projects, including partially for affordable housing funding.



Appendix IV. Racially Disparate Impacts Analysis

July 10, 2026

Introduction

In 2021, the Washington State Legislature passed House Bill 1220 (HB 1220) as an amendment to the state Growth Management Act (GMA). HB 1220 requires that local governments plan for housing at all income levels and assess the racially disparate impacts (RDI) of existing housing policies. Conditions that indicate that policies have racially disparate impacts can include segregation, cost burden, displacement, educational opportunities, and health disparities.

According to state guidance, there are five steps to understanding and addressing racially disparate impacts:

- Step 1: Engage the Community
- Step 2: Gather & Analyze Data
- Step 3: Evaluate Policies
- Step 4: Revise Policies
- Step 5: Review & Update Regulations

This report accounts for both Step 2 and Step 3 – it includes a summary of findings based on data from the US Census Bureau, U.S. Department of Housing and Urban Development (HUD), and other sources. These findings then inform the policy evaluations and recommendations found at the end of the report.

Key Findings

- Walla Walla is about as diverse as Walla Walla County; both jurisdictions are about 70 percent white with a much higher share of households identifying as Hispanic or Latino (24 percent and 22 percent, respectively) in comparison to the state (13 percent).
- While the share of White households and households of color that are cost-burdened is roughly equal (32 percent and 35 percent, respectively), 82 percent of Black households are cost-burdened. Asian households have the lowest cost burden, at 12 percent of households.
- Home ownership is most common among Asian and Other Race (includes multiple races) households in Walla Walla: 74 percent of Asian households own their homes, and 68 percent of Other Race households own their homes. White and Hispanic households are about equally as likely to be owners (59 and 58 percent, respectively); Only 18 percent of Black households own their homes.

- There is a shortage of housing available in Walla Walla for those making less than 30 percent of the Area Median Income (AMI) and those making greater than 80 percent AMI. However, from 2014 to 2019, the amount of housing affordable increased only for the two highest brackets (50-80 percent AMI and above 80 percent AMI).
- Asian households have the highest share in the above median income category (61 percent), while Black or African American households have the largest share in the extremely low-income category (77 percent). White and "All" groups have more balanced distributions, with notable portions in the above median income category (45 percent and 42 percent, respectively). Between 2015 and 2020, the share of households in the above median income category grew for White and Other Races households, while the share shrunk for all other racial groups. Conversely, the share of households in the extremely-low income bucket grew for all racial groups besides White and Other Races.

Historical Context

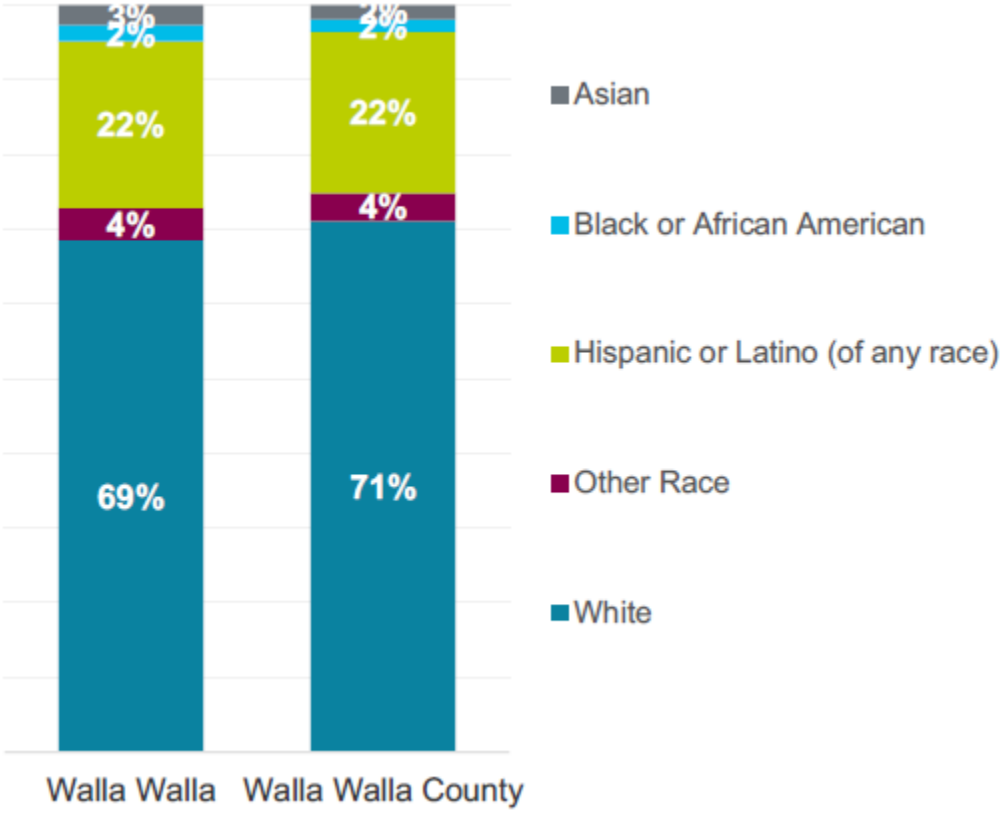
Throughout the history of the United States, a combination of laws and practices have impacted where specific groups of people live, what opportunities they have access to, and their ability to build wealth through stable housing.

Unfortunately, many of these policies explicitly or implicitly benefited white residents at the expense of all others. The legacy of policies like redlining, which used racial criteria in determining which neighborhoods were suitable for government-backed loans, highway development through predominantly-Black neighborhoods, and racial covenants explicitly excluding certain groups from owning specific properties continues to impact non-white communities today.

While many cities have acknowledged the harms of these policies, many of which are no longer legal, there are still policies in effect today that hold cities back from rectifying systemic harms. These can include policies that reference vague concepts like “neighborhood character,” as well as those that permit only the most expensive homes to be built, thus shutting lower-income residents out of high-opportunity areas.

Assessing Racially Disparate Impacts

Appendix IV Figure 1 below shows the racial and ethnic composition of Walla Walla and Walla Walla County. While Walla Walla County became slightly more diverse between 2015 and 2020, the racial distribution in the City of Walla Walla did not see significant changes. The Hispanic or Latino population decreased from 24 percent to 22 percent, while the share of white residents increased slightly from 68 percent to 69 percent.



Appendix IV Figure 1. Racial Composition of Walla Walla and Walla Walla County (2020)

Source: U.S. Census Bureau, 2016-2020 American Community Survey 5-Year Estimates (Table DP05); Washington Department of Commerce, 2023.

As shown below in Appendix IV Table 1, between 2015 and 2020, the city lost 201 Hispanic or Latino households, 122 American Indian/Alaska Native households and 22 Black/African American households over this period, despite gaining a net total of 994 new households.

Appendix IV Table 1. Change in Population by Race/Ethnicity, Walla Walla and Walla Walla County

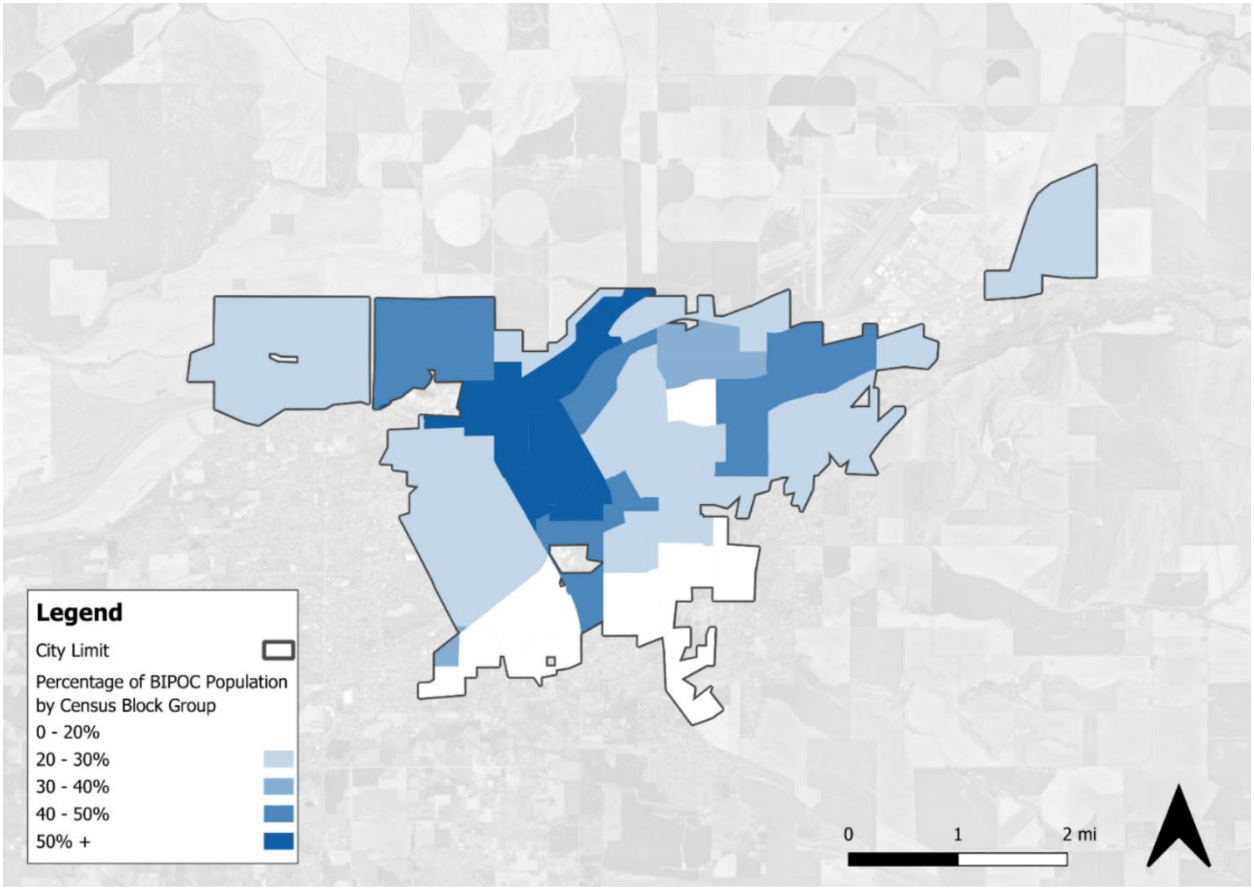
Race or Ethnic Category	Walla Walla 2015	Walla Walla 2020	Change	Walla Walla County 2015	Walla Walla County 2020	Change
American Indian and Alaska Native	227	105	-122	285	180	-105
Asian	726	878	152	918	1,119	201
Black or African American	713	691	-22	908	1,026	118
Hispanic or Latino (of any race)	7,567	7,366	-201	12,528	13,115	587
Native Hawaiian and Other Pacific Islander	19	58	39	41	104	63
Other Race	5	0	-5	94	45	-49
Two or more races	1,129	1,242	113	1,559	1,930	371
White	21,571	22,611	1,040	43,393	43,266	-127
Total	**31,957**	**32,951**	**994**	**59,726**	**60,785**	**1,059**

Source: U.S. Census Bureau, 2011-2015 and 2016-2020 American Community Survey 5-Year Estimates (Table DP05); Washington Department of Commerce, 2023.

The map of Walla Walla in Appendix IV Figure 2 indicates that Walla Walla's residents of color are spread across most of the city, with the highest concentrations in the northern and central areas. While residents of color made up 31 percent of the population in 2020, some census block groups are at least 50 percent residents of color, while other clusters are almost 100 percent white residents. The census block groups with the lowest share of residents of color—0 to 20 percent—are in the southern end of the city.

The remainder of the report indicates disparities in income and tenure (renter or homeowner) across race and ethnicity. Where these disparities are identified, it should be considered that the prevalence of those disparities are more concentrated in the areas shown in Appendix IV Figure 2.

City of Walla Walla | Race and Ethnicity, 2020



Appendix IV Figure 2. Race and Ethnicity in Walla Walla by Census Block (2020)

Source: 2020 U.S. Census Table P9, WSDOT, LCG

Household Tenure and Cost Burden

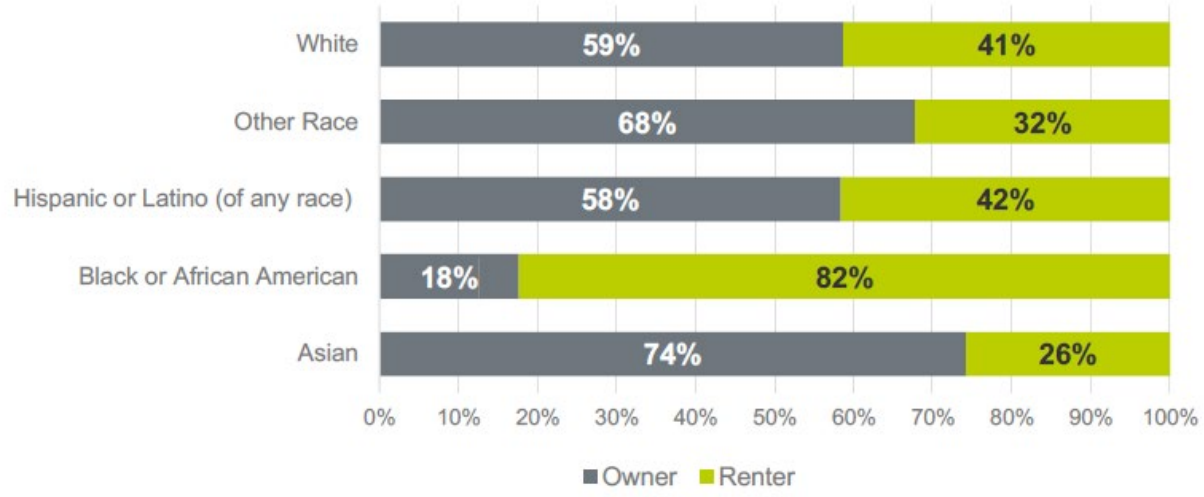
Appendix IV Table 2 below shows the most recently available counts for cost burden by race and ethnicity available through the U.S. Housing and Urban Development (HUD) Comprehensive Housing Affordability Strategy (CHAS) database. Though rates of cost burden have decreased in the years since the release of this dataset, disparities across renters and homeowners remain. This sharp divide in stability between renters and owners can result in racially disparate impacts when renters are more likely to be people of color.

Appendix IV Table 2. Number of Households by Cost Burden in Walla Walla (2019)

	White	Black or African American	Asian	American Indian or Alaskan Native	Pacific Islander	Other Race	Hispanic or Latino (of any race)	Total
Owner Households								
Not Cost Burdened	4,740	15	105	10	0	110	965	5,945
Total Cost-Burdened	970	0	10	0	0	25	235	1,240
Cost-Burdened (30-50%)	*555*	*0*	*10*	*0*	*0*	*10*	*135*	*710*
Severely Cost-Burdened (>50%)	*415*	*0*	*0*	*0*	*0*	*15*	*100*	*530*
Not Calculated	85	0	0	0	0	0	0	85
Total	5,790	15	115	10	0	135	1,200	7,265
Renter Households								
Not Cost Burdened	1,845	0	30	0	0	55	305	2,235
Total Cost-Burdened	2,180	70	10	4	0	10	520	2,794
Cost-Burdened (30-50%)	*960*	*25*	*0*	*0*	*0*	*0*	*245*	1,230
Severely Cost-Burdened (>50%)	*1,220*	*45*	*10*	*4*	*0*	*10*	*275*	1,564
Not Calculated	55	0	0	0	0	0	30	85
Total	**4,080**	**70**	**40**	**4**	**0**	**65**	**855**	**5,114**
Total Households	**9,870**	**85**	**155**	**14**	**0**	**200**	**2,055**	**12,379**

Source: U.S. HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 9); Washington Department of Commerce, 2023

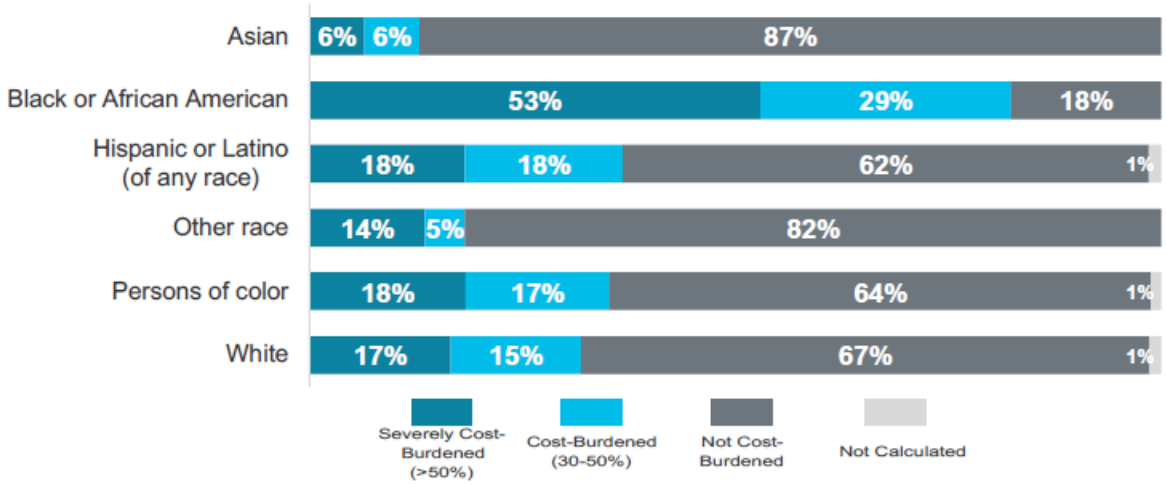
Appendix IV Figure 3 below shows the same CHAS dataset for rates of homeownership and renter households across race and ethnicity. As of 2019, in Walla Walla, 41 percent of White households rent their homes, compared to 82 percent of Black/African American households. However, Asian and other race households are more likely to own than white households, and Hispanic/Latino households have a comparable homeownership rate to white households in Walla Walla (58 percent).



Appendix IV Figure 3. Walla Walla Owner and Renter Households by Race & Ethnicity (2019)

Source: U.S. HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 9).

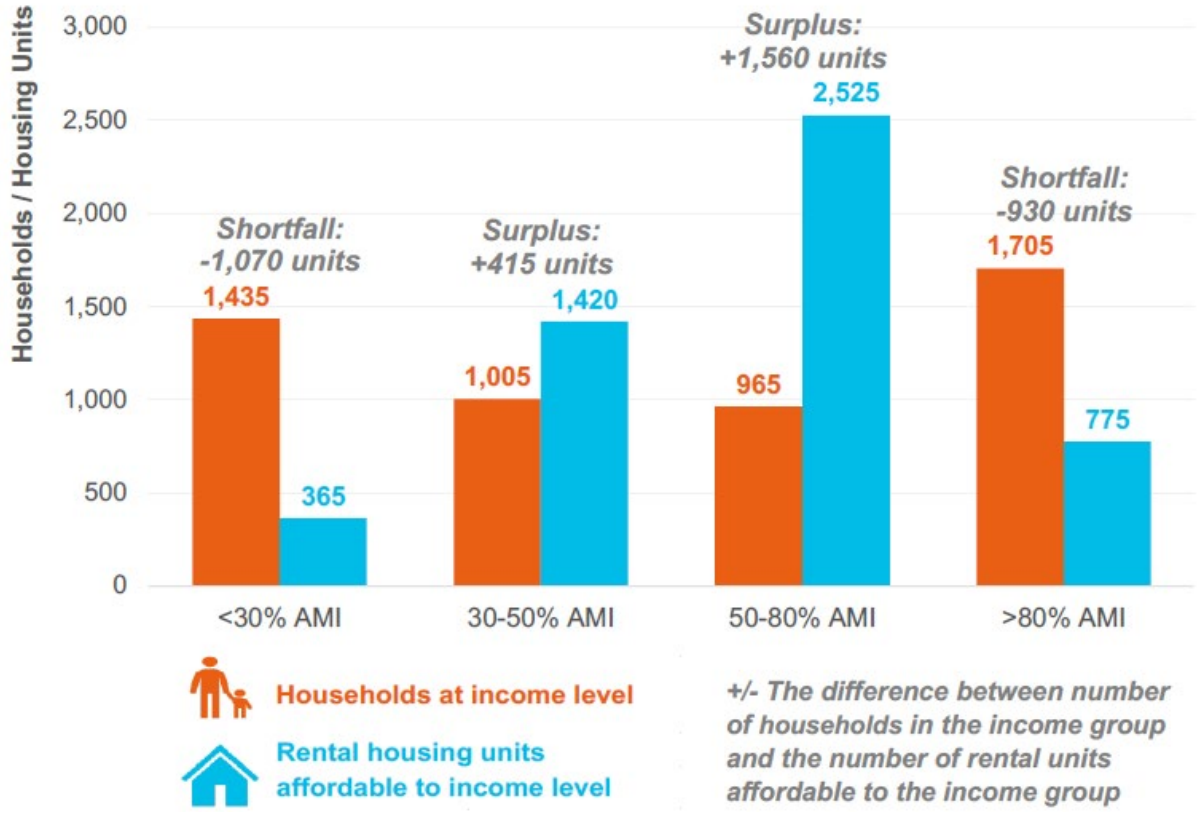
Appendix IV Figure 4below shows the same CHAS dataset for households experiencing housing cost burden. While 82 percent of Black/African American households are severely cost burdened, 32 percent of white households and 36 percent of Hispanic households are cost burdened.



Appendix IV Figure 4. Walla Walla Percent of All Households Experiencing Housing Cost Burden, 2019

Source: U.S. HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 9); Washington Department of Commerce, 2023.

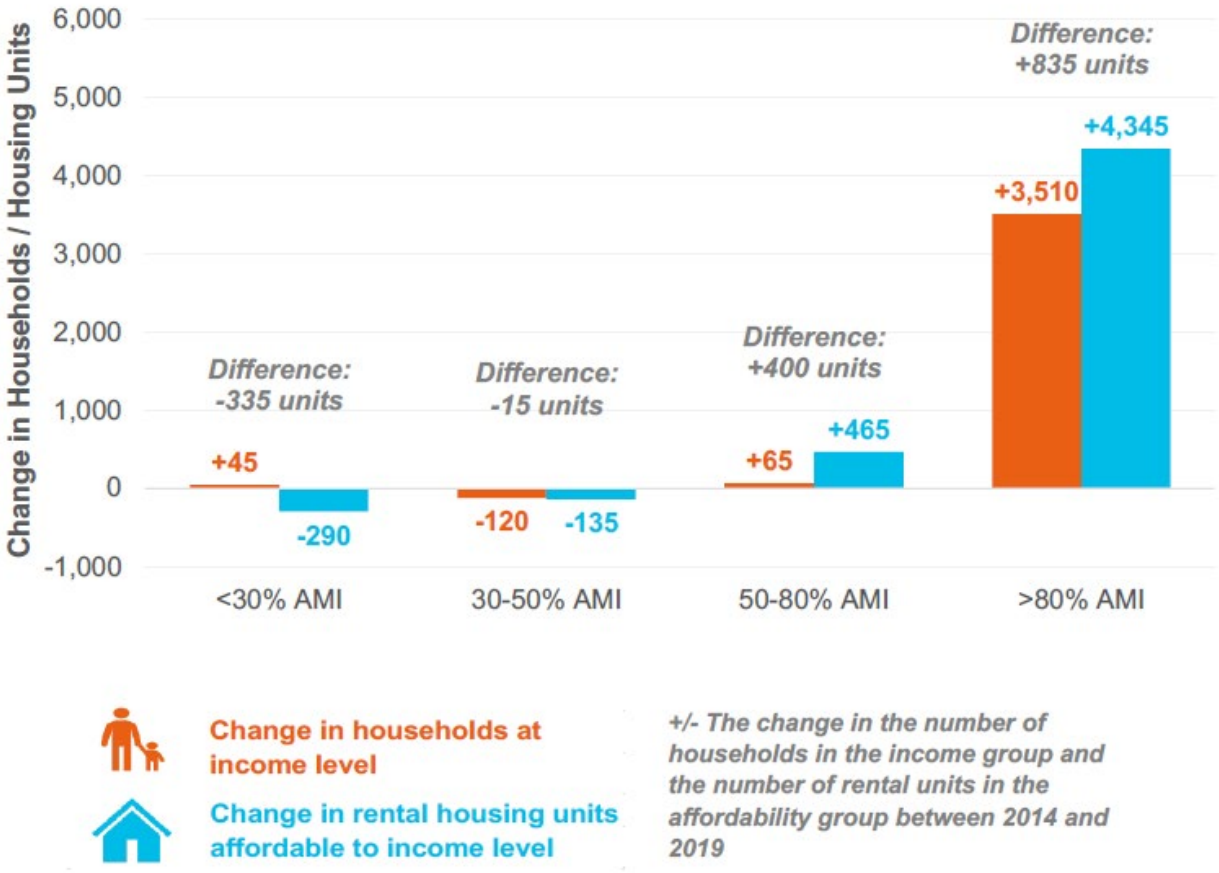
Appendix IV Figure 5 below shows a comparison of renters and rental units affordable across low-income households. This shows that the renter cost burden in Walla Walla is largely driven by a 1,070-unit shortfall of units affordable for households making less than 30 percent of area median income (AMI) and a 930-unit shortfall of units affordable for households making more than 80 percent AMI.



Appendix IV Figure 5. Walla Walla Renter Households by Income Compared to Rental Units by Affordability, 2019

Sources: U.S. HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 15C) & US HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 14B).

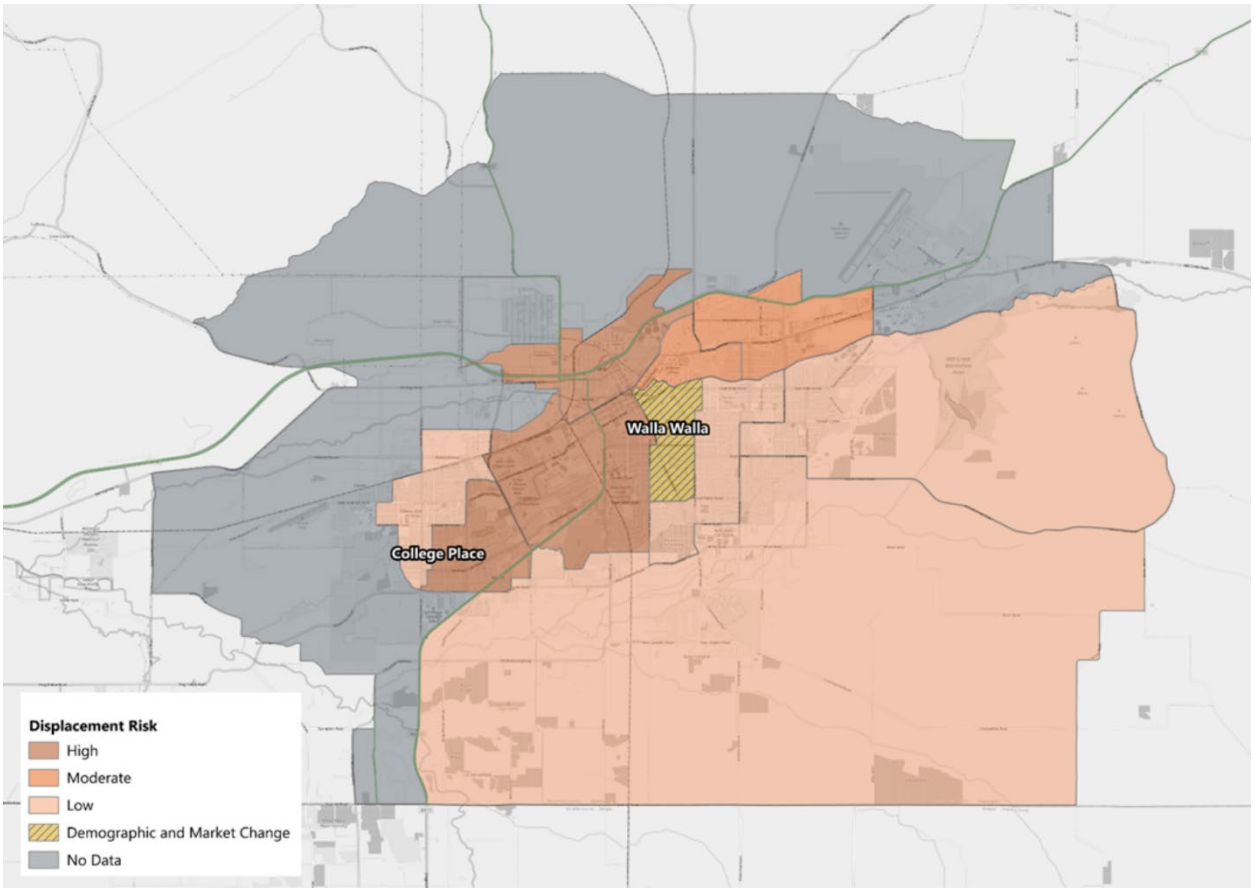
Appendix IV Figure 6 below shows that between 2014 and 2019, 4,810 more rental units were added to the stock of units affordable to households making at least 50 percent AMI, while Walla Walla lost 425 units affordable to households making less than that. These numbers do not necessarily reflect construction and demolition activity – in many cases, existing rental units have become more expensive due to increased market rents, and a lagging in household incomes, meaning that units that were once affordable to households making 50-80% AMI are now no longer affordable.



Appendix IV Figure 6. Walla Walla Five-Year Change in Renter Households by Income and Rental Units by Affordability, 2014-2019

Sources: U.S. HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 15C) & US HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 14B) & U.S. HUD, 2010-2014 Comprehensive Housing Affordability Strategy (CHAS) (Table 15C) & U.S. HUD, 2010-2014 Comprehensive Housing Affordability Strategy (CHAS) (Table 14B).

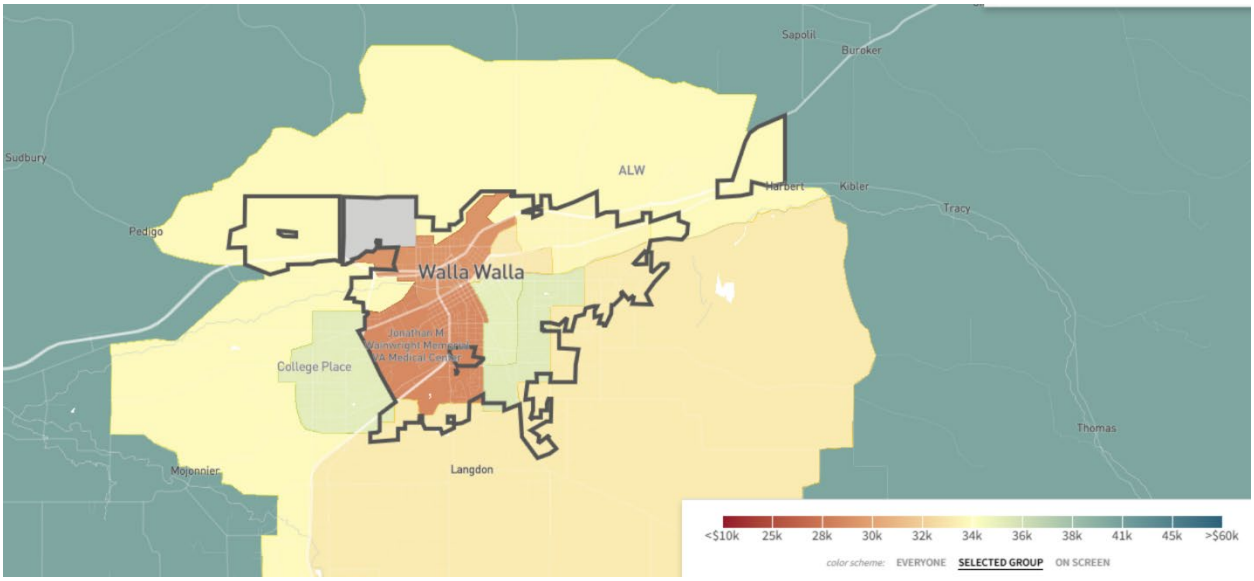
Appendix IV Figure 7below shows Washington Department of Commerce's Draft Displacement Risk Map. Walla Walla has significant areas with high displacement risks, particularly on the western side of town. The area just south of Downtown Walla Walla is currently undergoing demographic and market change, a measure indicating existing trends across three categories of analysis: a decrease in BIPOC populations and increase in incomes, an increase in rents between 2010 and 2020, and a prevalence of BIPOC, renter, and lower-income households. Notably, the areas of highest risk of displacement in the city closely map to the areas with the highest share of residents of color, indicating the need for City policy to address inequitable patterns of local development (see Policy Evaluation below).



Appendix IV Figure 7. Washington Department of Commerce Draft Displacement Risk Map for Walla Walla

Sources: Washington Department of Commerce Draft Displacement Risk Map Tool.

The Opportunity Atlas shown below in Appendix IV Figure 8 measures the average annual household income for low-income children who grew up in a specific area, regardless of race or gender. The tool shows that as of 2015, the earning potential for children who grew up in low-income households in Walla Walla is lower in areas that have a high displacement risk. In addition, those who grew up in and adjacent to the city of Walla Walla have lower earnings than those who grew up in other parts of the county.



Appendix IV Figure 8. Household Incomes at Age 35 for Children in Low-Income Households, Walla Walla & Surrounding Communities

Sources: Opportunity Atlas County & Metro Mobility Outcomes Map Tool.

Household Income

Appendix IV Table 3 below breaks down household income by race and ethnicity. In Walla Walla, 61 percent of Asian households make above the median income – the highest share among all racial and ethnic groups. Among white households, 45 percent make above median income compared with just 29 percent of Hispanic/Latino households. Over three quarters of Black/African American households make less than 30 percent AMI, and an additional five percent make between 30 and 50 percent AMI.

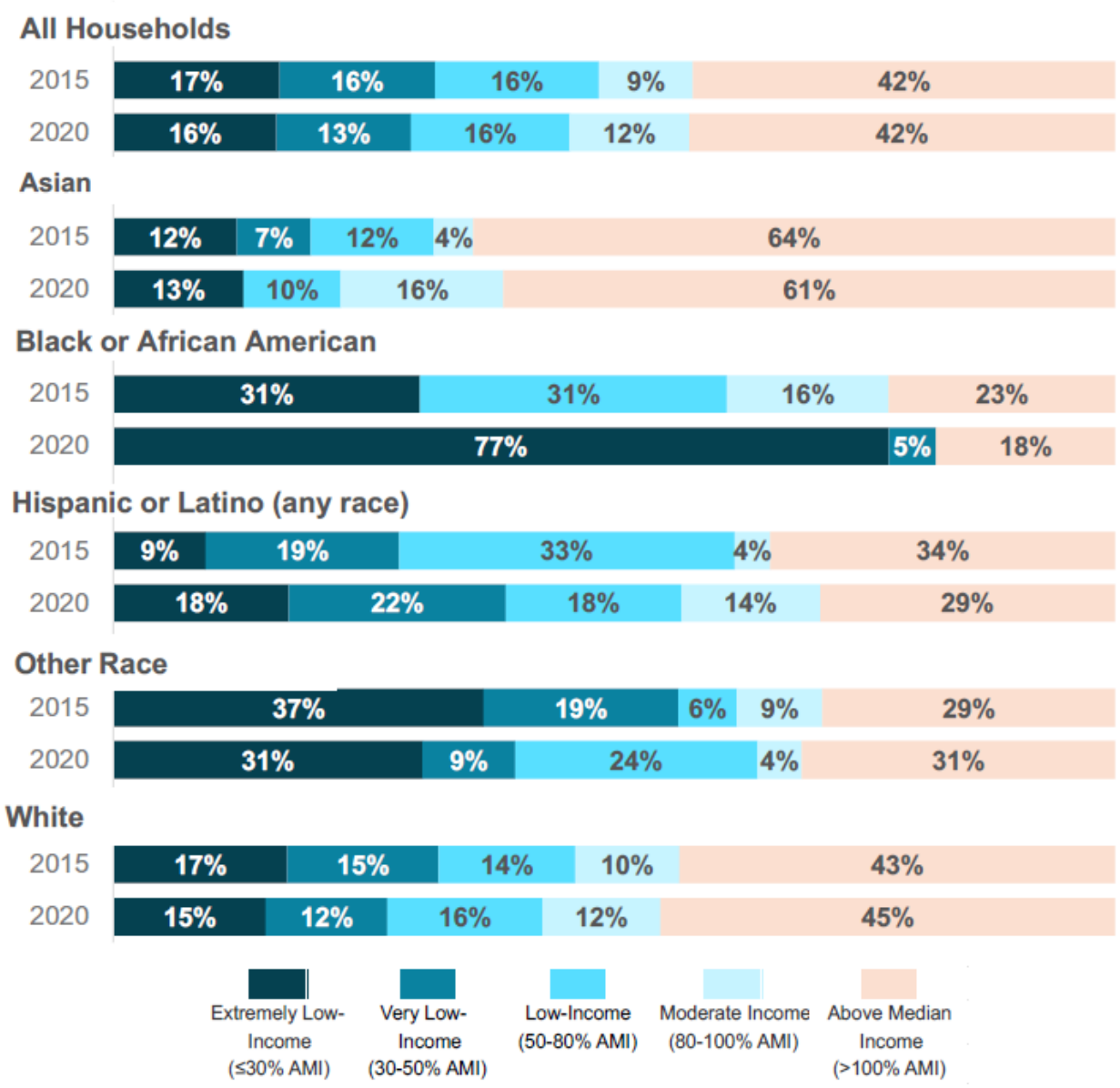
Appendix IV Table 3. Walla Walla Count of Households by Income and Race, 2019

Income Category (% of AMI)	American Indian or Alaskan Native	Asian	Black or African American	Hispanic or Latino (of any race)	Pacific Islander	White	Not Reported	All
Number								
Extremely Low-Income (≤30% AMI)		4		20		65	360	-
Very Low-Income (30-50%)	-		-			4	445	-
Low-Income (50-80%)		10		15	-		360	-
Moderate Income (80-100%)	-			25	-		285	-
Above Median Income (>100%)	-			94		15	605	-
Total for published estimates	14	154	84	2,055	-	9,860	213	12,375
Percentage								
Extremely Low-Income (≤30% AMI)	0%	1%	3%	18%	0%	74%	3%	
Very Low-Income (30-50%)	0%	0%	0%	27%	0%	72%	1%	
Low-Income (50-80%)	1%	1%	0%	18%	0%	78%	2%	
Moderate Income (80-100%)	0%	2%	0%	19%	0%	78%	1%	
Above Median Income (>100%)	0%	2%	0%	12%	0%	85%	1%	

** The category "Other (including multiple races, non-Hispanic)" is suppressed in source data (CHAS 2015-2019 Table 1)*

Sources: U.S. HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 1) & U.S. HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 8)

Appendix IV Figure 9 below shows the distribution of households by income and race. Between 2015 and 2020, the percentage of households making between 30 and 50 percent AMI decreased from 16 percent to 13 percent. Over that same period the percentage of Black/African American households making below 30 percent AMI increased significantly, from 31 percent to 77 percent. While the share of white households making above median income increased from 43 to 45 percent, the share of households at that income level decreased in nearly every other racial group.



Appendix IV Figure 9. Walla Walla Percentage of All Households by Income Category and Race (2010-2014 vs. 2015-2019)

Sources: U.S. HUD, 2015-2019 Comprehensive Housing Affordability Strategy (CHAS) (Table 1).

Policy Evaluation

Based on the above analysis, there is room for improvements to policies in Walla Walla to reduce racially disparate impacts, and the data was used to inform the next steps of the racially disparate impacts assessment process – evaluating and revising policies that reinforce historical patterns of segregation, displacement, and inequitable outcomes. Taking a proactive approach in shaping policy to address these challenges will benefit all Walla Walla households as the City seeks to build a more equitable future.

Based on guidance provided by the Washington State Department of Commerce, the following policy evaluation framework was used to evaluate Walla Walla's existing Housing Element policies:

Criteria	Evaluation
The policy is valid and supports meeting the identified housing needs. The policy is needed and addresses identified racially disparate impacts, displacement and exclusion in housing.	**S** Supportive
The policy can support meeting the identified housing needs but may be insufficient or does not address racially disparate impacts, displacement and exclusion in housing.	**A** Approaching
The policy may challenge the jurisdiction's ability to meet the identified housing needs. The policy's benefits and burdens should be reviewed to optimize the ability to meet the policy's objectives while improving the equitable distribution of benefits and burdens imposed by the policy.	**C** Challenging
The policy does not impact the jurisdiction's ability to meet the identified housing needs and has no influence or impact on racially disparate impacts, displacement or exclusion.	**NA** Not applicable

Appendix IV Table 4. Policy Evaluation

Existing Goal / Policy #	Existing Goal/Policy	Equity Assessment	Why	Notes
	Goal H 1: A broad range of housing choices is available to meet the needs of people of diverse socioeconomic status, household type, and age.			
H 1.1	Provide an array of housing choices such as apartments, small lot single-family housing, accessory dwelling units, townhomes, manufactured homes, and cottages to meet the needs of people of all incomes throughout their lifespan.	**Approaching**	Providing an array of housing choices will help support the needs of a variety of households. However, it is important to ensure that where these types of housing are located do not enforce any existing patterns of segregation.	Ensure that this array of housing choices is allowed throughout a variety of zones in the city, including lower density residential zones, to ensure that neighborhoods are socially, racially, and economically diverse.

Existing Goal / Policy #	Existing Goal/Policy	Equity Assessment	Why	Notes
H 1.2	Address the causes of homelessness by working with local agencies and non-profits that provide services to this community.	**Approaching**	Working with local organizations that provide homeless services can help the City better understand and address the causes of homelessness. However, the City should also address the needs of those at risk of homelessness and promote housing stability.	Along with local organizations serving homeless residents, the City should also work with residents experiencing housing precarity - such as the high share of Black households who are extremely cost burdened - to help keep people housed.
H 1.3	Encourage the use of existing housing stock to provide affordable housing for households with middle and lower incomes.	**Approaching**	It is not clear what is meant by "encourage the use of existing housing stock." Making this policy more specific will help the city to develop equitable programs.	Clarify what the City intends with this program, i.e., provide financial assistance for repairs and maintenance for low- and middle-income homeowners and owners of un-regulated affordable rental housing (as in H 2.7).
H 1.4	Develop incentives for construction of housing affordable to households with low and moderate incomes such as density bonuses, waived fees, multi-family property tax exemption, or a transfer of development rights program.	**Approaching**	Incentives for affordable housing construction will help improve affordability challenges and reduce cost burden for low- and middle-income households. However, it is important to ensure that this housing is not concentrated in one area of the city.	Ensure that affordable housing is allowed in enough areas that it is feasible to build and not concentrated in one location. Currently, Walla Walla's multifamily zone applies to just a small percentage of city land - the City should consider expanding that zone or allowing affordable multifamily housing in lower-density neighborhoods (as described in H 2.1).



Existing Goal / Policy #	Existing Goal/Policy	Equity Assessment	Why	Notes
H 1.5	Coordinate and collaborate with private agencies to ensure housing for people with special needs including seniors, people with physical and developmental limitation, victims of domestic violence, and homeless individuals and families.	**Approaching**	It is not clear what is meant by "ensure housing" - does the City intend to provide financial support or incentives for this type of housing, or provide services for permanent supportive housing?	Clarify how the City intends to ensure housing for these groups, and ensure that the housing can be built in a variety of neighborhoods - especially those near essential services.
H 1.6	Apply for state and federal housing program funds to support efforts to provide funding for housing to serve people with low and moderate incomes and people with special needs.	**N/A**	State and federal housing program funds are necessary to support the construction of housing for low- and moderate-income households.	Keep
H 1.7	Allow manufactured housing and accessory dwelling units in single-family residential areas.	**Supportive**	Allowing for lower-cost housing types like manufactured housing and accessory dwelling units will help ensure that lower-density neighborhoods will support households at a variety of income levels, including both renters and homeowners.	
H 1.8	Work with educational institutions to ensure the provision of adequate housing for students.	**N/A**		Keep
H 1.9	Explore the possibility of establishing a housing land trust.	**N/A**		Keep
	Goal H 2: Attractive and functional neighborhoods are welcoming to all types of households.			
H 2.1	Integrate housing for lower and moderate income households and those with special needs into a variety of geographical locations throughout the city.	**Supportive**	This policy will help ensure that Walla Walla's neighborhoods are economically, socially, and racially integrated.	

Existing Goal / Policy #	Existing Goal/Policy	Equity Assessment	Why	Notes
H 2.2	Develop minimum property maintenance standards to ensure the safety and suitability of existing housing stock.	**Challenging**	While minimum property maintenance standards can help maintain the attractiveness of neighborhoods as well as aging housing stock, penalties for failing to meet these maintenance standards can result in housing instability for lower-income households, particularly those with elderly residents.	Ensure that penalties for failing to meet property maintenance standards do not lead to housing instability for vulnerable groups. Ensure that policy H 2.7 is in place and funded to help lower-income residents maintain their homes.
H 2.3	Develop design guidelines to ensure that all new housing, including that for lower and middle income owners and renters, adheres to good standards of planning, design, and construction.	**Challenging**	While this is a laudable goal which will help ensure the longevity and attractiveness of lower- and middle-income housing, excessive planning and design standards can add significant costs to housing development. This can exacerbate the feasibility gap for low-income housing, creating a disincentive to build new, much needed housing units.	Work with affordable housing providers to ensure that the design guidelines are not overly rigid and couple design requirements with incentives for affordable housing, as described in H 1.4. Ensure that design requirements do not enshrine one style of housing and/or landscaping as superior - housing should be designed to meet personal and cultural needs.
H 2.4	Enhance the character of neighborhoods through superior design, responsible stewardship, the application of sustainability principles, and historic preservation.	**Challenging**	This policy seems a bit redundant with policies H 2.2, H 2.3, and H 2.5. The Department of Commerce RDI guidelines suggest removing references to neighborhood character, as this concept has historically led to patterns of segregation due to the prioritization of single family neighborhoods.	Remove this policy, or focus instead on providing resources for historic preservation, as the other parts of this policy are addressed in other policies.



Existing Goal / Policy #	Existing Goal/Policy	Equity Assessment	Why	Notes
H 2.5	Plan for energy efficient housing that is designed to maximize use of renewable resources such as solar and wind power.	**N/A**		Keep
H 2.6	Locate new housing near transportation and community facilities to allow seniors to age in place.	**Supportive**	Allowing seniors to age in place, especially in areas with access to transit and services, will help reduce displacement.	
H 2.7	Develop a housing assistance program that helps homeowners with low incomes with small remodeling projects to improve weatherization, increase sustainability, and provide accommodations for disabilities.	**Supportive**	This is an essential goal to support households without the resources to meet the city's goals regarding neighborhood attractiveness and will help support lower-income residents in houses that were not built to withstand the changing climate.	

Appendix V. Economic Profile

July 10, 2026

Introduction

This economic profile is intended to provide a basis for the goal and policy recommendations in the Economic Development element of the City of Walla Walla's comprehensive plan. It includes an overview of population and employment characteristics, recent business activity, education and workforce development, and an overview of the major commercial centers in Walla Walla and their impact on the local economy.

Key Findings

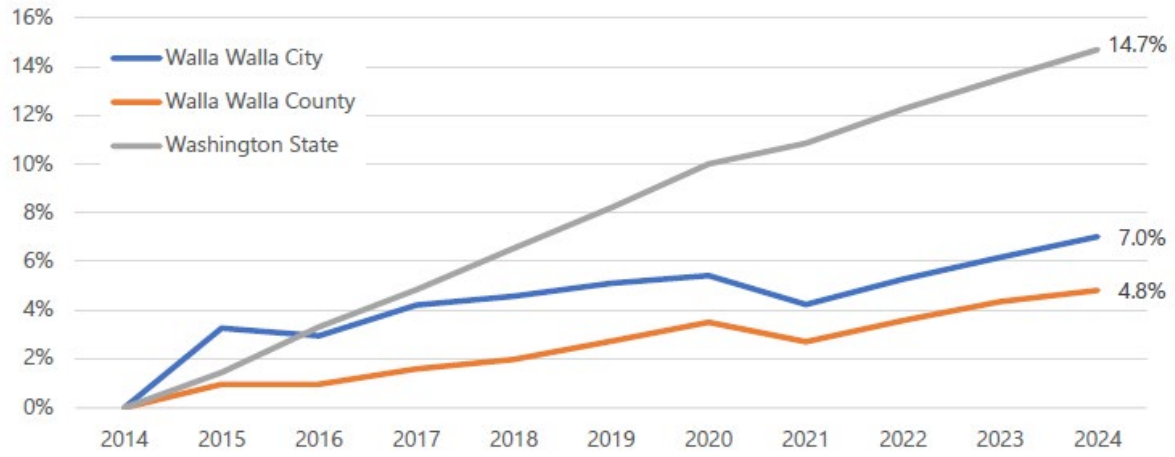
- Since 2014, Walla Walla City's population growth has outpaced the county's but lagged behind the state average. Over the past decade, it has grown by seven percent, an average of 0.7 percent per year. Continued population growth over this time reflects the area's strength as an economic center in the region.
- Walla Walla's population is becoming more educated, with a quarter of adult residents having attained a Bachelor's degree or higher as of 2023. Growth in the healthcare and education sectors will continue to bring more highly educated workers to the city.
- The median household income is lower in Walla Walla City than in the county, with over a fifth of city households making less than $25,000 annually. However, this is largely driven by the high concentration of students studying at local colleges and universities.
- Between 2012 and 2022, the sectors that added the most jobs in Walla Walla City were educational services, accommodation and food services, health care and social assistance, and public administration. Together, these sectors added nearly 2,000 jobs to the city's economy. Over the same period, the retail trade, finance and insurance, and other services sectors saw the most job losses.
- While wages for common jobs in Walla Walla's top sectors vary widely, jobs in the healthcare and education sectors are among the highest paying in the local economy. As these higher-paying sectors continue to grow, household incomes should rise. However, jobs in the accommodations and food services industry, important in the city's downtown business district and wine industry, are much lower paying. These jobs are essential to a healthy economy, but workers are susceptible to displacement as the cost of living rises.
- Ten of the top 15 employers in Walla Walla County are located in Walla Walla City. The largest of these include Providence St. Mary Medical Center, the Washington State Penitentiary, and Walla Walla Public Schools. The county's biggest manufacturing and food processing employers are largely located outside of the city in areas like Prescott and Wallula.

- Between 2020 and 2023, taxable sales grew in the retail, construction, and accommodations and food services industries in Walla Walla County. In 2022, food and beverage sales reached $105 million, up from $47 million in 2020 at the peak of the COVID-19 pandemic. However, in 2023 taxable sales in the industry dropped significantly, recovering only slightly in 2024.
- Educational institutions in Walla Walla, including Whitman College and Walla Walla Community College, offer a unique opportunity for workforce development and business attraction, especially for students and employers in the health care, food services, and viticulture sectors. Building on this opportunity will be key to economic growth in the future.
- Downtown Walla Walla is a significant commercial center for the region as well as a high-quality amenity for residents, visitors, and businesses. Investments in Downtown—like the recent completion of Walawála Plaza and Heritage Square—will help attract new workers and businesses to the city.
- The wine industry is a major driver of tourism and has contributed to significant growth in the accommodations sector, but headwinds in the beverage industry could pose a challenge for future growth. Still, there are opportunities to grow this sector beyond the wine industry to create opportunities for year-round visits as well as nightlife and family-oriented amenities for residents.

Population and Household Demographics

Population Growth

Although the City of Walla Walla has grown over the past decade, growth in both the city and county have lagged behind statewide growth. As of 2024, the population in Walla Walla is 34,580, roughly 55 percent of the County population of 63,375. Since 2014, Walla Walla's population grew by 7 percent, an average of 0.7 percent annually. Over the same period, Walla Walla County's population grew by just under 5 percent (0.6 percent annually) and Washington's population grew by nearly 15 percent (1.4 percent annually).



Appendix V Figure 1. Cumulative Population Growth in Walla Walla City, Walla Walla County, and Washington (2014-2024)

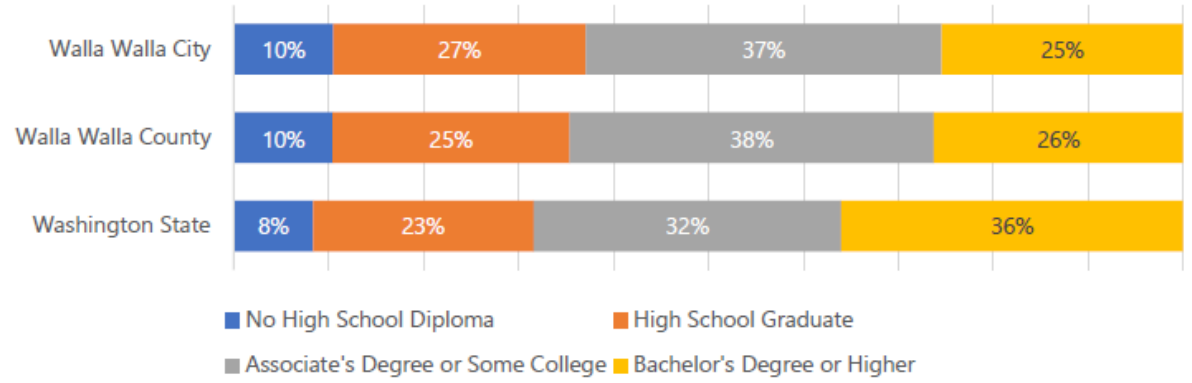
Source: Washington Office of Financial Management.

Educational Attainment

Education is an important sector in Walla Walla, providing a supply of educated young workers and potential opportunities for workforce development. The concentration of higher education institutions, including Whitman College and Walla Walla University, impacts the housing needs and demographics of the city. Many of the students are under the age of 25 with a high share living in dorms or similar group arrangements. Between 2015 and 2020, roughly 4,000 Walla Walla residents resided in group quarters. They also tend to work part time, earning lower annual incomes than other residents. The Education & Workforce Development of this report highlights opportunities for the City to capitalize on its role as a regional education hub to attract businesses and improve workforce skills.

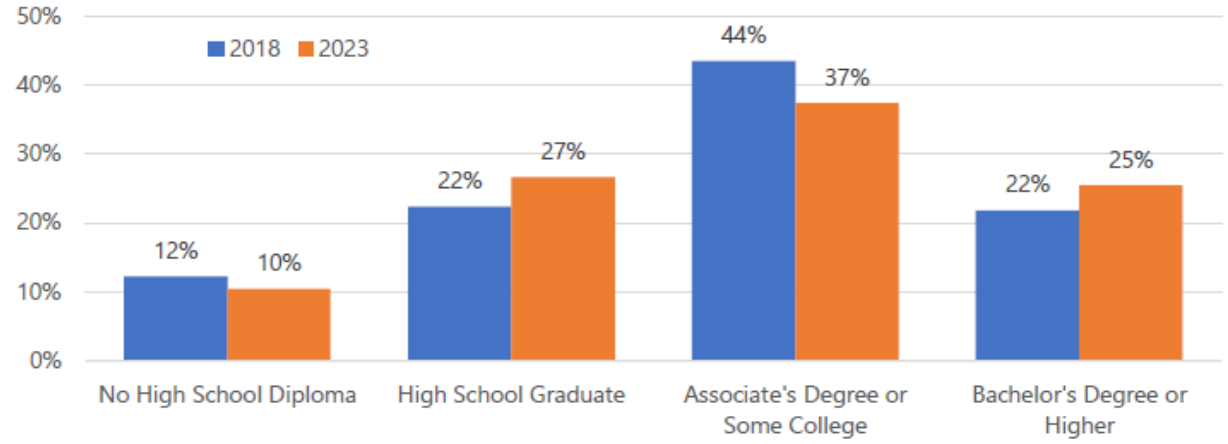
While both Walla Walla City and Walla Walla County have lower shares of residents with at least a bachelor's degree than the state, the city's population has grown more educated since 2018. As of 2023, a quarter of residents have at least a bachelor's degree, compared with 22 percent in 2018, likely brought on by the growth in both education and healthcare. However, stakeholders interviewed during this planning process, including business owners and local elected officials, have indicated a lack of professional job opportunities and affordable housing has led many recent graduates to leave Walla Walla after graduating, despite some wanting to stay.

Housing, in particular, is a limiting factor in drawing new businesses due to an inability to find and attract more educated workers.



Appendix V Figure 2. Population over 18 by Educational Attainment, 2023

Source: U.S. Census Bureau 2023 Five-Year ACS, Table S1501



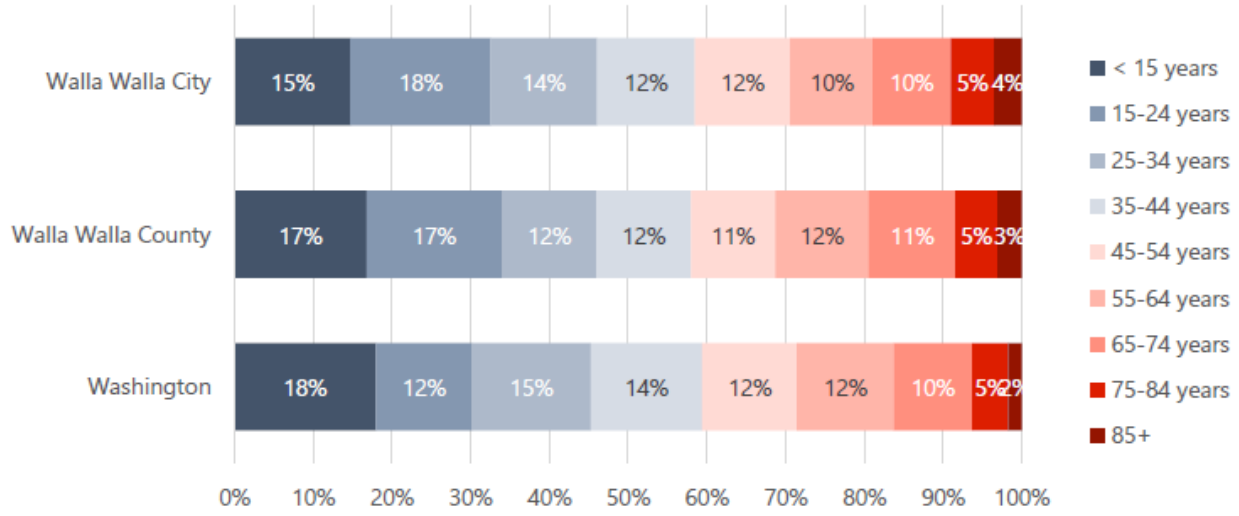
Appendix V Figure 3. Educational Attainment among Adults 18 or Older in Walla Walla, 2018-2023

Source: U.S. Census Bureau 2023 Five-Year ACS, Table S1501.

Age Distribution

Understanding the age distribution of the population can help drive economic decision making. Employers are attracted to locations that have a high share of upwardly mobile young workers and an educated workforce. From a retail and services perspective, age distribution can provide insights into what types of businesses and amenities can best serve the population. The Tourism Master Plan, which is discussed in more detail in the **Error! Reference source not found.** section of this report, found that Walla Walla's relatively young population is interested in more opportunities for nightlife as well as family-friendly activities.

Age distribution among Walla Walla City residents is similar to both the County and the State, though Walla Walla County and City have a higher share of residents between the ages of 15 and 24, likely due to the large student population. In Walla Walla City and County, 19 percent of residents are at least 65 years old, compared to 16 percent statewide, a number that has grown in recent years. Though nearly half (49 percent) of Walla Walla City residents are between the prime working ages of 25 and 64, the increase in older residents could lead a shrinking of the local workforce.

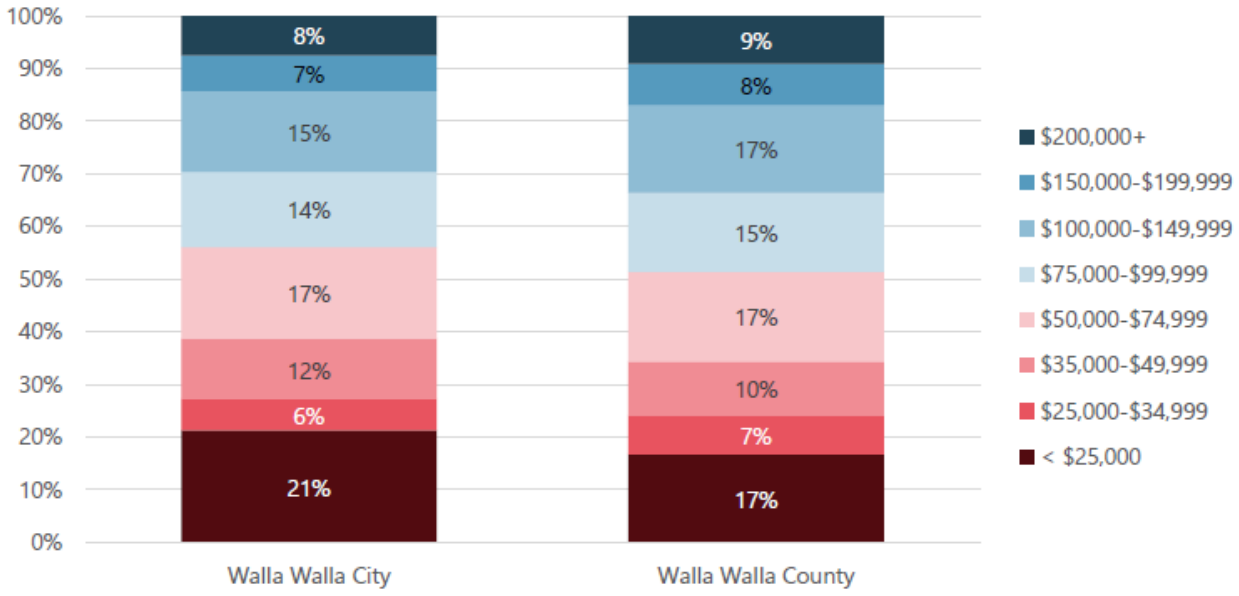


Appendix V Figure 4. Age Distribution in Walla Walla City, Walla Walla County, and Washington, 2023

Source: U.S. Census Bureau 2023 Five-Year ACS, Table S0101.

Household Income

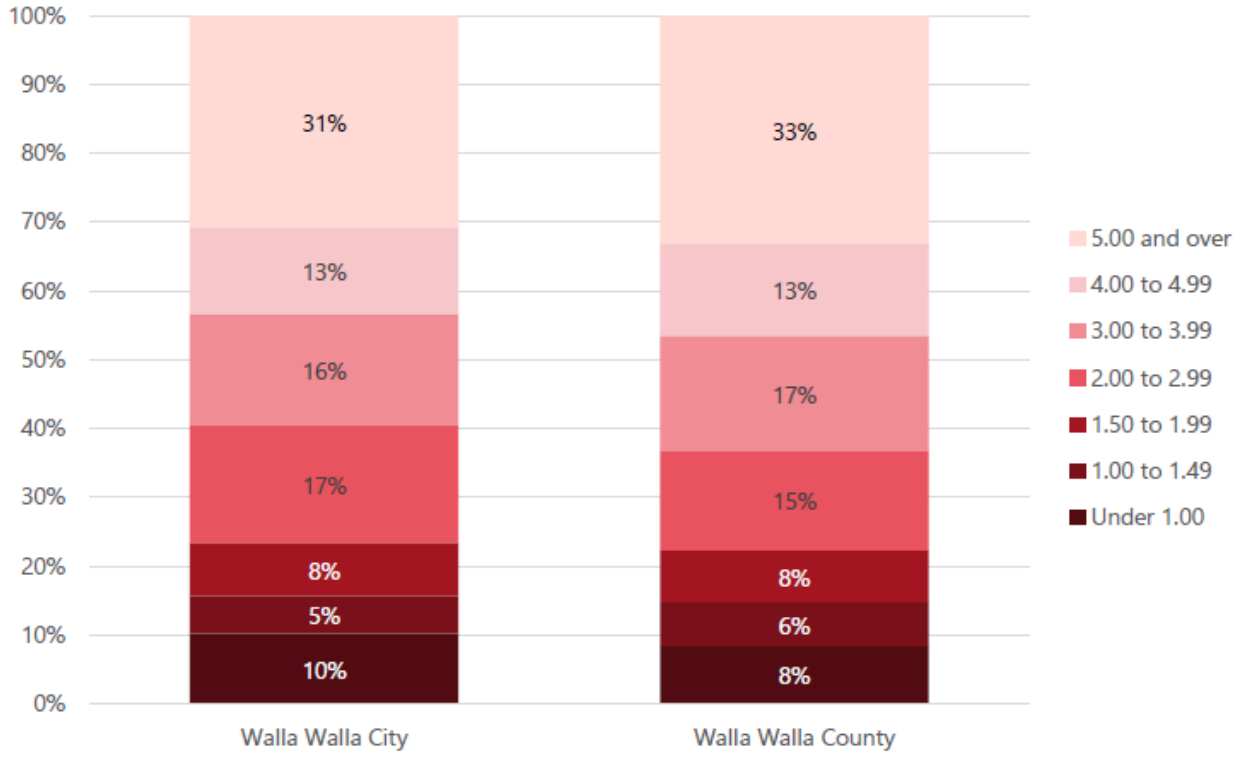
The median household income in Walla Walla City is $65,493 compared to $72,212 countywide. Around 21 percent of Walla Walla City residents make less than $25,000 annually, in part due to the high share of students in the city. Countywide, over a third of households make at least $100,000. This suggests significant purchasing power, which can help support local retail, entertainment, and food services.



Appendix V Figure 5. Share of Households by Income, Walla Walla City and County, 2023

Source: U.S. Census Bureau 2023 Five-Year ACS, Table S1901.

Ten percent of Walla Walla City residents have incomes below the federal poverty level, compared to 8 percent countywide. This represents a decrease over 2018 poverty levels, when 14 percent of City residents and 10 percent of County residents were below the poverty level. More than three-quarters of city residents make at least twice the poverty level, as shown below. As Walla Walla's economy grows, City leaders should ensure that there are attainable opportunities for low-income residents to live, work, and access educational opportunities.



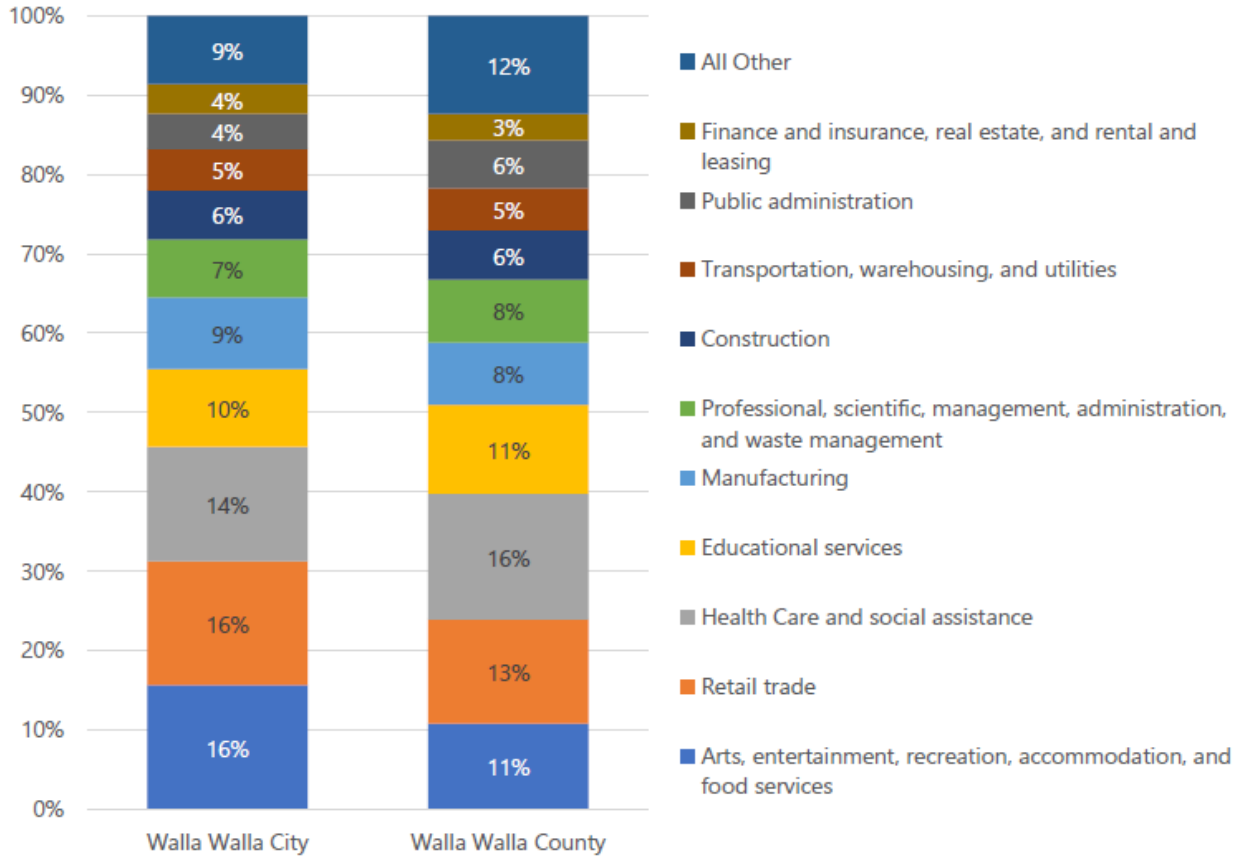
Appendix V Figure 6. Income to Poverty Ratio in Walla Walla City and County, 2023

Source: U.S. Census Bureau 2023 Five-Year ACS, Table B17026.

Employment Characteristics

Employment by Industry

The largest employment sectors among Walla Walla City residents are arts, entertainment, and recreation, retail trade, health care and social assistance, and educational services. While these are also the largest sectors countywide, Walla Walla City has a higher share of residents working in arts, entertainment, and recreation (16 percent) than the county (11 percent). A higher share of county residents is employed in health care and social assistance (16 percent) compared to city residents (14 percent). These industries include jobs at a variety of income levels, suggesting a need for housing, services, and other amenities at a variety of price points.



Appendix V Figure 7. Employment by Industry among Residents in Walla Walla City and Walla Walla County (2023)

Source: U.S. Census Bureau 5-Year ACS, Table S2405.

As of 2022, the City of Walla Walla was home to 15,754 jobs, up from 13,944 in 2012 (an increase of 13 percent). The largest employment sectors in Walla Walla City include healthcare and social assistance, public administration, educational services, and accommodation and food services. Between 2012 and 2022, the educational services sector saw the highest employment gains, adding 797 jobs to the city's economy. The "other services (excluding public administration)" sector shank by 626 jobs over the same period. This category covers a wide range of jobs,

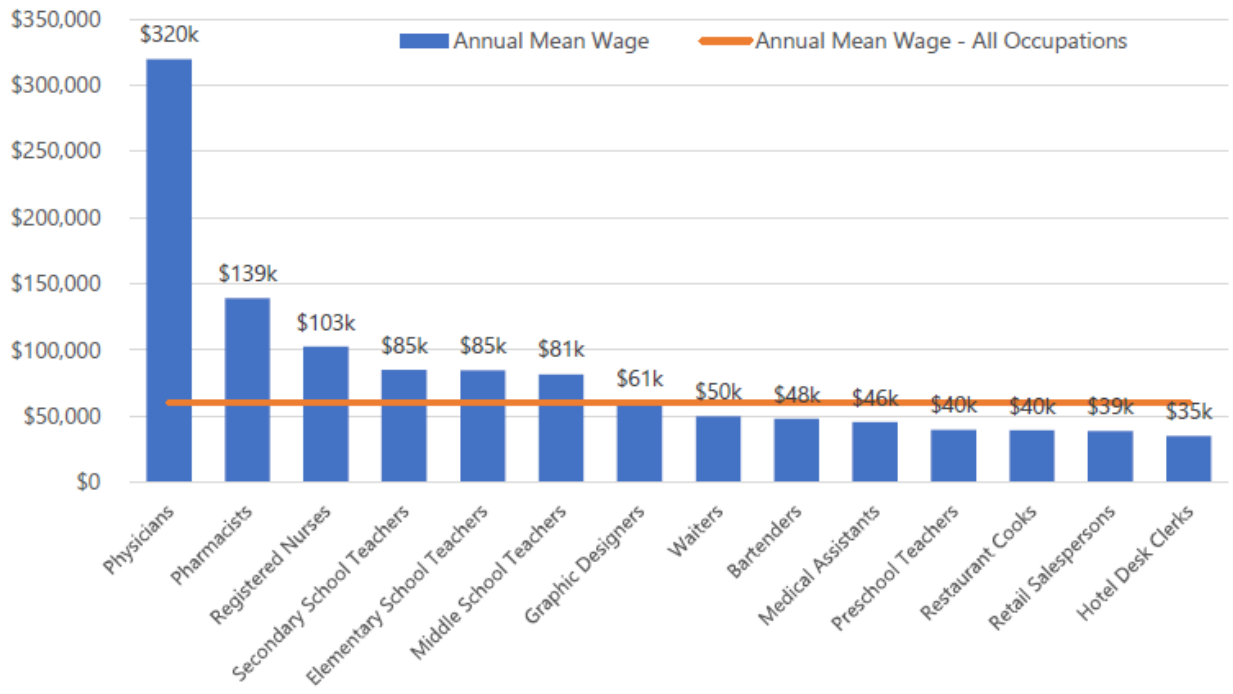
including equipment and machine repair, religious activities, advocacy, dry cleaning, personal care, and pet care services.

Appendix V Table 1. Walla Walla City Jobs by Sector, 2012-2022

	2012	2022	Change	% Change
Educational Services	1,105	1,902	797	72%
Accommodation and Food Services	1,385	1,815	430	31%
Health Care and Social Assistance	3,664	4,050	386	11%
Public Administration	1,547	1,926	379	24%
Construction	352	551	199	57%
Arts, Entertainment, and Recreation	197	355	158	80%
Administration & Support, Waste Manage	279	397	118	42%
Wholesale Trade	278	393	115	41%
Agriculture, Forestry, Fishing and Hunting	76	153	77	101%
Manufacturing	839	881	42	5%
Professional, Scientific, and Technical Services	339	371	32	9%
Utilities	68	86	18	26%
Transportation and Warehousing	133	148	15	11%
Management of Companies and Enterprise	27	41	14	52%
Mining, Quarrying, and Oil and Gas Extract	1	4	3	300%
Real Estate and Rental and Leasing	181	180	(1)	-1%
Information	263	247	(16)	-6%
Retail Trade	1,620	1,470	(150)	-9%
Finance and Insurance	640	460	(180)	-28%
Other Services (excluding Public Administration)	950	324	(626)	-66%
	13,944	**15,754**	**1,810**	

Source: U.S. Census Bureau via LEHD OntheMap.

The annual mean wage for jobs in top sectors for the Walla Walla MSA varies significantly, from nearly $320,000 per year for Physicians to $35,000 annually for hotel desk clerks. Jobs in the fast-growing health care and education sectors are among the highest paying, though medical assistants and preschool teachers make less than the annual mean wage for all occupations ($60,600).



Appendix V Figure 8. Annual Mean Wages for Jobs in Top Sectors, 2023

Source: U.S. Bureau of Labor Statistics May 2023 Metropolitan & Nonmentropolitan Area Occupational Employment and Wage Estimates (OEW).

Top Employers

The major employers in Walla Walla County reflect the top job sectors, though outside of the city there is a higher concentration of manufacturing jobs. Among the top 15 employers in Walla Walla County, 10 are located within the city of Walla Walla. The largest employers in the city include Providence St. Mary Medical Center, the Washington State Penitentiary, Walla Walla Public Schools, and Whitman College. Walmart is the largest retailer countywide.

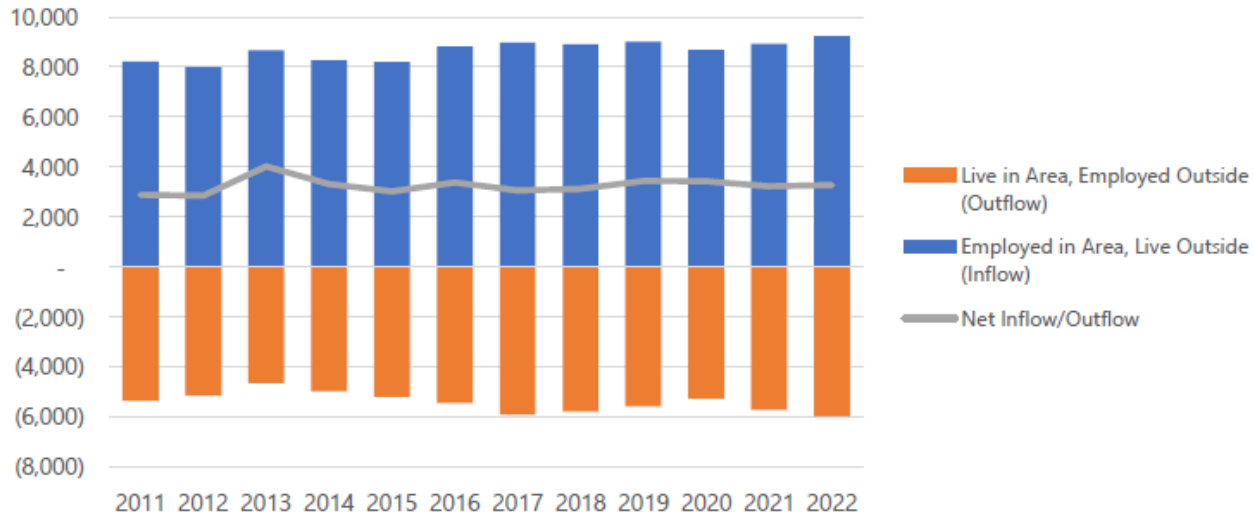
Appendix V Table 2. Top Employers in Walla Walla County, 2019

Employer	Sector	Location	Total Employees (FT + PT)
Broetje Orchards	Agriculture	Prescott	2,500
Tyson Fresh Meats, Inc.	Food Processing	Wallula	1,460
Providence St. Mary Medical Center	Health Care	Walla Walla	1,173
Washington State Penitentiary	Corrections	Walla Walla	1,080
Walla Walla Public Schools	Education	Walla Walla	833
Whitman College	Higher Education	Walla Walla	609
U.S. Dept. of Veterans Affairs	Health Care	Walla Walla	558
Walla Walla Community College	Education	Walla Walla	597
Packing Corp. of America / Boise Paper	Manufacturing	Wallula	456
City of Walla Walla	Government	Walla Walla	445
Walla Walla University	Education	College Place	416
Key Technology, Inc.	Manufacturing	Walla Walla	405
U.S. Army Corps of Engineers	Government	Walla Walla	358
Walmart	Retail	Various	338
Walla Walla County	Government	Walla Walla	312

Source: Port of Walla Walla Business Survey.

Commute Patterns

As of 2022, 9,232 workers in Walla Walla City lived in other communities (inflow), while 5,955 Walla Walla residents commuted elsewhere (outflow) and 6,522 residents both live and work in the city. The net inflow has held relatively stable over time, indicating that Walla Walla is a major regional employment center attracting workers from other communities.

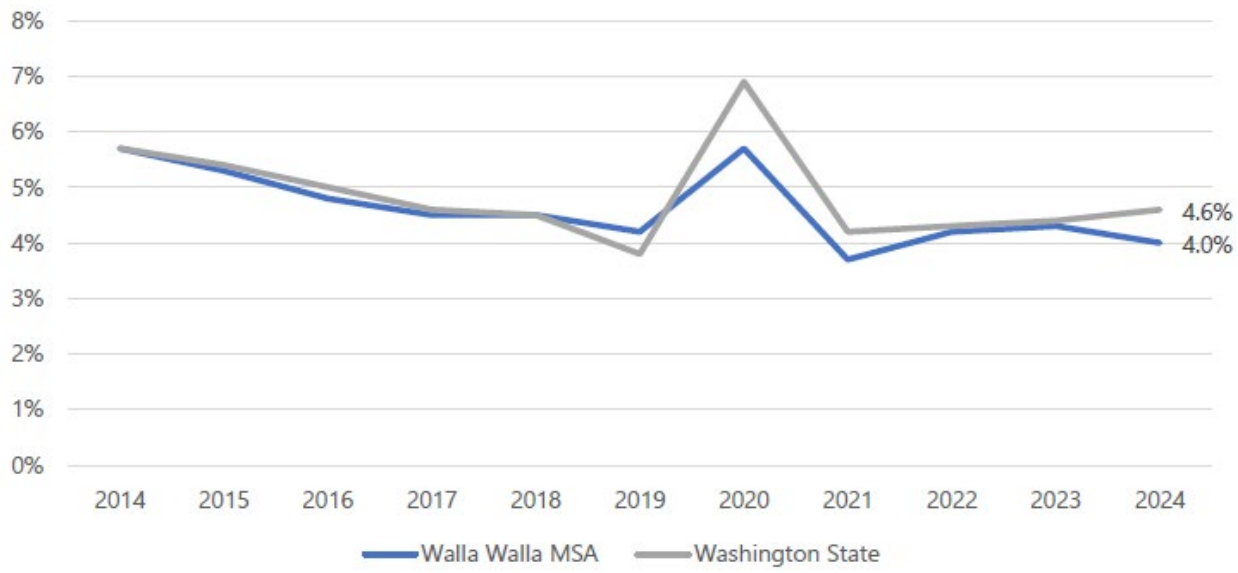


Appendix V Figure 9. Worker Inflow-Outflow in Walla Walla City, 2022

Source: U.S. Census Bureau via LEHD OntheMap.

Unemployment

As of November 2024, the unemployment rate in the Walla Walla MSA was 4 percent, slightly lower than the statewide rate of 4.6 percent. For most of the past decade, the MSA's unemployment rate has remained slightly below the state's but has followed the same general trajectory. In November of 2020, Walla Walla's unemployment rate was just 5.7 percent, indicating that it was recovering more quickly than the state from COVID-19 pandemic business closures. While low unemployment is a positive sign for the regional economy, it also suggests that business growth may be challenging as workers become harder to find. Increasing opportunities for workforce development will help Walla Walla's economy continue to grow by increasing the pool of skilled workers.



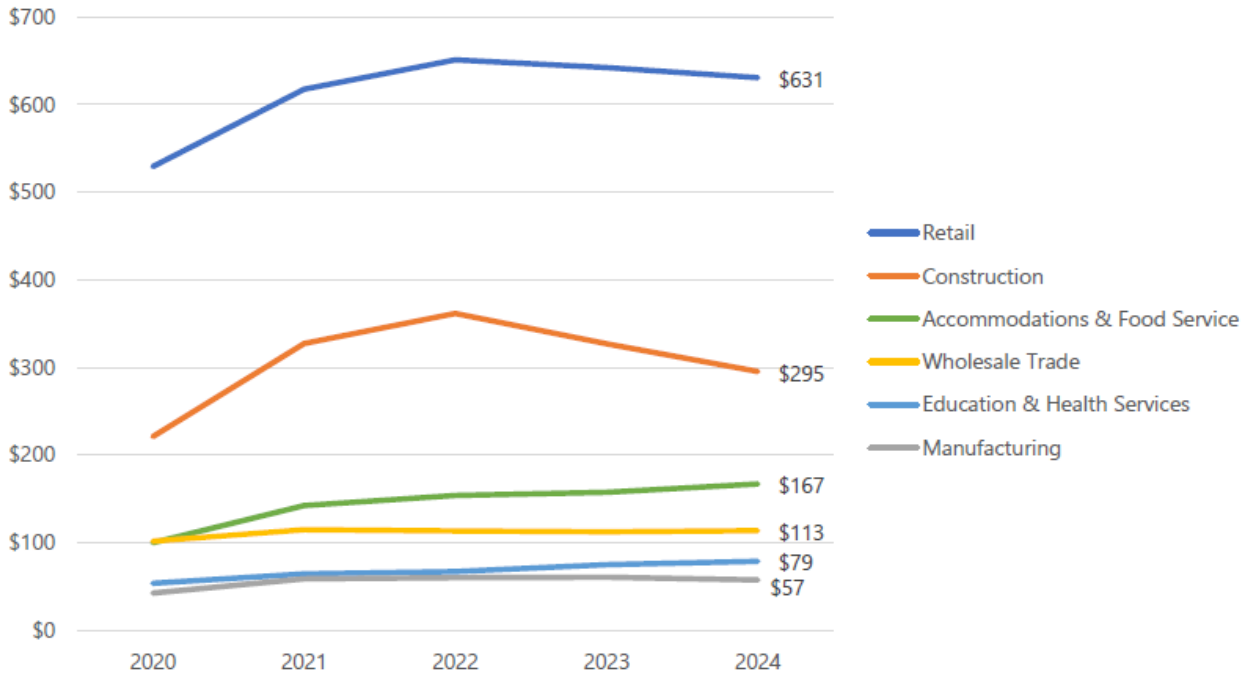
Appendix V Figure 10. Unemployment Rate in the Walla Walla MSA and Washington State, 2014-2024

Source: Federal Reserve Bank of St. Louis (FRED). Data as of November of each year.

Business Activity

Taxable Sales

Sales tax is an important revenue source for Washington cities and counties. Between 2020 and 2024, taxable sales in Walla Walla County grew from $1.2 billion to over $1.5 billion. Sales in the manufacturing and construction sectors saw the highest growth over that period (36 and 34 percent, respectively). Taxable retail sales grew by over 19 percent as the economy recovered from the COVID-19 pandemic. As of 2024, the County had $631 million in taxable retail sales, up from $529 million in 2020 but slightly below the $642 million in taxable sales countywide in 2023. The recently completed Tourism Master Plan includes strategies to increase year-round tourism opportunities, which should help bolster sales tax revenues in the retail and accommodations and food service sectors.

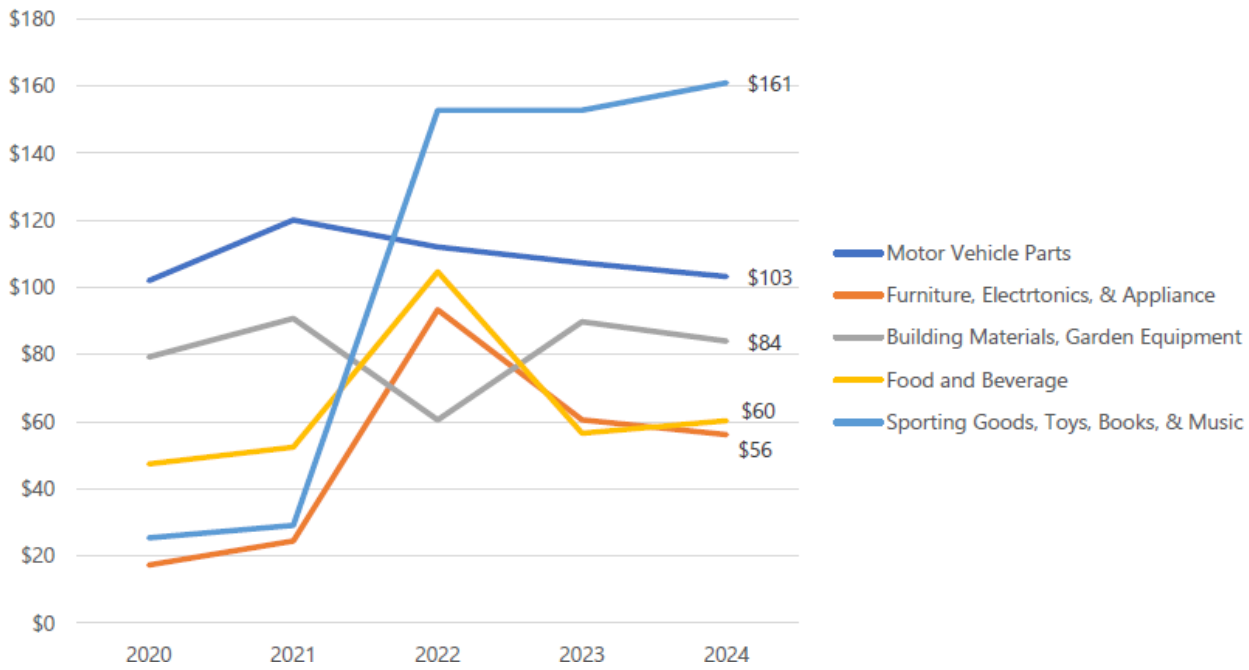


Appendix V Figure 11. Taxable Sales ($MM) by Industry in Walla Walla County, 2020-2024

Source: Washington State Department of Revenue via Port of Walla Walla.

Retail Sales

Within the retail sector, the biggest subcategories by taxable sales were sporting goods, toys, books and music followed by motor vehicle parts. While food and beverage had a strong year in 2022 with $105 million in taxable sales, sales in 2023 dropped to near 2021 levels. Between 2023 and 2024 the sector saw a modest increase in taxable sales of $3 million, but it is still down significantly from the 2022 peak. This trend likely reflects broader challenges in the beverage industry.



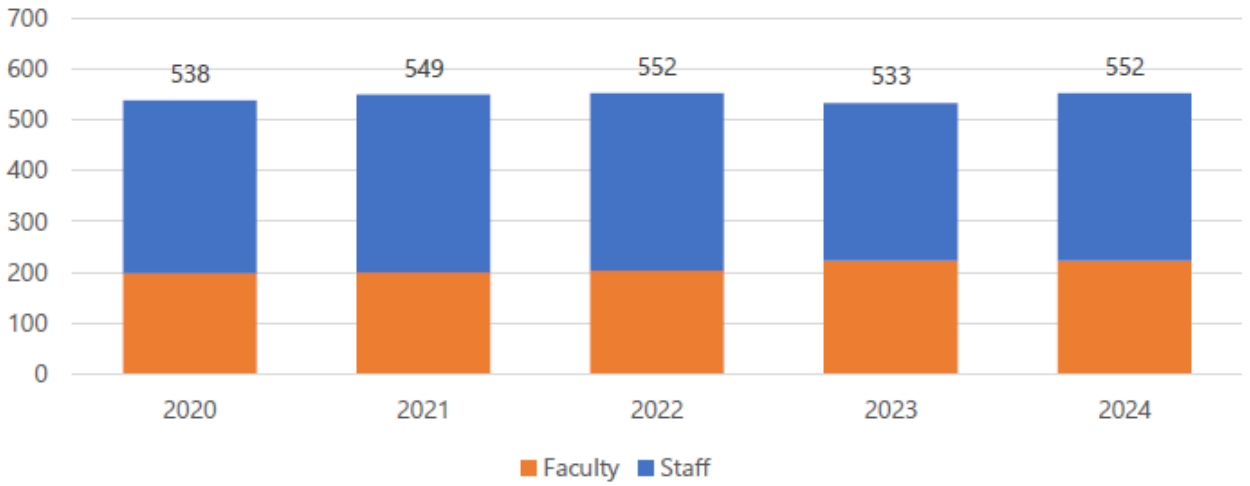
Appendix V Figure 12. Taxable Sales ($MM) by Retail Category, 2020-2024

Source: Washington State Department of Revenue via Port of Walla Walla.

Education and Workforce Development

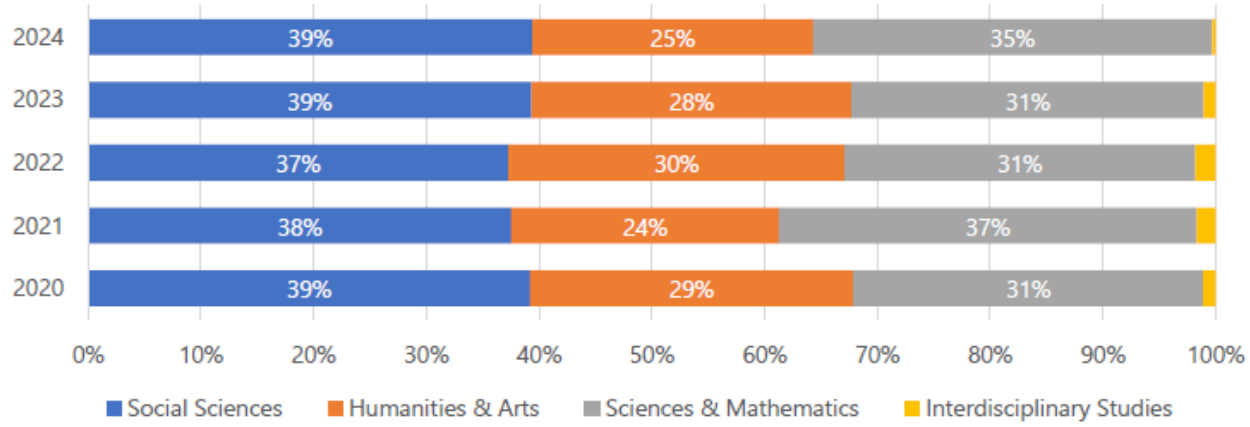
Higher Education

The educational sector is a major asset for Walla Walla. Along with the 1,902 jobs in the sector citywide, the presence of multiple higher education institutions provides the city with unique opportunities to grow its workforce and attract employers. As of the Fall of 2024, Whitman College employed 223 faculty and 329 staff, with 460 of these employees working full time. Student enrollment has also grown from 1,360 in 2020 to 1,561 in 2024. Nearly 40 percent of 2024 graduates majored in the social sciences, and another 35 percent in sciences and mathematics. The most popular majors in the social sciences are psychology and anthropology-environmental studies, while the most common sciences and mathematics majors are biology and biochemistry.



Appendix V Figure 13. Whitman College Employment (Full and Part Time), 2020-2024

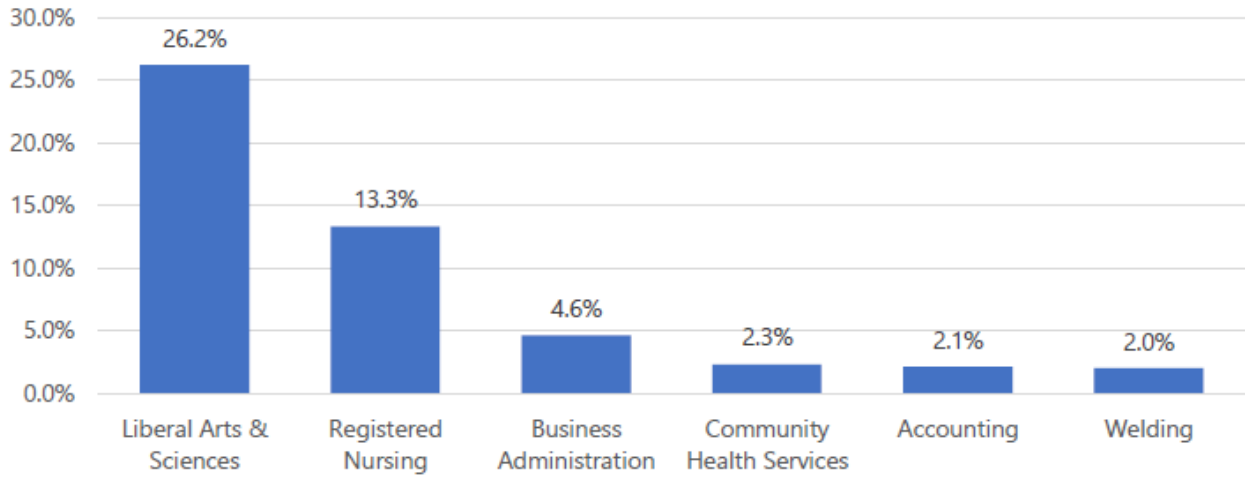
Source: Whitman College



Appendix V Figure 14. Whitman College Graduates by Major, 2020-2024

Source: Whitman College

Similarly, health care fields are among the top Associate's degree programs at Walla Walla Community College. While over a quarter of degree recipients study liberal arts and sciences, 13 percent study registered nursing and an additional 2.3 percent study community health services. WWCC also has strong culinary arts and viticulture programs. These majors could align with the needs of employers in the fast-growing health care and social assistance sector, as well as the accommodation and food services sectors.



Appendix V Figure 15. Walla Walla Community College Top Associate's Degree Programs by Enrollment

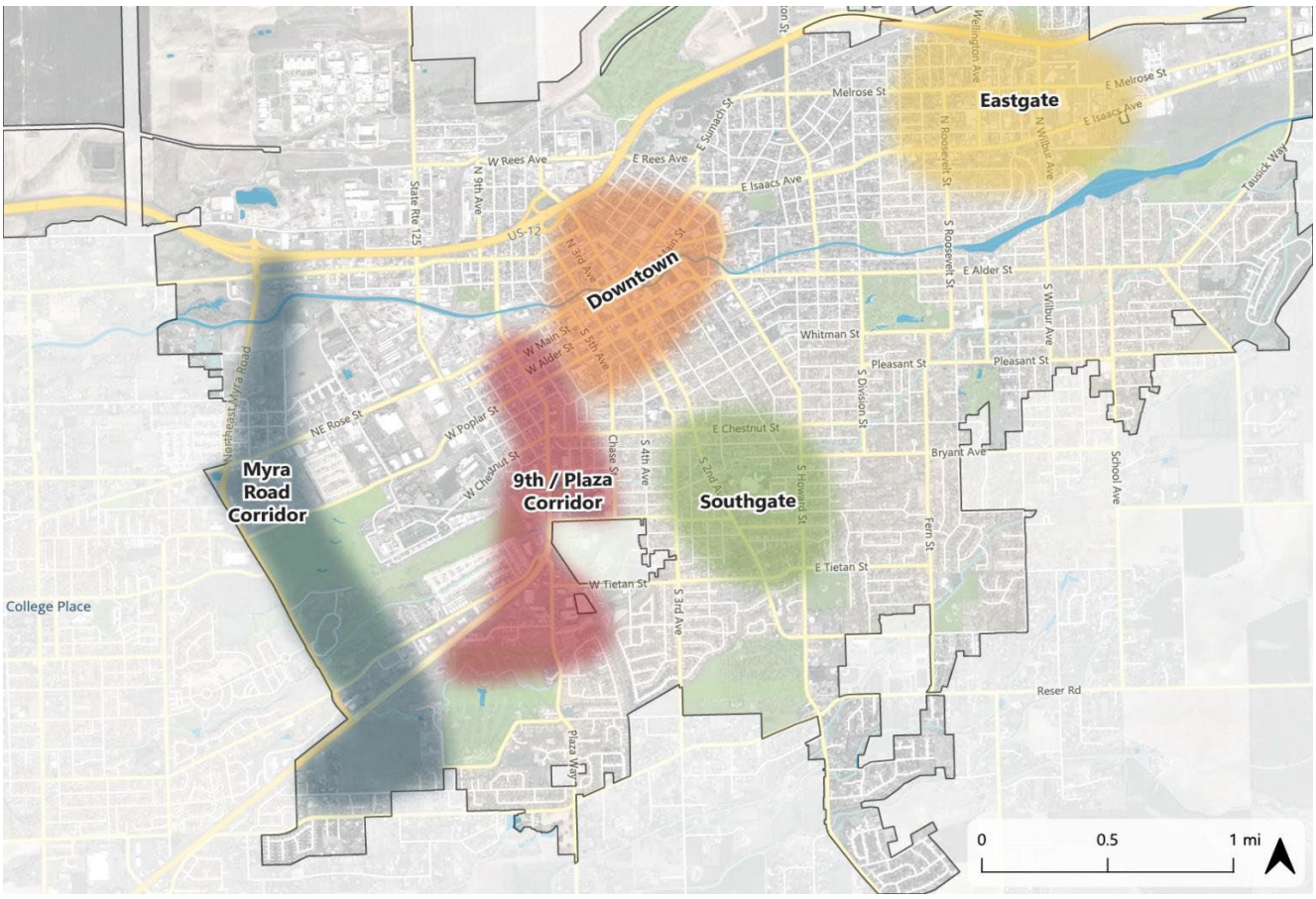
Source: IPEDS via Google

Finding ways to connect local employers with educational institutions can help encourage graduates to stay in Walla Walla once they have obtained their degrees, helping to grow the regional employment base.

Commercial Centers

This section profiles the areas of Walla Walla with the most significant commercial activity. Figure 18 below shows the five identified centers, which include:

- **Downtown Walla Walla**, the physical and historic center of Walla Walla.
- **Eastgate,** centered on Isaacs Avenue and North Wilbur Avenue, this center is anchored by the Eastgate Marketplace, a major shopping center in the northeast of the city.
- **Southgate,** focused along South 2nd Avenue between East Chestnut Street and West Tietan Street, this center is a major employment center anchored by the Southgate Medical Park and the Southgate Shopping Center.
- **9th and Plaza Corridor**, located along South 9th Avenue and Plaza Way between West Poplar Street and Granite Place, this center represents the newest hub of retail activity in the city, and is anchored by Safeway, Bi-Mart, and Rosauers.
- **Myra Road/Poplar Street/Rose Street,** centered on these streets and anchored by the Walla Walla Town Center



Appendix V Figure 16. Walla Walla Commercial Centers

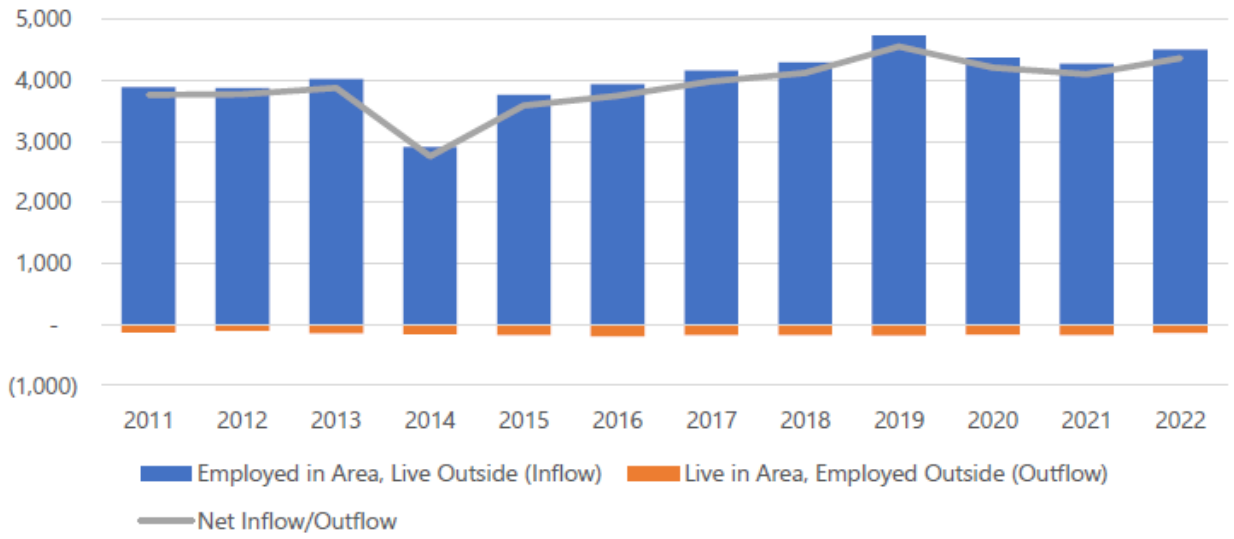
Source: Leland Consulting Group

Downtown Walla Walla

Downtown Walla Walla is a major commercial hub in the city and broader region, with the densest concentration of businesses, shops, and restaurants in the city and region. It is also a significant amenity attracting residents, visitors, and businesses. Walawála Plaza, a pedestrian plaza that was completed in Downtown in 2023, has become a major attraction and gathering place for the city, providing a sense of community and identity for residents.

Investing in placemaking and community amenities in Downtown Walla Walla will help attract more investment citywide.

As of 2022, there were 4,523 jobs in Downtown Walla Walla. Most of these jobs are filled by people living outside of Downtown, which is primarily a commercial district. Just 23 people both live and work in Downtown Walla Walla, while 4,500 Downtown workers commute from other locations and 136 Downtown residents commute out.



Appendix V Figure 17. Inflow and Outflow in Downtown Walla Walla

Source: U.S. Census Bureau via LEHD OntheMap.

Health Care and Social Assistance is the largest job sector in Downtown Walla Walla, and added the most jobs of any sector between 2012 and 2022. This is largely due to the presence of Providence St. Mary Medical Center. Accommodation and food services and public administration are also major job sectors downtown that have seen growth over the past decade. Over the same period, Downtown lost 154 jobs in the finance and insurance sector.

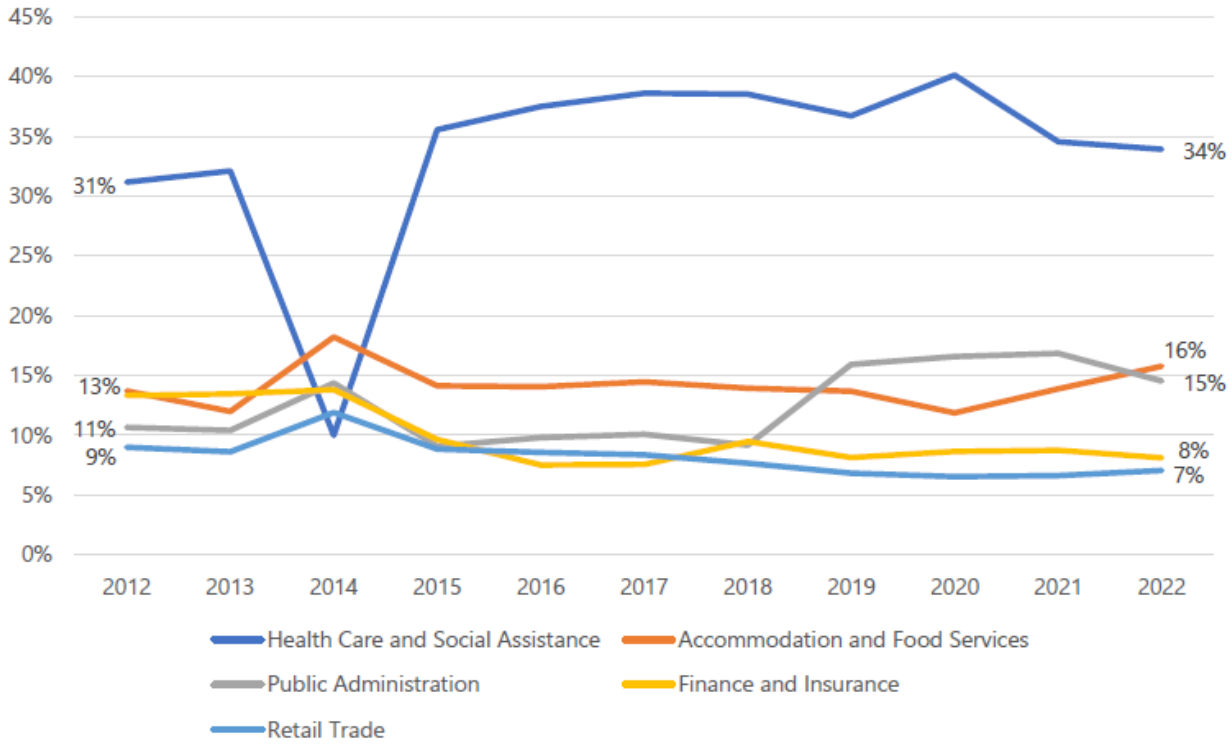
Appendix V Table 3. Jobs in Downtown Walla Walla, 2012-2022

	2012	2022	Change	% Change
Health Care and Social Assistance	1,217	1,533	316	26%
Public Administration	416	657	241	58%
Accommodation and Food Services	535	713	178	33%
Arts, Entertainment, and Recreation	13	91	78	600%
Administration & Support, Waste Management	150	214	64	43%
Real Estate and Rental and Leasing	39	70	31	79%
Educational Services	0	14	14	1400%
Manufacturing	93	104	11	12%
Transportation and Warehousing	1	9	8	800%
Agriculture, Forestry, Fishing and Hunting	10	15	5	50%
Mining, Quarrying, and Oil and Gas Extraction	1	0	(1)	-100%
Management of Companies and Enterprises	3	0	(3)	-100%
Construction	20	15	(5)	-25%
Professional, Scientific, and Technical Services	184	178	(6)	-3%
Information	121	110	(11)	-9%

Source: U.S. Census Bureau via LEHD OntheMap.

Health care and social assistance has consistently been the top job sector since 2012, except for in 2014. As of 2022, 34 percent of all Downtown jobs are in this sector. The share of public administration jobs has grown over time, from 11 percent in 2011 to 15 percent in 2022. The share of finance and insurance jobs has decreased from 13 percent in 2012 to 8 percent in 2022.



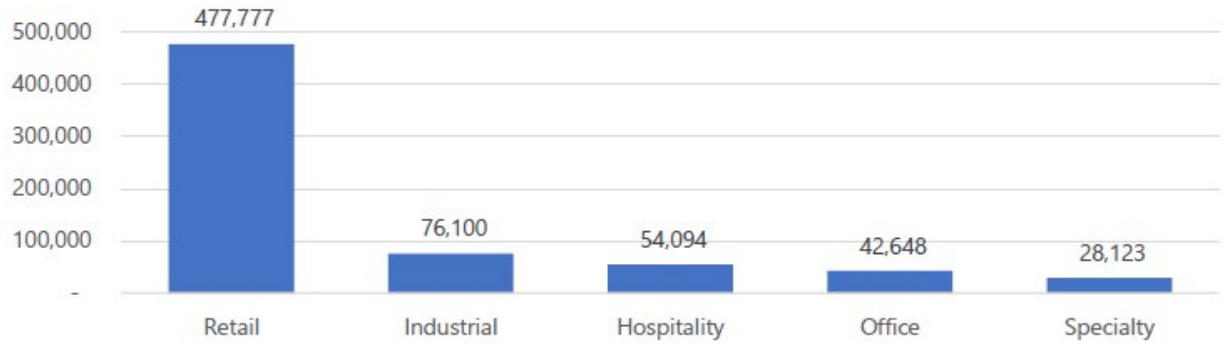


Appendix V Figure 18. Share of Downtown Jobs for Top Sectors, 2012-2022

Source: U.S. Census Bureau via LEHD OntheMap.

Eastgate

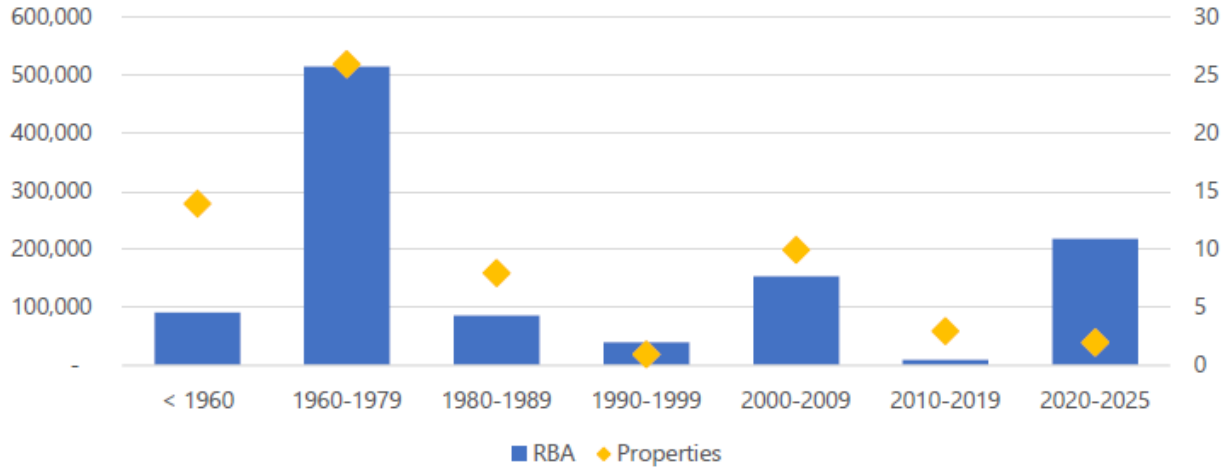
The Eastgate commercial area is located just south of Highway 12, roughly between White Street and Criss Lane. Major retailers in this area include Safeway and Harbor Freight. Eastgate includes 59 commercial and eight multifamily properties, with a total of over 1 million square feet of rentable building area (RBA). Of this, nearly 480,000 square feet (45 percent) is retail space.



Appendix V Figure 19. Eastgate RBA by Property Type

Source: CoStar

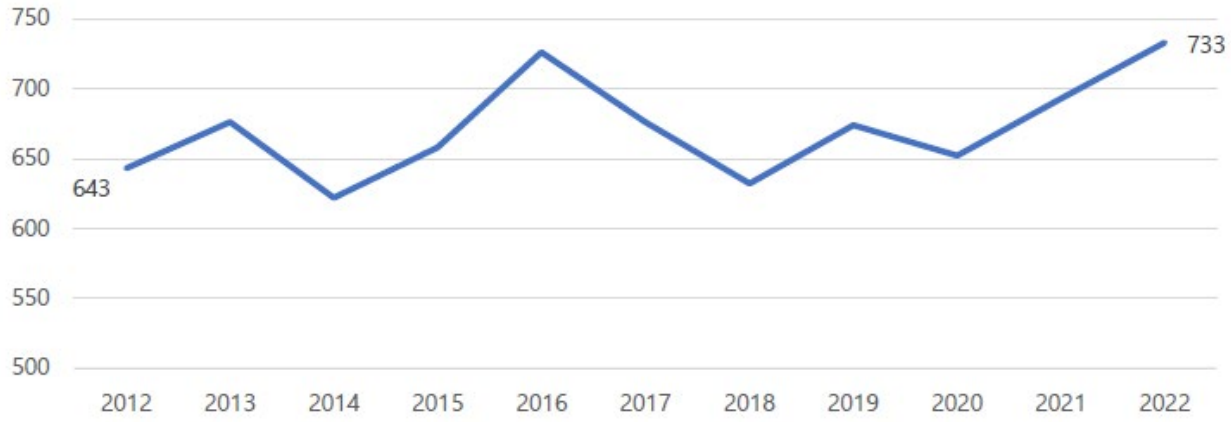
Properties in the Eastgate area are aging. Around 41 percent of properties in Eastgate were built between 1960 and 1979. Just five properties with a total of 228,000 square feet have been built since 2010, and the average vintage of retail properties is 1976. As commercial properties in this area continue to age, they could be targets for redevelopment.



Appendix V Figure 20. RBA and Properties by Decade Built in Eastgate

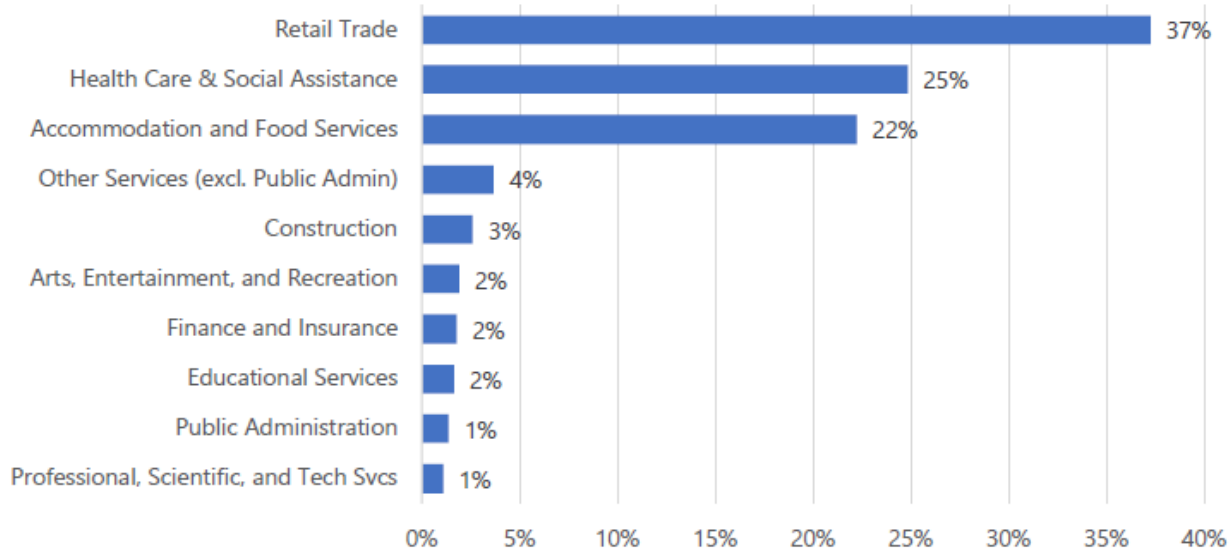
Source: CoStar

Between 2012 and 2022, 90 jobs were added to the Eastgate commercial center, an increase of 14 percent. As of 2022, the area is home to 733 jobs – 37 percent of these jobs are in the retail sector, and a quarter are in health care and social assistance.



Appendix V Figure 21. Figure 24. Jobs in Eastgate, 2012-2022

Source: U.S. Census Bureau via LEHD OntheMap.



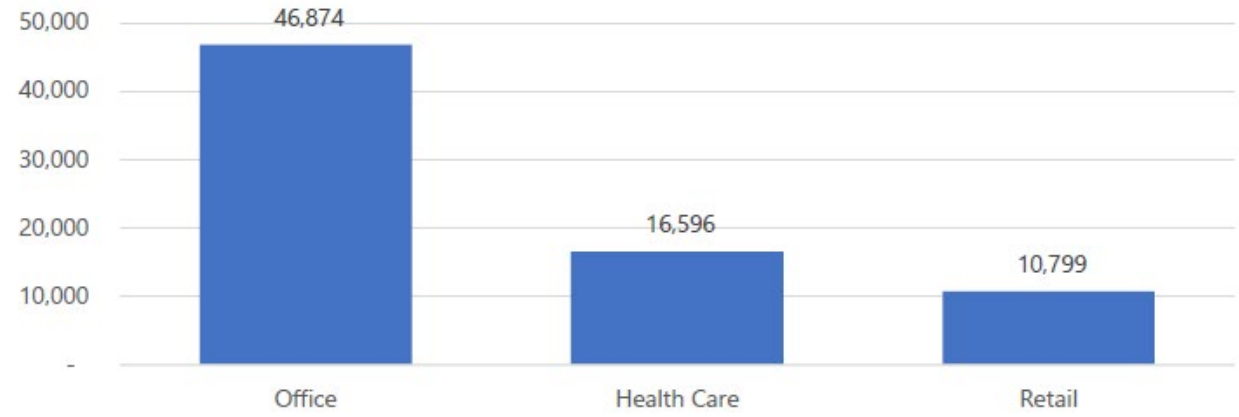
Appendix V Figure 22. Share of Jobs by Sector in Eastgate

Source: U.S. Census Bureau via LEHD OntheMap.

Southgate

The Southgate commercial area is located along South 2nd Avenue between Chestnut Street and Tietan Street. Major anchors include the Southgate Shopping Center and Providence Urgent Care.

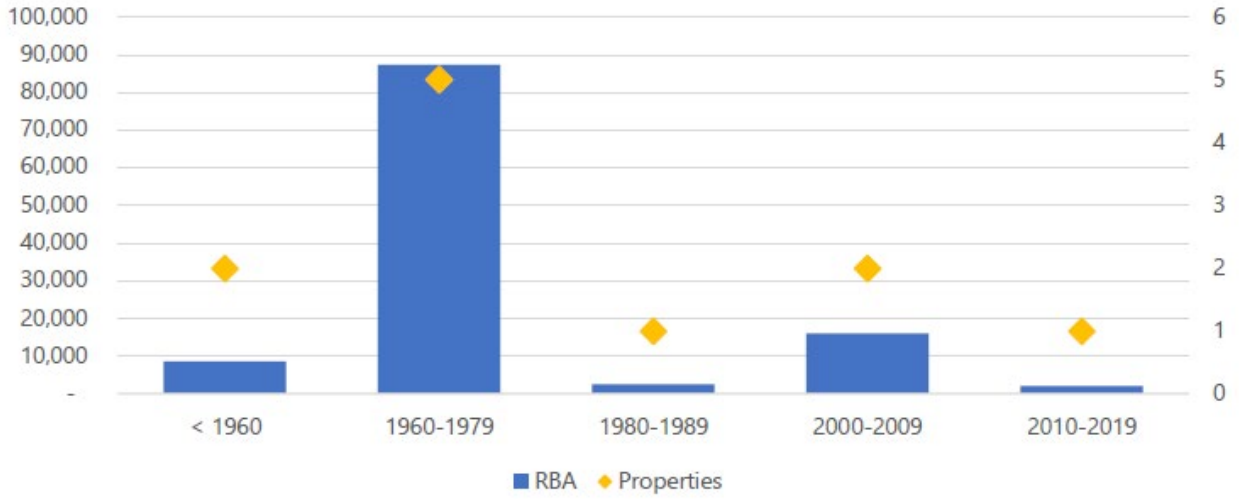
The area includes over 74,000 square feet of commercial and 44,700 square feet of multifamily residential space. Of the commercial space, 63 percent is office and 22 percent is health care.



Appendix V Figure 23. Southgate RBA by Property Type

Source: CoStar

As in Eastgate, a substantial share (75 percent) of rentable building area in the Southgate commercial area was built between 1960 and 1979. Just one property — a 12-unit apartment building on Durum Drive — has been built since 2010. The average vintage of office properties in Southgate is 1984, compared with 1979 for health care properties and 1955 for retail.



Appendix V Figure 24. RBA by Decade Built in Southgate

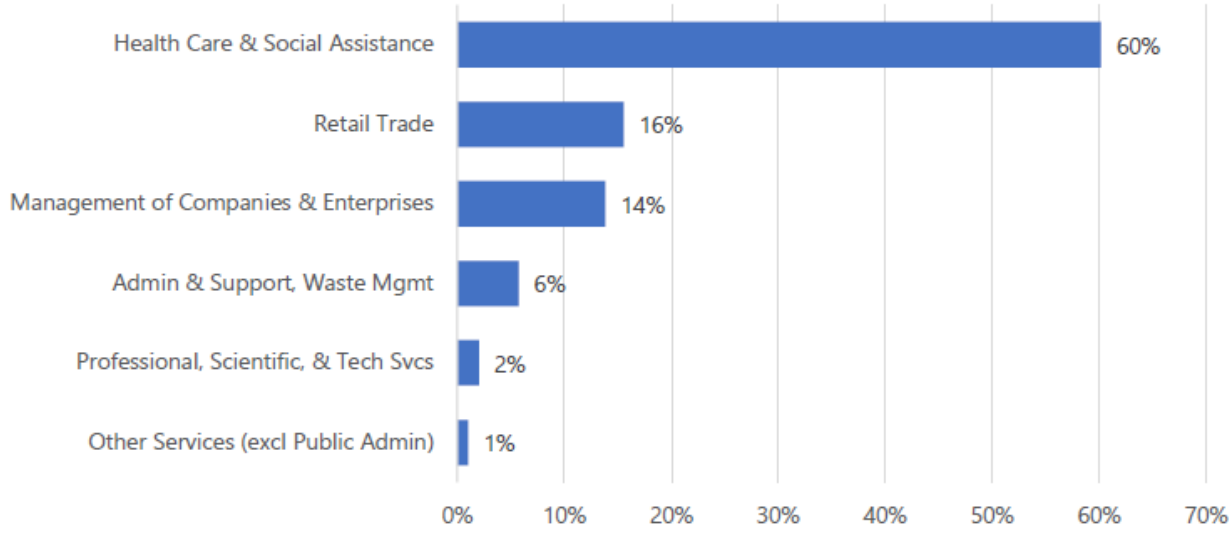
Source: CoStar

Between 2012 and 2022, Southgate lost 82 jobs, a decline of 21 percent. Most of these job losses have occurred since 2017. As of 2022, the area was home to 296 jobs, 60 percent of which were in the health care and social assistance sector.



Appendix V Figure 25. Jobs in Southgate, 2012-2022

Source: U.S. Census Bureau via LEHD OntheMap.



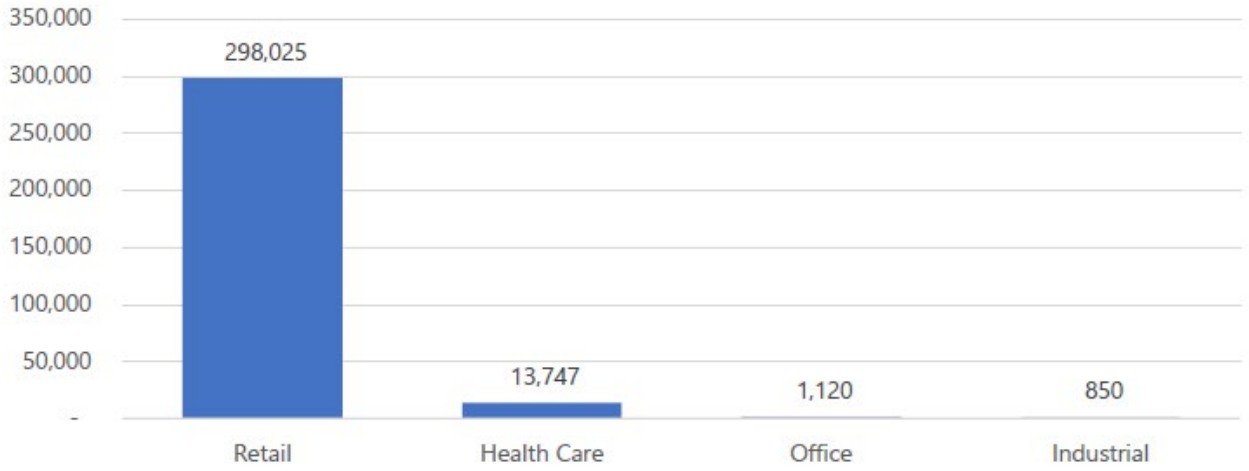
Appendix V Figure 26. Share of Jobs by Sector in Southgate

Source: U.S. Census Bureau via LEHD OntheMap.

9th / Plaza Corridor

The 9th / Plaza Corridor is a retail dominated commercial center located along South 9th Avenue and Plaza Way between West Poplar Street and Granite Place. Anchors include Safeway, Bi-Mart, and Rosauers

The corridor has nearly 314,000 square feet of commercial RBA and 309,000 square feet of multifamily. Of the commercial space, 95 percent is retail.



Appendix V Figure 27. Ninth / Plaza Commercial RBA by Property Type

Source: CoStar

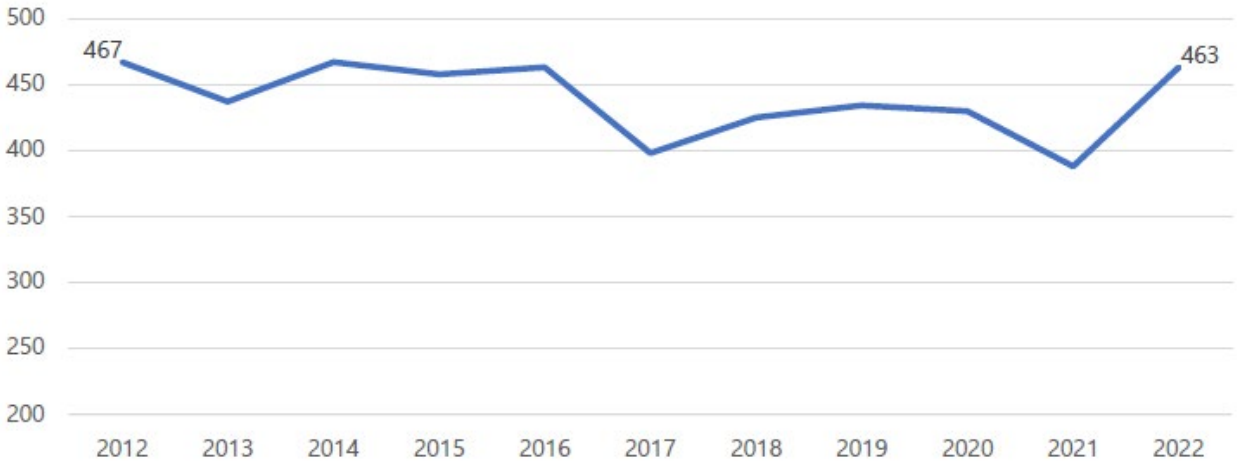
The retail in this corridor is newer than in Eastgate and Southgate, with an average year built of 1980. The major health care employer is the Park Manor Rehabilitation Center, which was built in 1962. Three properties have been built in this area since 2010.



Appendix V Figure 28. RBA by Decade Built in the Ninth / Plaza Corridor

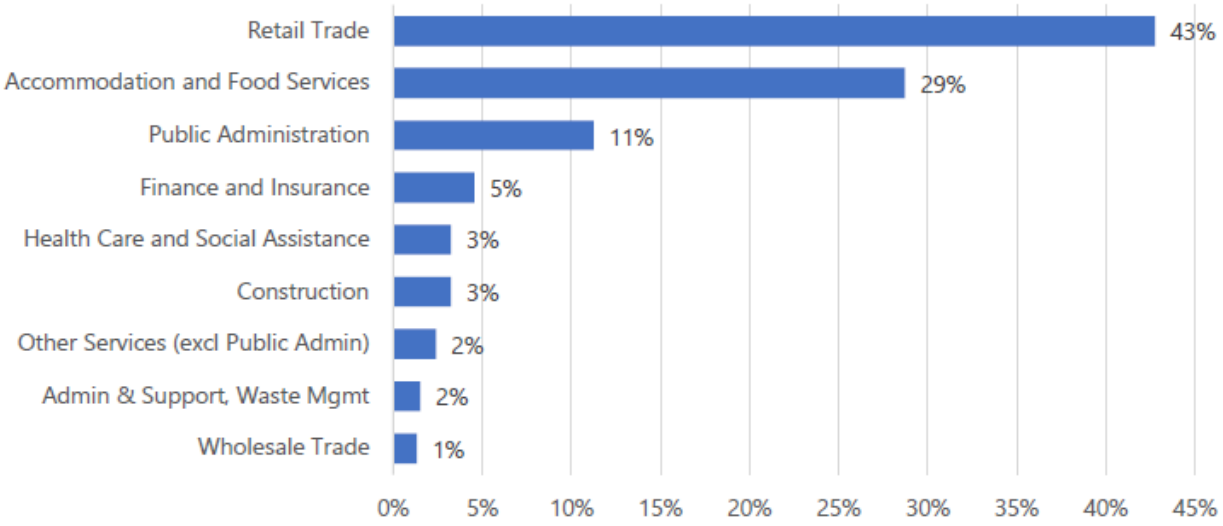
Source: CoStar

Employment remained relatively stable in the Ninth / Plaza Corridor between 2012 and 2022, with the area losing just four jobs over that period. Of the area's 463 jobs, 43 percent are retail and 29 percent are in the accommodations and food services industry. This commercial center has a wider variety of employment than Eastgate and Southgate, with jobs in the public administration, construction, and administrative support sectors.



Appendix V Figure 29. Employment in the Ninth / Plaza Corridor, 2012-2022

Source: U.S. Census Bureau via LEHD OntheMap.

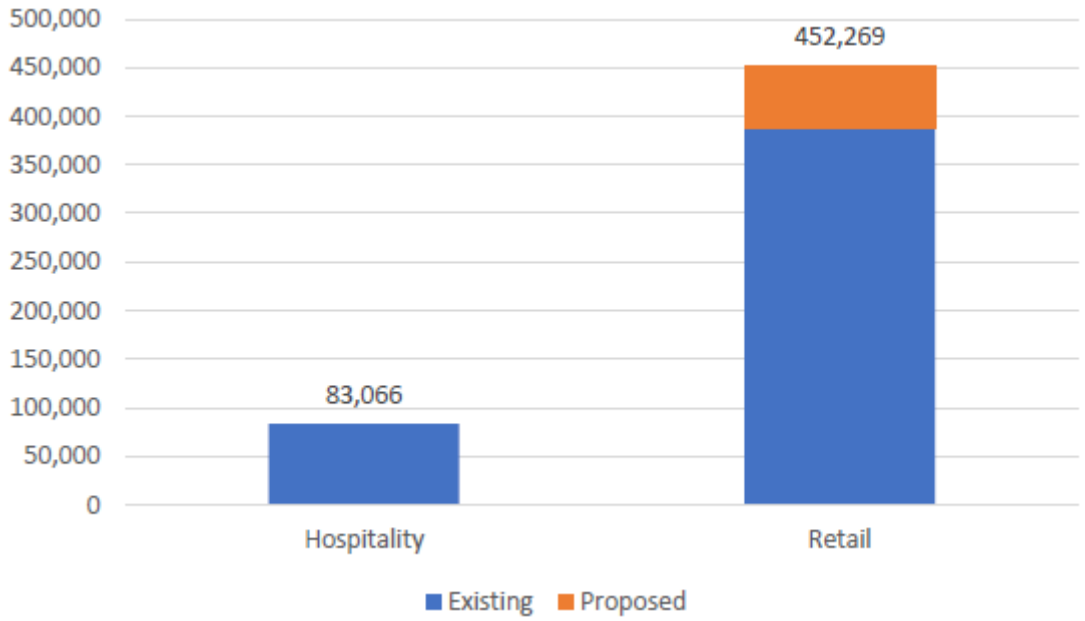


Appendix V Figure 30. Share of Jobs by Sector in the Ninth / Plaza Corridor

Source: U.S. Census Bureau via LEHD OntheMap.

Myra Road Corridor

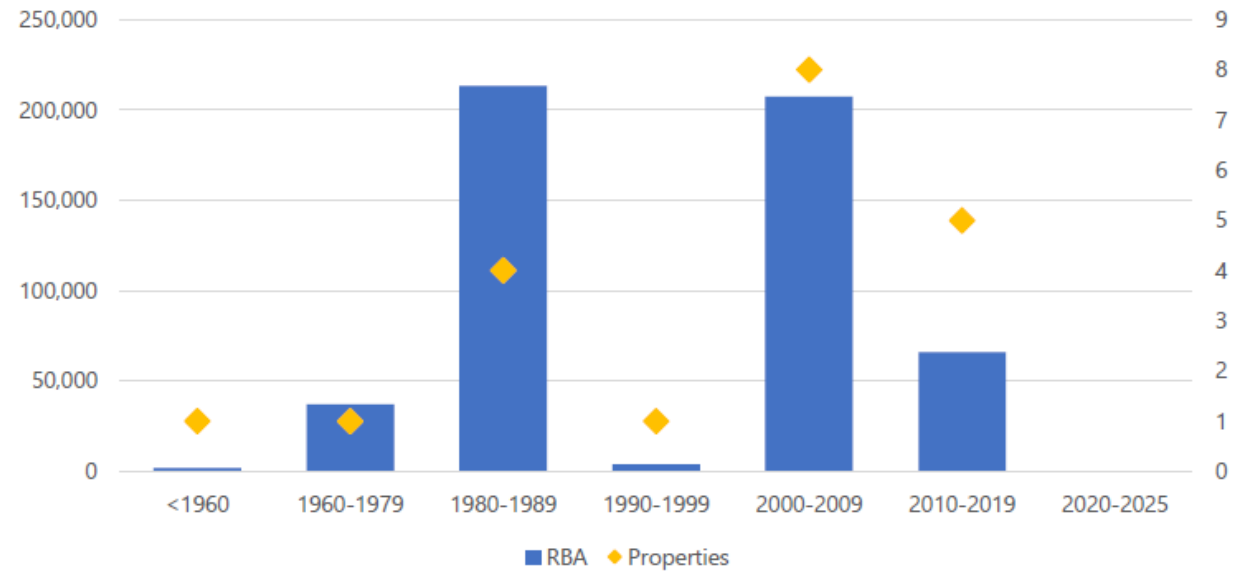
The Myra Road Corridor is located along the western edge of the City along Myra Road between Highway 12 and Taumarson Road. The area includes 157 hotel beds and 86 apartments as well as 388,269 square feet of retail space. An additional 64,000 square feet of retail space is proposed in the Walla Walla Town Center.



Appendix V Figure 31. Myra Road Corridor RBA by Property Type

Source: CoStar

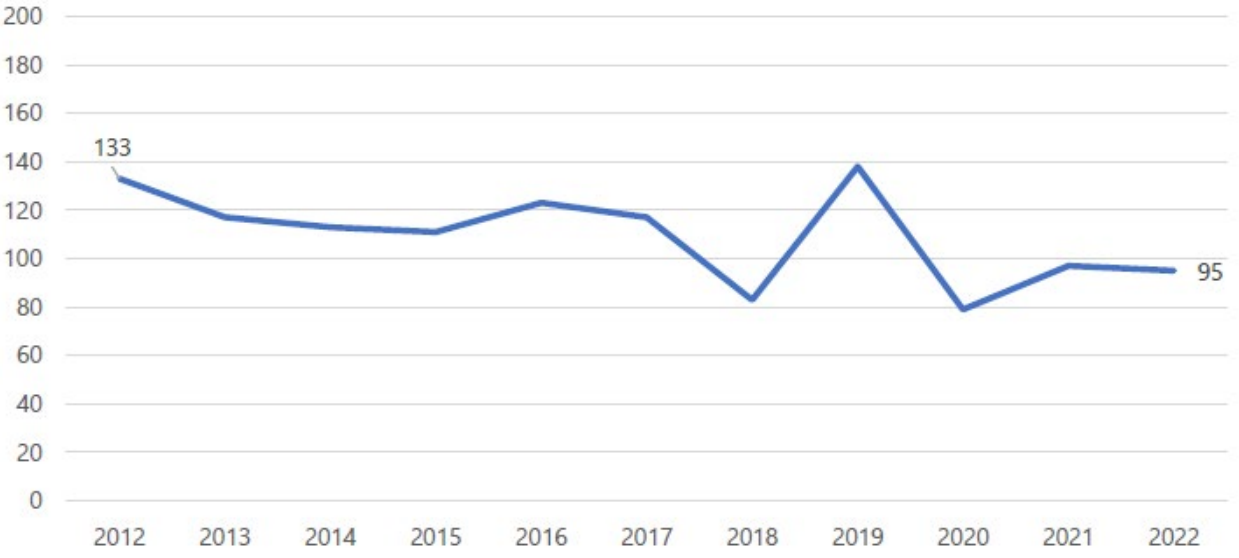
Most of the properties in the Myra Road Corridor were built between 2000 and 2008. An additional five properties were built between 2018 and 2019, though these properties were much smaller on average. New development occurred in the Myra Road Corridor in 2026 along the Myra Road South Extension.



Appendix V Figure 32. RBA by Decade Built in the Myra Road Corridor

Source: CoStar

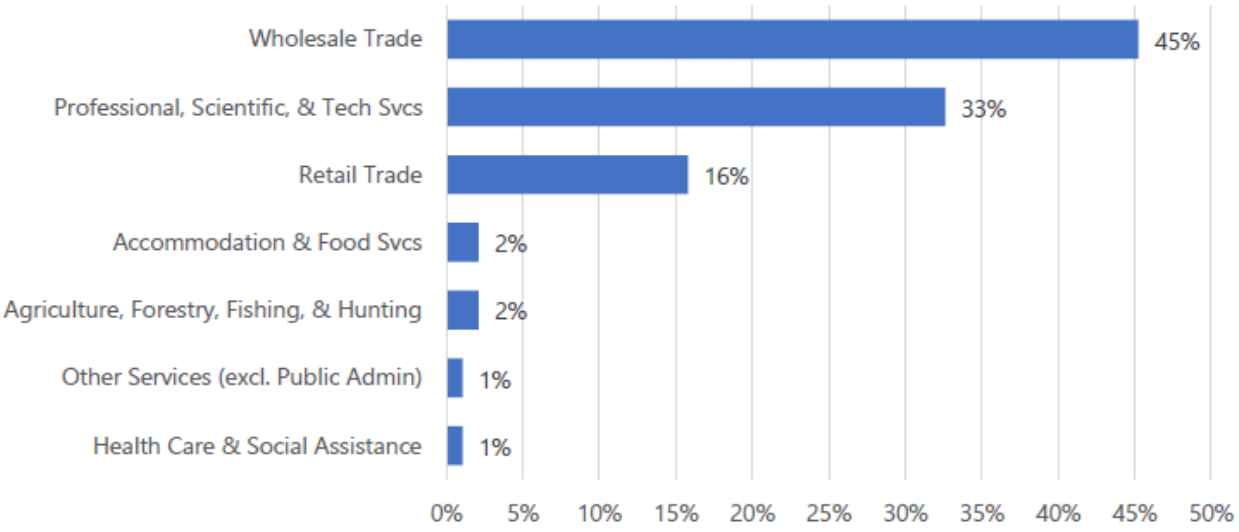
As of 2022, the Myra Road area was home to just 95 jobs, down from 133 in 2012. Between 2019 and 2020, the number of jobs in the corridor dropped from 138 to 79, largely due to impacts from the COVID-19 pandemic on retail businesses. While the corridor has regained some of those jobs, it has not recovered to its pre-pandemic peak.



Appendix V Figure 33. Employment in the Myra Road Corridor, 2012-2022

Source: U.S. Census Bureau via LEHD OntheMap.

Nearly half of the jobs in the Myra Road Corridor are in wholesale trade, while an additional 33 percent are in professional, scientific, and tech services. Despite the presence of the Walla Walla Town Center, just 16 percent of jobs are in retail trade and 2 percent are in accommodation and food services.



Appendix V Figure 34. Share of Jobs by Sector in the Myra Road Corridor

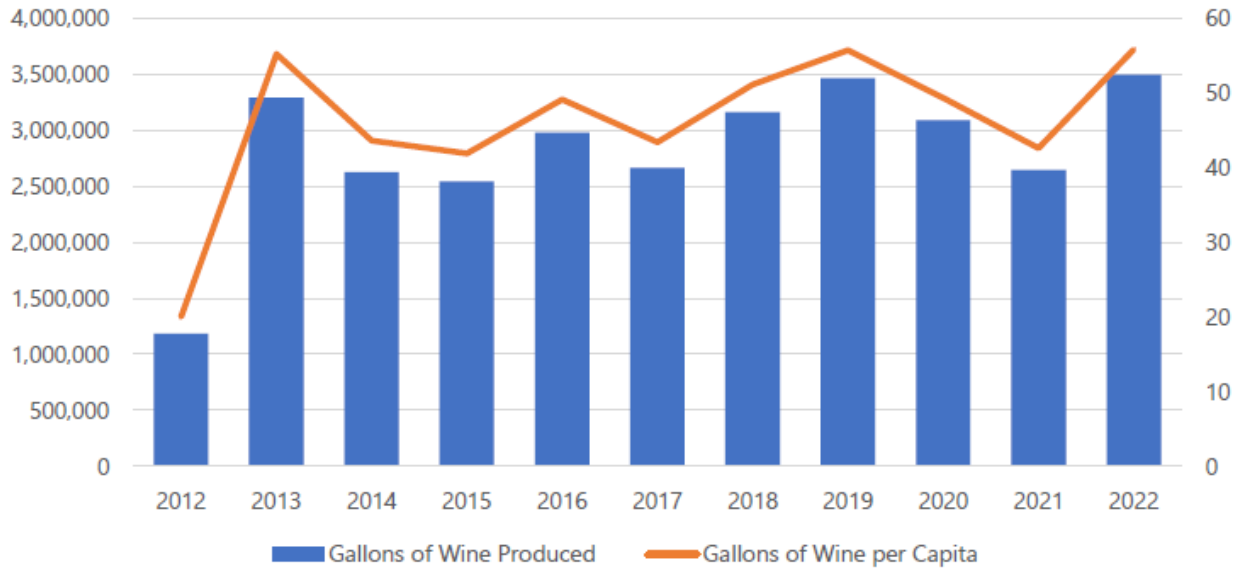
Source: U.S. Census Bureau via LEHD OntheMap.

Regional Economy and Tourism

Walla Walla recently completed a Tourism Master Plan that highlighted the continued importance of tourism and the wine industry on the local economy. The ten-year plan for tourism includes maintaining a robust wine tourism industry, taking advantage of opportunities for new amenities, investing in resources and partnerships to support a sustainable tourism industry, and identifying big-picture ideas that could lead to long-term improvements. The plan provides strategic direction to strengthen and diversify the tourism industry while focusing on benefits to the local community.

In 2022, winemakers in Walla Walla County produced nearly 3.5 million gallons of wine (55.8 gallons per capita). This is the highest production level since at least 2009, indicating strong growth in the sector and a rebound from the height of the COVID-19 pandemic. However, there are indications that the alcoholic beverage industry, and wine in particular, could face significant headwinds in the coming years. Nationwide, the demand for wine has been declining since 2020. A report by Silicon Valley Bank[1] shows that across the U.S. the total wine volume consumed has declined in 2021, 2022, 2023, and 2024. These trends indicate that Walla Walla may need to diversify its economic and tourism base beyond wine to achieve sustainable growth in the near term.

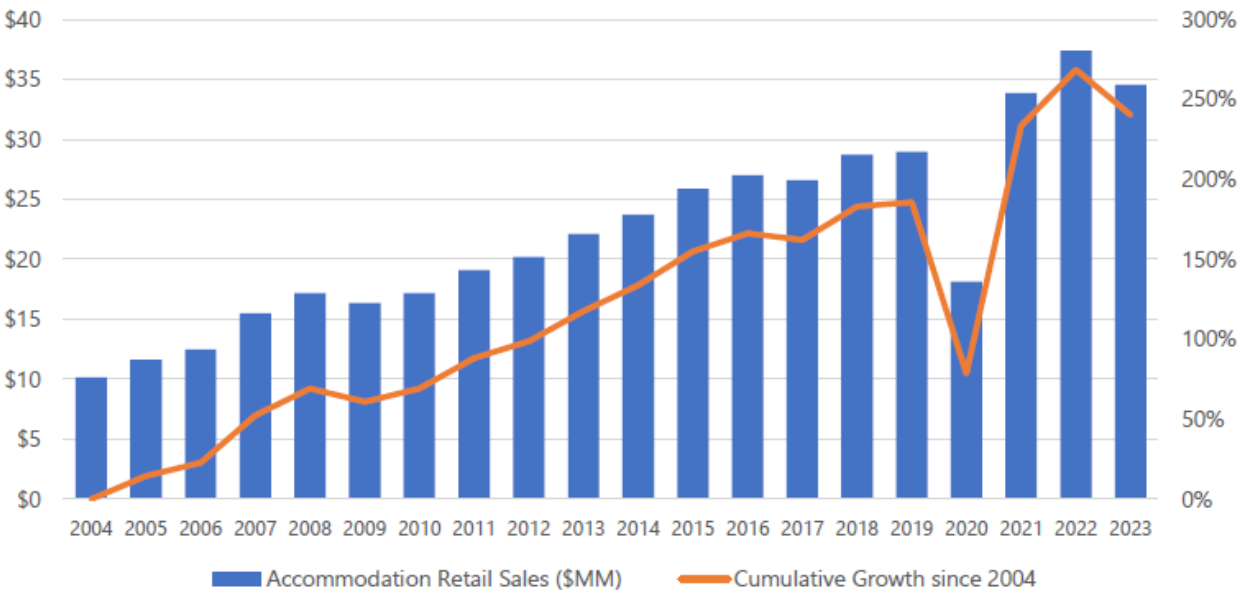
[1] Silicon Valley Bank. *State of the US Wine Industry 2025.* svb.com/globalassets/library/uploadedfiles/wine/svb-state-of-the-us-wine-industry-report-2025.pdf



Appendix V Figure 35. Wine Production in Walla Walla County

Source: Walla Walla Trends

Accommodation sales have also seen strong growth in Walla Walla County recently. Sales in the accommodation sector have been growing consistently since 2004, dropping in 2020 during the height of the COVID-19 pandemic but rebounding significantly in 2021 and 2022. While 2023 saw a slight drop from 2022, sales were higher than in 2021. Between 2004 and 2023, accommodation retail sales grew by 240 percent countywide.



Appendix V Figure 36. Total Accommodation Retail Sales and Cumulative Growth since 2004

Source: Walla Walla Trends

While tourism, driven by the wine industry, continues to be an economic driver for the region, survey results from the Tourism Master Plan reveal that there is concern that the benefits of this growth are not accruing to residents. Residents expressed concerns over the rising cost of living and the need for more recreation, retail, and nightlife opportunities that cater directly to the community of full-time residents. Local leaders are hoping to attract more year-round businesses and entertainment opportunities to temper the seasonality of the tourism industry and to foster a stronger sense of community. To this end, the Tourism Master Plan recommends investing in transportation infrastructure, workforce development, cultural assets, events, and outdoor recreation. These investments should help bolster the tourism economy while providing improved services and new opportunities for residents.



Appendix VI. Comprehensive Plan Final Environmental Impact Statement



City of Walla Walla
Comprehensive Plan Update
Final Enivronmental Impact Statement

May 2018

City of Walla Walla

1.0 Summary

1.0 Summary

1.1. PURPOSE OF PROPOSED ACTION

The City of Walla Walla is updating its Comprehensive Plan in compliance with the Growth Management Act (GMA). The update includes the following:

- Revisions to the Walla Walla Comprehensive Plan Elements to address growth during the 2018-2038 planning period; land use plan and zoning changes to accommodate growth targets for population, housing, and employment; transportation and capital facilities plans, and housekeeping amendments.
- Amendments and updates to comprehensive plan elements to ensure consistency with the City's review of its plans in response to GMA requirements and Countywide Planning Policies.
- Consideration of changes to the Urban Growth Area (UGA) to accommodate new growth in an area that is easier to serve with urban infrastructure and remove an area that is difficult to serve and can only support low-density development.

Updates to zoning and development regulations for consistency with the updated future land use plan.

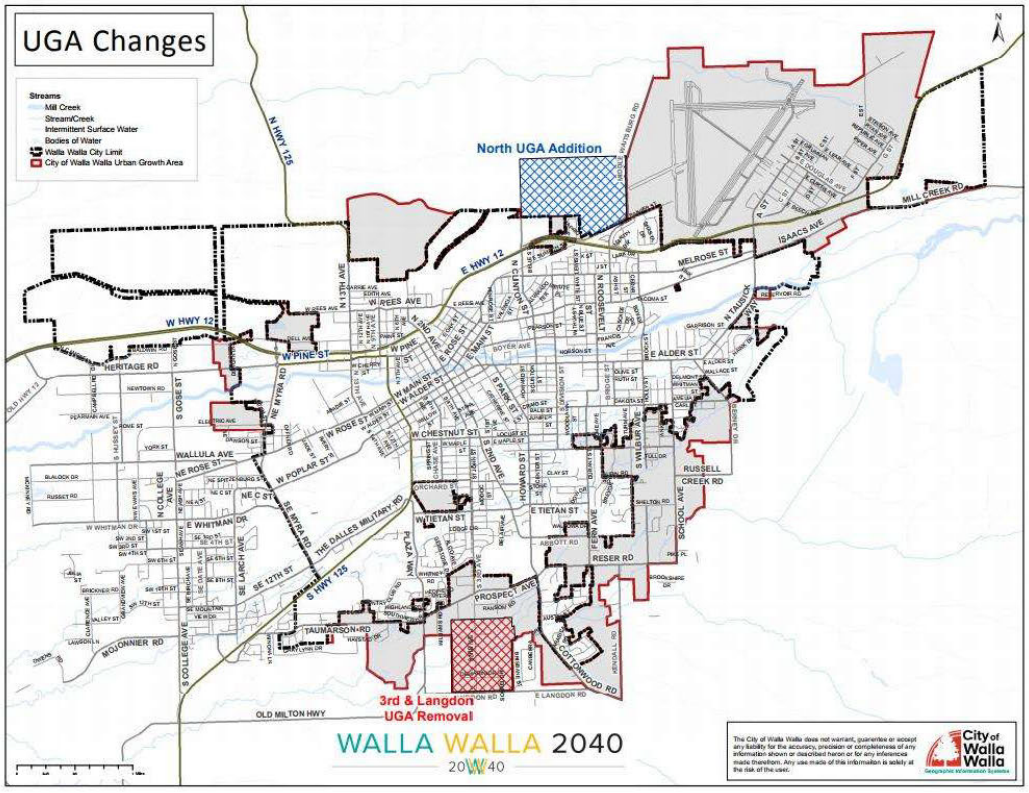
1.2. PLANNING AREA

The primary study area includes the City of Walla Walla and its designated Urban Growth Area (UGA), which is currently approximately 13,238 acres. The proposed areas studied for UGA change include:

- Withdrawal of approximately 198 acres near 3rd and Langdon in the south part of the UGA. This area is characterized by more intensive rural development including 1 unit/acre development on septic and wells. The location, development pattern, and presence of critical areas make it cost prohibitive to provide urban services and facilities in this location.
- Addition of 329 acres to the UGA for the North Area properties. The properties are adjacent to existing urban services and facilities and would be used for future mixed use development.

See Exhibit 1-1. for a map of the City of Walla Walla, its UGA, and the proposed UGA changes.

Exhibit 1-1 Walla Walla Planning Area with UGA Change Study Areas



Source: Walla Walla, 2018.

1.3. STATE ENVIRONMENTAL POLICY ACT PROCESS

This section describes the State Environmental Policy Act (SEPA) and the use of the Environmental Impact Statement (EIS) to solicit public input.

1.3.1. Purpose of the EIS

The purpose of this EIS is to assist the public and local government decision makers in considering future growth and land use patterns as well as goals, policies, and development regulations as part of the Walla Walla Comprehensive Plan Update. These broad decisions will provide direction and support for more specific actions by the City, such as capital improvements and implementing regulations.

1.3.2. Programmatic and Integrated Analysis

The Draft EIS provided a qualitative and quantitative analysis of environmental impacts as appropriate to the general nature of a comprehensive plan update. This Final EIS includes comments received on the Draft EIS and responses to those comments. Together the Draft EIS and Final EIS make up the EIS for this

proposal.

The adoption of comprehensive plans or other long-range planning activities is classified by SEPA as a nonproject (i.e., programmatic) action. A nonproject action is defined as an action that is broader than a single site-specific project and involves decisions on policies, plans, and programs. An EIS for a nonproject proposal does not require site-specific analyses; instead, the EIS discusses impacts and alternatives appropriate to the scope of the nonproject proposal and to the level of planning for the proposal (Washington Administrative Code [WAC] 197 11-442).

The City has elected to integrate SEPA and the Washington State Growth Management Act (GMA) in both the process and the document. Integration of the environmental analysis with the planning process informs the preparation of GMA comprehensive plan amendments and facilitates coordination of public involvement activities. The information contained in the EIS will assist the City in refining a preferred alternative, related comprehensive plan amendments, and implementing regulations.

1.3.3. Phased Review

SEPA encourages the use of phased environmental review to focus on issues that are ready for decision and to exclude from consideration issues already decided or not yet ready for decision making (WAC 197-11-060(5)). Phased review is appropriate where the sequence of a proposal is from a programmatic document, such as an EIS addressing a comprehensive plan, to documents that are narrower in scope, such as those prepared for site-specific, project-level analysis. The City is using phased review in its environmental review of the City Comprehensive Plan update with a programmatic review of the proposal and alternatives. Examples of proposals that may require more area-specific or site-specific SEPA review when more details are known include, but are not limited to, capital improvement projects and private development.

1.3.4. EIS Scoping and Public Comment

In accordance with the requirements of SEPA and GMA, the City has provided for continuous public review and comment over the course of the planning process. First, the City conducted scoping, including an opportunity for written and oral comments. In addition, the City held comment period that was initiated with issuance of this Draft EIS. Public meetings will be held before the Planning Commission and City Council to secure the required approvals for the implementation of this proposal. The required approvals are identified in the fact sheet at the front of this document.

1.4. PUBLIC INVOLVEMENT

The City of Walla Walla adopted a Comprehensive Plan in compliance with the Washington State Growth Management Act (GMA) in 1996. The Comprehensive Plan was updated significantly in 2007. There have also been minor amendments on an annual basis. Each plan update process included extensive opportunities for public involvement both in plan development and as part of the public involvement and notice provisions required for compliance with SEPA.

The City has begun the 2018 Comprehensive Plan Update as required by the GMA. Staff has completed the Periodic Update Checklist for Cities, public workshops seeking the public's vision for the future, and a survey. Feedback from the public involvement process influenced development of the proposal being analyzed as part of the Draft EIS process. The City received few comments on the Draft EIS. These comments and the City's responses to comments are shown in Chapter 2. Comments received on the Draft

EIS resulted in minor changes to the Comprehensive Plan. However, these changes did not affect the analysis of potential impacts in the Draft Environmental Impact Statement.

1.5. PROPOSED ACTION, ALTERNATIVES, AND OBJECTIVES

1.5.1. Objectives

As part of describing proposed actions and alternatives, SEPA requires the description of proposal objectives and features. Agencies are encouraged to describe a proposal in terms of objectives, particularly for agency actions to allow for consideration of a wider range of alternatives and measurement of the alternatives alongside the objectives.

The objective of the proposal is to plan for the next 20 years of population and employment growth in Walla Walla and its UGA and to complete a periodic update consistent with the Growth Management Act (GMA). The Alternatives provide different means of implementing City goals for addressing growth. Although the Comprehensive Plan as a whole guides the development of the City over the next 20 years, the following objectives from the 2007 Comprehensive Plan provide more specific direction for this proposal.

- Objective 1.1 To make development decisions within the context of the Comprehensive Plan.
- Objective 1.2 To ensure compatibility among land uses.
- Objective 1.4 To preserve and enhance the natural beauty of Walla Walla's setting and natural environment, including its many streams.
- Objective 2.1 To preserve historic areas and buildings and to identify unique areas of the City for preservation.
- Objective 2.4 To encourage public participation in planning and implementation.
- Objective 3.3 To incorporate urban design to concentrate development and improve transportation and commuting choices.
- Objective 4.1 To provide an array of sustainable employment and housing choices for all income and age levels.
- Objective 4.6 To encourage a broad range of housing options adequate to meet the needs of underserved middle to lower-income households.
- Objective 6.1 To balance commercial, industrial, and residential development with conservation of natural resources.
- Objective 7.1 To promote an approach to growth management to better conserve infrastructure, land, and natural resources.
- Objective 7.2 To maintain a sound financial condition to allow flexibility that ensures the City is in a position to react and respond to changes in the economy and new service challenges without measurable financial stress.

1.5.2. Proposed Action and Alternatives

The City of Walla Walla is updating its Comprehensive Plan and development regulations in compliance

with the GMA consistent with the purpose objectives above. To consider alternative means to accomplish the purpose and objectives of the update, the following alternatives were developed for the Draft EIS:

Alternative 1 No Action: This is a required alternative under the State Environmental Policy Act (SEPA). This alternative accommodates medium growth through 2038 within the current City limits and UGA boundaries. Minimal policy changes would be made to update the plan to meet new GMA requirements, otherwise no other changes would be made to update the Comprehensive Plan.

Alternative 2 Medium Growth with UGA Alterations: This alternative accommodates medium growth through 2038 within the current City limits and a modified UGA boundary. Approximately 198 acres of the southern UGA near "3rd and Langdon" would be removed because they are encumbered with critical areas and difficult to serve with urban infrastructure and services. Approximately 329 acres in the "North Area" would be added to the UGA for new mixed use development. Other land use changes include adoption of a new residential land use designation that would allow for a greater variety of housing forms and increased density, any privately initiated amendments, and amendments to correct consistency and compatibility issues. In addition to meeting new GMA requirements, there would be a number of policy changes to the plan. These policy changes would address: community character, health, energy efficiency, enhancement of the Mill Creek corridor, improvement of parks and gathering spaces, climate change, housing affordability, neighborhood commercial uses, and transportation improvements.

Alternative 3 High Growth: Alternative 3 looks at how higher growth could be accommodated within the existing City limits and UGA boundaries. Land use changes would be limited to the adoption of a new residential land use designation that would allow a greater variety of housing forms and increase density, any privately initiated amendments, and amendments to correct consistency and compatibility issues. Policy changes would include the changes in Alternative 2 plus additional policy support for multi-family zoning and infill development.

The following Preferred Alternative was developed in response to Walla Walla County's proposal for its Comprehensive Plan update. Walla Walla County is not proposing to extend the City of Walla Walla's UGA into the North Area at this time.

- Preferred Alternative Medium Growth with UGA Alterations and Identification of Long-term Planning Area. This preferred alternative is very similar to Alternative 2. It accommodates medium growth through 2038 within the current City limits and a modified UGA boundary. Approximately 198 acres of the southern UGA near "3rd and Langdon" will be removed because they are encumbered with critical areas and difficult to serve with urban infrastructure and services. However, the approximately 329 acres in the "North Area" will not be added to the UGA. Instead it will be identified as a Long-term Planning Area for new mixed-use development for future growth beyond the 20-year planning horizon. Other land use and policy changes identified in Alternative 2 are included in the Preferred Alternative.

The Preferred Alternative is within the range of alternatives studied in the DEIS. It has similar impacts to Alternative 2. However, some impacts are reduced because the North Area is not added to Walla Walla's UGA. Instead it is identified as future planning area for further study.

The following table compares the features of the three Draft EIS alternatives and the Preferred Alternative.

Exhibit 1-2 Alternative Comparisons

Topic	Alternative 1 (No Action)	Alternative 2 Moderate Growth with UGA Changes	Alternative 3 Higher Growth without UGA Changes	Preferred Alternative Moderate Growth, UGA Changes, Long-term Planning Area
Comprehensive Plan and Development Regulation Update				
Policy Updates	Consistency updates only	Consistency updates plus community character, health, energy efficiency, enhancement of the Mill Creek corridor, improvement of parks and gathering spaces, climate change, housing affordability, neighborhood commercial uses, and transportation improvements.	Same as Alternative 2, plus additional policies to support multi-family housing and infill.	Same as Alternative 2.
Zoning Map and Regulations	Current Map only	Update	Update	Update
Capital Facility Plan Update	Current Plan	Update	Update	Update
UGA Changes				
3rd and Langdon	Remain in UGA	Remove from UGA	Remain in UGA	Remove from UGA
North Area Properties	Continue as Rural	Expand UGA	Continue as Rural	Continue as Rural, but designate as a long-term planning area for future study.
Population (net increase) 2017-2038	5,690	5,690	6,480	5,690

Source: BERK Consulting, 2018.

1.6. SUMMARY OF IMPACTS AND MITIGATION MEASURES

1.6.1. Earth, Water, and Natural Resources

How did we analyze Earth, Water, and Natural Resources?

The DEIS analyzes potential impacts to Earth, Water, and Natural Resources by comparing existing conditions to the projected land use in each alternative. It looks at potential effects of activities associated with urban development, including vegetation removal and increased impervious surfaces. Existing conditions were identified through review of City documents such as critical area studies, maps, and shoreline studies.

What impacts did we identify?

Potential impacts are related to increased urbanization including: habitat loss, decreased vegetation, increased impervious surfaces, soil compaction, and environmental contamination.

What does it mean? What is different between the alternatives?

Alternative 2 allows the opportunity for additional protection of critical areas and habitat with the removal of the 3rd & Langdon area from the UGA. Alternative 3 has the highest level of urban growth and is most likely to result in impacts.

In Alternative 1, urban development is expected to change the natural landscape of the City, which may increase erosion, soil compaction, impervious surface coverage, and decrease vegetation. This may lead to increase potential for landslides and habitat loss. Increases in impervious surfaces could affect water flows and reduce groundwater recharge. Changes in waterflow could also include changes in water quality and result in more contaminants in aquatic organisms. Alternative 2 and the Preferred Alternative have the same potential impacts as Alternative 1 for most of the City. However, the removal of 198 acres of rural land encumbered by critical areas in the 3rd & Langdon area would provide additional opportunities to maintain habitat corridors and preserve critical areas. Alternative 3 would provide the highest amount of growth and increase the likelihood of the impacts discussed in Alternative 1.

What are some solutions or mitigation for the impacts?

The City's Critical Area regulations, Shoreline Master Program, stormwater regulations, and tree protection regulations will mitigate adverse impacts. Changes to zoning codes or other regulations, such as landscaping regulations, could further reduce or minimize the cumulative impacts of increased urban development.

With mitigation, what is the ultimate outcome?

There will be some losses of habitat and vegetation and some increase in pollutants as a result of urban development. Although not wholly unavoidable, mitigation can reduce the impacts.

1.6.2. Land Use and Housing

How did we analyze Land Use and Housing?

We used current land use information from the County Assessor to analyze existing patterns of land use and housing. Projected levels of growth and policy change in each of the alternatives were compared to existing land use conditions to identify areas where growth could potentially occur, how land use might change, and if there were potential land use compatibility issues.

What impacts did we identify?

Growth in Walla Walla will consume vacant lands for residential and commercial development. Some lands could also be redeveloped into higher-density development.

What does it mean? What is different between the alternatives?

Alternative 1 would reinforce existing land use patterns with commercial growth along highways and arterials and with residential development in outlying areas, mostly to the south and east of the planning area. Residential development will primarily consist of single-family homes since there are no redevelopable lands zoned for multi-family development. Alternative 2 would consolidate residential land use designations, making it easier to rezone residential areas for increased density in the City or for construction of additional housing units. Removing the 3rd & Langdon area would have little effect on land use patterns because it is difficult to develop and serve. However, adding the North Area Properties would make it possible to develop that area for a mixed use Master Planned Community in the north part of Walla Walla. This alternative would best allow higher-density residential development and promote housing diversity. Alternative 3 would result in the greatest conversion of land uses within the existing City planning area. This would require policy and code updates to accommodate a high level of growth. The Preferred Alternative would be similar to Alternative 2, but a new mixed used community would not be designated in the North Area because it would not be included in the UGA.

What are some solutions or mitigation for the impacts?

Changes to the zoning code, development regulations, and design standards would allow additional development, ensure quality of design, and make it possible for additional diversity and density of housing.

With mitigation, what is the ultimate outcome?

There will be additional development of vacant and underutilized lands and a general increase in intensity of development. Adverse effects can be managed through appropriate mitigation, but some level of change is an unavoidable aspect of growth.

1.6.3. Plans and Policies

How did we analyze Plans and Policies?

The DEIS examines the plans, policies, and regulations that guide or inform the proposal. This includes the Growth Management Act (GMA), the Walla Walla Countywide Planning Policies (CPPs), the Walla Walla Valley Metropolitan Planning Organization (WWVMPO) and Sub-Regional Transportation Planning Organization (SRTPO), Walla Walla's current Comprehensive Plan and development regulations.

What impacts did we identify?

The alternatives are generally consistent with the plans and policies. However, it should be noted that Alternatives 2 and 3 include updates to the Walla Walla Comprehensive Plan to accommodate changes necessary to implement these alternatives, such as policies supporting community character, healthy, energy efficiency, housing affordability, transportation improvements, and land use and zoning changes to support mixed use.

What does it mean? What is different between the alternatives?

Alternatives 1 reinforces existing development patterns and policies in the current Comprehensive Plan. Alternative 2 supports population growth within a UGA boundary that is easier to serve with public services and utilities; it also provides more protection for critical areas by removing the 3rd & Langdon area from the UGA, as well as considers infill development. Alternative 3 might better accommodate higher growth through additional multi-family zoning and infill development, which makes good use of existing infrastructure. The Preferred Alternative provides more protection for critical areas by removing the 3rd & Langdon area from the UGA and is consistent with the latest draft of the Walla Walla County Comprehensive Plan, which does not recommend expansion of the UGA into the North Area at this time.

What are some solutions or mitigation for the impacts?

Alternatives 2 and 3 contain changes to plans and policies that prevent these actions from inconsistency with adopted plans and policies. Regular updates to plans, including those for capital facilities and transportation, will ensure future consistency.

With mitigation, what is the ultimate outcome?

With mitigation, the Comprehensive Plan would be consistent with state and regional policy guidance and requirements. No significant unavoidable adverse impacts have been found.

1.6.4. Community Character and Historic Preservation

How did we analyze Community Character and Historic Preservation?

The DEIS compared the existing conditions for Community Character and Historic Preservation and analyzed how they may change in response to increased urban development.

What impacts did we identify?

New growth with bring new development, most likely to occur on vacant and redevelopable lands throughout the City. New development has the potential to alter existing character both in terms of increasing density and by introducing new styles of development. Redevelopment pressures may impact the preservation or adaptive reuse of buildings in historic areas, reducing historic character.

What does it mean? What is different between the alternatives?

All alternatives have the potential to alter community character, including historic preservation. Alternative 3 includes the highest amount of growth and has the most potential for impacts. Alternative 2 would make the North Study Area properties available for new development, which could reduce impacts related to new development in other parts of the City. However, it will change the character of that area from rural to urban.

What are some solutions or mitigation for the impacts?

Policy changes in the Comprehensive Plan in Alternatives 2 and 3 would support historic preservation efforts that could mitigate increased pressure to redevelop in historic districts. The adoption of design guidelines and a Parks and Open Space plan could potentially mitigate or minimize impacts related to

increased density.

With mitigation, what is the ultimate outcome?

As Walla Walla grows, some community character will be unavoidably altered, but mitigation measures can help to mitigate the negative impacts of this outcome.

1.6.5. Transportation and Traffic

How did we analyze Transportation and Traffic?

Traffic counts from the past three years were used as a baseline for a review of how growth under each of the alternatives would impact level of service at key intersections throughout the City and UGA.

What impacts did we identify?

Additional growth will result in a reduced level of service at a handful of intersections throughout the city.

What does it mean? What is different between the alternatives?

Alternative 1 and Alternative 3 would result in four intersections falling below the adopted level of service standard without mitigation: 9th Avenue/Dalles Military Road/Plaza Way; 9th Avenue/Pine Street; Howard Street/Chestnut Street; and 3rd Avenue/Tietan Street. Alternative 2 would affect all the above intersections except 9th Avenue/Pine Street, but it would require an additional feasibility study for the vicinity of US Highway 12/Clinton Street. Alternative 3 would result in the same impacts as Alternative 1, plus impacts to Cottonwood Road/Prospect Avenue. The Preferred Alternative would likely result in the same four intersections falling below adopted level of service standard without mitigation as in Alternative 1 and 3. It is unlikely to result in the additional impacts of Alternative 2 as those are primarily related to expansion of urban land uses into the North Area. Nor is it likely to result in the additional impacts of Alternative 3, which are related to a higher growth assumption.

What are some solutions or mitigation for the impacts?

The City is working on a Transportation Management Plan concurrently with its Comprehensive Plan. That plan will identify concurrency requirements to address mitigation of impacts. Additional measures such as an interchange feasibility study for the US 12, changes in signalization, or lane improvements are anticipated to mitigate impacts.

With mitigation, what is the ultimate outcome?

Adverse impacts are likely to be mitigated through various types of intersection improvements, but growth will bring an unavoidable increase in traffic.

1.6.6. Public Services, Capital Facilities, and Utilities

How did we analyze Public Services, Capital Facilities, and Utilities?

The DEIS uses population projections to estimate future demand for water and wastewater utilities, parks facilities, fire and police protection, and public schools. Estimated needs are compared to current and

future estimates of capacity.

What impacts did we identify?

All alternatives will increase the demand for public services, utilities, and capital facilities. Without mitigation there will be a need for additional police and fire services, public school services, and parks facilities under all the alternatives. There is adequate capacity in the water and wastewater facilities to accommodate future growth under all the alternatives.

What does it mean? What is different between the alternatives?

Alternatives 1 and 3 would use the existing service area for City-provided public services and utilities. Growth will generate localized demands, particularly with the higher growth projected in Alternative 3, but improvements will be located within the existing service area. Alternative 2 and the Preferred Alternative alter the UGA boundaries, which would modify the service area. The 3rd & Langdon area, which is difficult to serve due to critical areas and other constraints, would be removed. Expansion of the service area into the North Area Properties is expected to be more efficient in Alternative 2.

What are some solutions or mitigation for the impacts?

Comprehensive Plan policies require maintaining an adequate level of service for public services and facilities without straining City financial resources. The City also plans to maintain and regularly update functional plans for water, wastewater, capital facilities, and parks that specifically plan for future growth, capital facility needs, operation, and maintenance. Increased tax revenue related to growth may pay for some upgrade facilities and services. The City may also consider impact fees and other financial tools to provide facilities and services.

With mitigation, what is the ultimate outcome?

The City should be able to maintain adequate levels of service with mitigation.

1.7. PRIVATELY INITIATED COMPREHENSIVE PLAN AMENDMENTS

In addition to the overall changes to the Comprehensive Plan, Alternatives 2 and 3 include a series of privately initiated Comprehensive Plan Amendments that are under City review. These minor adjustments to the Future Land Use Map are detailed in the table and maps that follow in Exhibit 1-3 and 1.7-2.

Exhibit 1-3. Privately Initiated Comprehensive Plan Amendments

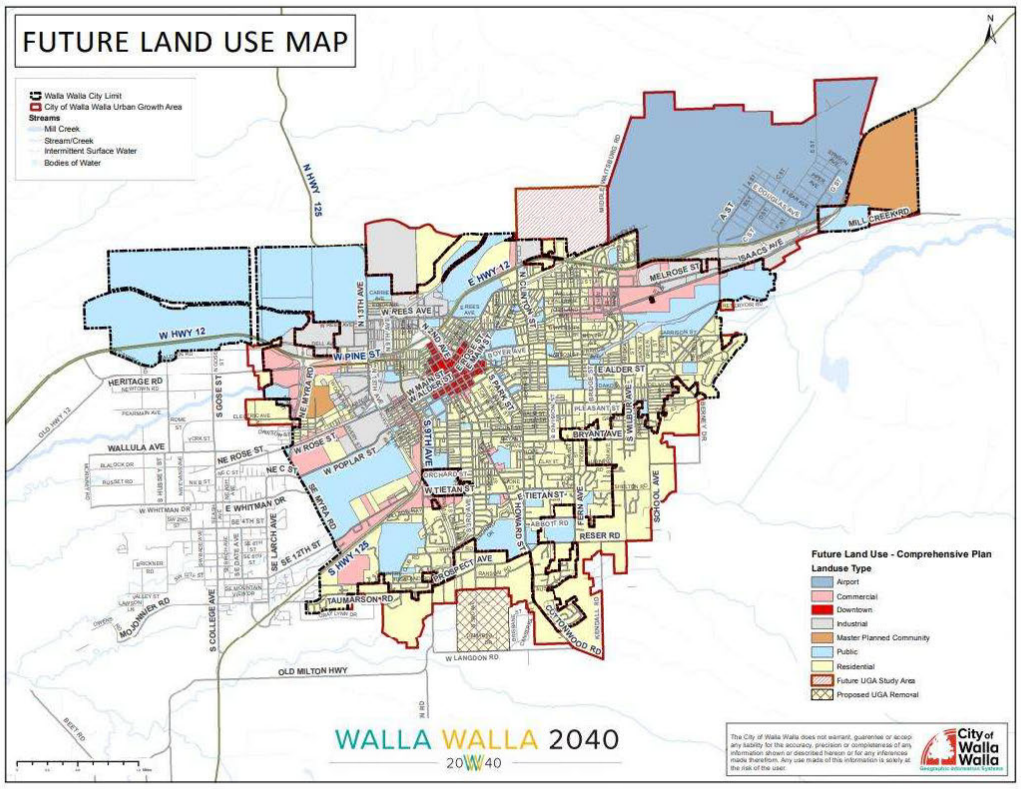
Map Amendment Number	Applicant	Location and Parcel Number	Current Designation	Requested/ Proposed Land Use	Proposed/ Corresponding Zoning
1	Galen Tom	Myra Road and Dell Ave 350724130036, 350724420023, 350724420022, 350724410071	Residential (R-96)	Commercial and Industrial	Highway Commercial and Light Industrial/ Commercial
2	Steven Pao	625 Woodland Ave	Residential (R-96)	Industrial	Light Industrial/ Commercial

		360719330002			
3	Steven Pao c/o Davis Trust	537 Woodland Ave 360719330011	Residential (R-60)	Industrial	Light Industrial/ Commercial
4	Mark Anderson	500 block of Woodland Street 360719330027	Residential (R-60)	Industrial	Light Industrial/ Commercial
5	City of Walla Walla	East of Woodland Ave (400 Block) 360719340032	Residential	Industrial	Light Industrial/ Commercial
6	City of Walla Walla	West of Woodland Ave (300 Block) 360730210012	Residential	Industrial North and Residential South	Light Industrial/ Commercial, South Multi-Family Residential
7	Gary Petersen	North 11th Ave at Cherry Street 360719593802	Residential (R-60)	Industrial	Light Industrial/ Commercial
8	City of Walla Walla	Country Club Road (WW Country Club Driving Range) 360731510115, 360731410067, 360731410061	Residential	Public	Public Reserve
9	City of Walla Walla	8th and Poplar (St. Mary's Parking Lot) 36072952080436	Residential	Public	Public Reserve
10	City of Walla Walla	Downtown	Historic and Downtown Boundary	Remove and Amend Boundary	Varies
11	City of Walla Walla	1400 Block of Lower Waitsburg Road 360716650002, 360716320029	Residential (R-96)	Industrial	Light Industrial/ Commercial
12	Anthony Wenham	Highway US 12 /Clinton Street 360717440036	Residential (R-72)	Industrial	Light Industrial/ Commercial
13	Evans Trust	Lower Waitsburg Road 360717410002, 360717440028	Residential (R-96)	Approx. 15 Acres Commercial adjacent to Hwy 12	15 Acres Highway Commercial; rezone 15 acres to Multi-Family Residential
14	City of Walla Walla	Tietan/Modoc Street (WW Clinic) 360732120027, 360732120010, 360732120009, 360732120014	Residential	Public	Public Reserve
15	City of Walla Walla	1625 E Alder Street (Church)	Residential	Commercial	Highway Commercial

		360722560002			
16	City of Walla Walla	Isaacs Avenue/Melrose Street	Commercial	Industrial	Light Industrial/ Commercial
17	City of Walla Walla	Tausick Way 360722140049	Public	Residential	Multi-family Residential

Source: City of Walla Walla, 2018.

Exhibit 1-4. Land Use Changes Related to Privately Initiated Amendments



Overall, the changes represented by these private amendments have no significant impact and no impact beyond what is studied in Chapter 3 of this DEIS. The table below in Exhibit 1-5 evaluates the potential level of impact of each request.

Exhibit 1-5. Specific Impacts Related to Privately Initiated Amendments

Map Amendment Number	Earth, Water, and Natural Resources[a]	Land Use and Housing	Plans and Policies	Community Character and Historic Preservation	Traffic and Transportation[f]	Public Services, Capital Facilities, and Utilities
1	○	⊙[b]	○	○	○	○
2	○	⊙[b]	○	⊙[d]	○	○
3	○	⊙[b]	○	⊙[d]	○	○
4	○	⊙[b]	○	○	○	○
5	○	⊙[b]	○	○	○	○
6	○	⊙[b]	○	○	○	○
7	○	⊙[b]	○	⊙[e]	○	○
8	○	⊙[b]	○	○	○	○
9	○	⊙[b]	○	○	○	○
10	○	○	○	○	○	○
11	○	⊙[b]	○	○	○	○
12	○	⊙[b]	○	○	○	○
13	○	⊙[b]	○	○	○	○
14	○	⊙[b]	○	○	○	○
15	○	⊙[b]	○	○	○	○
16	○	⊙[b]	○	○	○	○
17	○	⊙[c]	○	○	○	○

Notes:

a. At the policy level there is no anticipated impact, but environmental review is phased and will take place on future development proposals.
b. No current housing units will be lost. This change represents a small loss of residential capacity, but there is adequate capacity Citywide under all alternatives to address the loss.
c. This may result in a small increase in residential capacity, but does not significantly affect citywide capacity.
d. This proposed change affects an area that is currently in transition between residential and industrial character, so the potential character impacts are unknown.
e. This would alter residential character in the area in which the proposal is located.
f. Potential transportation impacts of these changes are included in the Traffic and Transportation analysis

KEY: ○ No additional impact beyond what is studied in the DEIS ⊙ May have a minor impact ● Significant Impact

Source: City of Walla Walla and BERK Consulting, 2018.

1.8. MAJOR ISSUES, SIGNIFICANT AREAS OF CONTROVERSY AND UNCERTAINTY, AND ISSUES TO BE RESOLVED

All alternatives result in increased population, housing, and growth that will lead to some unavoidable changes to the environment, land use, housing, transportation, and capital improvements. Prior to development of the FEIS, the following issues are anticipated to be resolved:

- Selection and refinement of future land use and zoning within the ranges studied by the alternatives.
- Refinement of the goals and policies of the Walla Walla Comprehensive Plan.
- Refinements on proposed code changes to implement actions within the range studied by the alternatives.
- Refinements to the growth projections and allocations for Walla Walla County as a whole.
- Consideration of the requests for UGA changes.

Key environmental issues and options facing decision makers include:

- Alternative land use patterns in relation to the 20-year growth estimates and the community's vision for Walla Walla.
- The relationship between the land use patterns and the natural environment, land use compatibility, the availability of housing, and community character.
- The effect of growth on the demand for public services, utilities, parks, and transportation.

2.0 Comments and Responses

The City of Walla Walla received only one comment on the DEIS during the comment period. It was from the Washington State Department of Transportation. However, the City has chosen to include other comments that it received related to issues in the DEIS and provide responses to those comments.

All comments are shown on the pages that follow. Comment letters are numbered one through five (1-5), with individual comments numbered within each letter. After the comment letters is a table of responses from the City of Walla Walla.

Comment 1 – Confederated Tribes of the Umatilla Indian Reservation

Confederated Tribes *of the*
Umatilla Indian Reservation
Department of Natural Resources
Administration

46411 Timíne Way
Pendleton, OR 97801

www.ctuir.org ericquaempts@ctuir.org
Phone 541-276-3165 Fax: 541-276-3095

September 18, 2017

Letter 1

Elizabeth Chamberlain
Development Services Director
City of Walla Walla
55 E. Moore Street
Walla Walla, WA 99362

Delivered electronically to: echamberlain@wallawallawa.gov

Dear Ms. Chamberlain:

Thank you for the opportunity to provide input to the City of Walla Walla Comprehensive Plan update. We appreciate previous emphasis on incorporating Mill Creek as a vital community asset and the work detailed in both the Comprehensive Plan and the Downtown Master Plan to revitalize Mill Creek as a "spine of amenities that give special identity to the area" (City of Walla Walla, 2004). In particular, we support the following goals and objectives identified in the 2007 Comprehensive Plan: Goals 1, 3, and 6 and objectives 1-4, 3-2, 6-1, 6-2, 6-3, and 6-4.

The Lower Mill Creek Habitat and Passage Assessment and Strategic Action Plan that was recently completed by the CTUIR in collaboration with a broad group of local representatives provides additional actions and recommendations to improve fish passage, fish habitat, and the vital touchstones characteristic of healthy river systems identified in the CTUIR's *River Vision*[1], while maintaining or improving flood control and facilitating support among key stakeholders. With a plan focusing on multi-use, multi-purpose goals and objectives, many of the recommendations in the Lower Mill Creek Habitat and Passage Assessment and Strategic Action Plan echo and reinforce the City of Walla Walla's desire to embrace the preservation and enhancement of Mill Creek as a natural system and a community amenity. In particular, portions of the Downtown Master Plan suggest concepts very similar to those in the Strategic Action Plan, such as sections of Mill Creek having a "naturalized channel section," additions of pedestrian paths to create a "Mill Creek Walk," and generally incorporating Mill Creek into the City as an amenity rather than an eyesore.

With the above goals and objectives in mind, the CTUIR asks that you consider the following recommended changes and/or additions to the Comprehensive Plan.

1. Continue to emphasize goals and policies identified in the 2007 Comprehensive Plan including Goal 6 (Walla Walla will protect and enhance its natural environment for the safety and enjoyment of this generation and those that follow) and the policies identified in section 2.3.7 Environment and Natural Resources and section 2.3.8 Land Use. 1-1

[1] The *River Vision* touchstones are from the "*Umatilla River Vision: A Process-Based Approach to Umatilla River Restoration to Support Tribal Harvest and Use of First Foods*," which was prepared for the Department of Natural Resources of the Confederated Tribes of the Umatilla Indian Reservation and is available online at: http://data.umatilla.nsn.us/fisheries/downloads/CTUIRDNRUmatillaRiverVision100108.pdf.

CTUIR DNR Letter to Elizabeth Chamberlain
Subject: Walla Walla Comprehensive Plan Update
September 18, 2017
Page 2 of 2

2. Develop a Mill Creek Comprehensive Improvement Plan as previously recommended in the Comprehensive Plan and the Downtown Master Plan. This Improvement Plan should incorporate portions of the Lower Mill Creek Assessment and Strategic Action Plan as a stakeholder-supported path forward for the future of the downtown portion of Mill Creek. 1-2
3. Create a resource protection overlay district along Mill Creek and its distributaries. This district would have a specific plan that encapsulates the long-term management strategy for lower Mill Creek and its distributaries within the City limits. The areas targeted for restoration/infrastructure improvements will be identified within the special district map and all proposed new development or proposed renovation or repair of existing buildings and infrastructure will be required to comply with the special district's plans for stream restoration and ROW expansion. 1-3
4. Increase shoreline buffers, particularly in areas where the buffer is currently zero feet (no buffer). Recommended buffers should be 200 feet on undeveloped properties along Mill Creek, 75 feet on Yellowhawk Creek, and 50 feet on all other creeks. 1-4
5. Create a land use code for non-development that can be used to protect open spaces and prevent new development along Mill Creek and its distributaries. 1-5
6. Adopt more protective restrictions than are currently required for new construction in close proximity to Mill Creek, Yellowhawk Creek, and Garrison Creek, thereby preserving opportunities for floodplain expansion and connectivity. 1-6
7. Develop a plan for managing old and/or condemned structures within or adjacent to the lower Mill Creek ROW. Our recommendation is that these structures be removed entirely or at a minimum, require innovative designs that incorporate and maintain stream corridor features. 1-7
8. Amend critical areas designations to further protect shorelines and floodplains.
9. Support the development of greenways to encourage community connection to Mill Creek. 1-8
10. Emphasize protection rather than mitigation in all aspects of the Comprehensive Plan.

I appreciate your consideration of the above recommendations for the update of the City of Walla Walla Comprehensive Plan. CTUIR staff desire to work closely with your project team in developing the new Plan, specifically in development of goals and objectives that are consistent with the overall goal established in the CTUIR Lower Mill Creek Passage and Habitat Assessment and Strategic Action Plan. In addition, we are working with City of Walla Walla staff on development of a collaborative Mill Creek water management plan that will hopefully have benefits to both municipal and instream flow needs. The CTUIR, with local, state and federal partners, continues to seek restored Mill Creek ecological functions necessary to achieve water quality standards, delist ESA-listed bull trout and steelhead, and restore and sustain the CTUIR's First Foods and our Treaty-secured rights based on them. Please do not hesitate to contact me at the number above or Mike Lambert, Habitat Program Supervisor, at 541-429-7240, if you have questions regarding these comments. Thank you.

Sincerely,

Eric Quaempts
Director, Department of Natural Resources

Treaty June 9, 1855 ~ Cayuse, Umatilla and Walla Walla Tribes

Comment 2 – Department of Archaeology and Historic Preservation

dahp
protect the past. shape the future.

Allyson Brooks Ph.D., Director
State Historic Preservation Officer

February 5, 2018

Letter 2

Ms. Melissa Shumake
City of Walla Walla
55 East Moore Street
Walla Walla, Washington 99362

In future correspondence please refer to:
Project Tracking Code: 2018-02-00877
Re: Walla Walla Comp Plan Update Determination of Significance and Request for Comments

Dear Ms. Shumake:

The Washington State Department of Archaeology and Historic Preservation (DAHP) is in receipt of the above referenced Determination of Significance and Request for Comments on the Scope of the EIS. In response, we have taken the opportunity to review drafts elements of the Comprehensive Plan Update including the draft Historic Preservation element. As a result of our review we submit the following comments and recommendation:

- Thank you for drafting and including the historic preservation element as part of the Walla Walla 2040 comprehensive plan update. We note and support the goals and policies for historic preservation work in Walla Walla. We also note the Policy Connection paragraph and the Translating Policy into Action matrix as a valuable tool for implementation.
- While the Policy Connection paragraph touches upon several policy implications of historic preservation with other planning issues, upon reviewing the other draft planning elements (Capital Facilities, Natural Resources, Parks & Recreation, Land Use, etc.) we are concerned that the text does not recognize the connections or overlap of historic preservation with these other elements. Historic preservation efforts will affect, and are affected by, progress in achieving other goals and policies in the plan. However, the language in the other planning elements does not appear to recognize the connections. As a result, opportunities could be missed that would otherwise work toward mutually supportive goals, for instance in land use, parks, natural resources, and capital facilities.
- Therefore, we recommend that other planning elements in the comprehensive plan draft be reviewed and revised with language that supports and builds upon relationships with historic preservation goals. One example is Land Use Policy 1.4 that could be changed to read as follows:

  Review new development proposals to ensure they support the objectives of the Comprehensive Plan such as land use, transportation, community character, historic preservation, and sustainability.

2-1

State of Washington • **Department of Archaeology & Historic Preservation**
P.O. Box 48343 • Olympia, Washington 98504-8343 • (360) 586-3065
www.dahp.wa.gov

Ms. Melissa Shumake
February 5, 2018
Page Two

These comments are based on the information available at the time of this review and on behalf of the State Historic Preservation Officer (SHPO) under the auspices of the State Environmental Policy Act (SEPA). Please note that in order to streamline our responses, DAHP requires that all documents related to project reviews be submitted electronically. Correspondence, reports, notices, photos, etc. must now be submitted in PDF or JPG format. For more information about how to submit documents to DAHP please visit: http://www.dahp.wa.gov/programs/shpo-compliance. To assist you in conducting a cultural resource survey and inventory effort, DAHP has developed guidelines including requirements for survey reports. You can view or download a copy from our website:www.dahp.wa.gov.

Thank you for the opportunity to review and comment. If you have any questions, please contact me at 360-586-3073.

Sincerely,

Gregory Griffith
Deputy State Historic Preservation Officer

C: Patrick Baird, Nez Perce Tribe, THPO
Jon Campbell, Washington State Advisory Council on Historic Preservation
Catherine Dickson, Confederated Tribes of the Umatilla Indian Reservation
Katherine Ferguson, Cultural Resources, Walla Walla VAMC
Paul Johnson, Growth Management Services, Commerce
Mike Rizzitiello, City of College Place

State of Washington • **Department of Archaeology & Historic Preservation**
P.O. Box 48343 • Olympia, Washington 98504-8343 • (360) 586-3065
www.dahp.wa.gov

Comment 3 – Washington State Department of Transportation – February 1, 2018

Washington State Department of Transportation

South Central Region
2809 Rudkin Road
Union Gap, WA 98903-1648
509-577-1600 / FAX: 509-577-1603
TTY: 1-800-833-6388
www.wsdot.wa.gov

February 1, 2018

City of Walla Walla Development Services
55 East Moore Street
Walla Walla, WA 99362

Letter 3

Attention: Melissa Shumake, Planner

Subject: City of Walla Walla – Comprehensive Plan Update
Request for Comments on Scope of EIS

We have reviewed the scope of the Environmental Impact Statement (EIS) and supporting information for the City's Comprehensive Plan Update. We support your efforts and have the following comments.

1. US Highway 12 and State Route 125 are part of the National Highway System and pass through the city limits of Walla Walla. US 12 is a Limited Access Partially Control facility and access is limited to the current interchanges and intersections. Access designations and limitations and Level of Service (LOS) deficiencies of these facilities should be included in the EIS and subsequent impact analysis. 3-1

2. The Comprehensive Plan information did not include an updated Transportation Element. A Transportation Element will be essential for our review of the Comprehensive Plan. The Transportation Element will need to include a traffic analysis for both the current and future conditions. The EIS should show details on the proposed land use changes including location and potential increases to densities. The state highways are an integral part of the transportation network in the Walla Walla area and region. The analysis needs to include the state transportation system as part of the study. 3-2

   The traffic analysis should reflect the updated Transportation Element and must include state highways in addition to local systems as part of the transportation inventory. Also needed are freight movement, single occupancy vehicle alternatives, airport, pedestrian, and bicycle components.

   In addition, LOS standards, traffic forecasts for 10-year period, deficiency analysis, consistency determination with adopted transportation planning policies and plans, and a multi-year financial plan are also required. If funding is insufficient for any required improvements, identification of how additional funding will be raised or land use assumptions reassessed to ensure that LOS will be met.

3. The current and future traffic analysis must not include any improvements to the state system without agreement from WSDOT. 3-3

P:\459005\Comp Plans\Walla Walla County\2018 city of WW update\Comp Plan Update_EIS Scope_2018final.docx

4. The proposed northern Urban Growth Area (UGA) annexation area is located near the intersection of Lower Waitsburg Road and US 12 and would allow mixed-use developments. Recently, a proposed industrial park development (LWR Industrial Park/Corliss Commercial Development, SPR-15-002) in this vicinity was required to install vehicle movement restrictions at US 12/Lower Waitsburg intersection that limit through traffic across US 12 and also left/right turns from Lower Waitsburg Road and Clinton Street onto US 12. These improvements helped mitigate impacts of that development. However, the proposed 329 acre master planned community and UGA expansion would ultimately generate higher traffic volumes which requires an impact analysis to the existing transportation system. 3-3

   The Walla Walla Valley Metropolitan and Regional Transportation Plan 2040 (March 2016) identified a future improvement, specifically a grade separated interchange at US 12/Lower Waitsburg/Clinton Street. The DKS Draft Memo Walla Walla Transportation Plan Background Document Review Figure 3 (2/16/2017), indicates a future interchange would be constructed at US 12/Middle Waitsburg Road at Rainier Drive/Wellington Avenue which is currently an undercrossing. These improvements are unfunded.

   Further development of the UGA north of US 12 requires traffic impact analyses to identify potential issues related to the transportation network.

5. The proposed comprehensive plan change from residential to commercial uses near US 12 at Myra Road has the potential to generate increased traffic volumes and should also be evaluated for impacts to the recently improved interchange at this location. 3-4

6. We support the policies and requirements that promote multi-modal, transit, non-motorized and active transportation systems.

Thank you for the opportunity to review and comment on scope of the EIS for the City's Comprehensive Plan update. We are interested in reviewing and commenting on the completed draft and the EIS, as well as the updated comprehensive plan. If you have any questions, please contact John Gruber at (509) 577-1636.

Sincerely,

Paul Gonseth, P.E.
Planning Engineer

PG: jg/df
cc: Larry Batterton, Area 4 Maintenance Superintendent
Todd Daley, WSDOT SCR Traffic Engineer

P:\459005\Comp Plans\Walla Walla County\2018 city of WW update\Comp Plan Update_EIS Scope_2018final.docx

Comment 3A – Washington State Department of Transportation – March 30, 2018

Washington State Department of Transportation

South Central Region
2809 Rudkin Road
Union Gap, WA 98903-1648
509-577-1600 / FAX: 509-577-1603
TTY: 1-800-833-6388
www.wsdot.wa.gov

March 30, 2018

RECEIVED
APR 02 2018

City of Walla Walla Development Services
55 East Moore Street
Walla Walla, WA 99362

Letter 3 - A

Attention: Elizabeth Chamberlain, Director

Subject: City of Walla Walla – Comprehensive Plan Update

The Washington State Department of Transportation has reviewed the Draft Environmental Impact Statement (EIS) and Draft Comprehensive Plan Update documents. We understand that the North Area UGA expansion is no longer part of the update but will be part of a future study and periodic update. We look forward to working with you on future studies and updates.

We have no further comments and thank you for the opportunity to provide comments. If you have any questions, please contact John Gruber at (509) 577-1636.

Sincerely,

Paul Gonseth, P.E.
Planning Engineer

PG: jg/df

cc: Larry Batterton, Area 4 Maintenance Superintendent
Todd Daley, WSDOT SCR Traffic Engineer

P:\459005\Comp Plans\Walla Walla County\2018 city of WW update\Comp Plan Update_Mar2018.docx

Comment 4 – RL McFarland

1

1/31/18

Letter 4

To: Melissa Shumake, Planner, Walla Walla Development Services

From: Richard L. McFarland

Re: Determination of Significance and **Request for Comments** on Scope of EIS Walla Walla Comprehensive Plan Update Environmental Impact Statement

*UGA addition of 329.4 acres referred to as the "north properties".

*UGA removal of 197.8 acres referred to as "3rd and Langdon".

*Public Notice published in the Union-Bulletin 12/26/17.

The Public Notice, under the heading of "**EIS Required**", states the following:

"The lead agency has identified the following areas for discussion in the EIS: earth, water and natural resources, plants and animals, relationship to plans, policies and regulations, transportation and traffic, and public services and utilities."

To begin:

Under the heading of "**Description of Proposal**", the public is told that the "*Zoning for the north properties would allow for mixed-use development*.

Without having a better understanding of what "*mixed use development*" specifically means, it is impossible to directly address issues related to what could be built and for what use and under what specific conditions, regulations and/or exceptions along with what combination of necessary zoning it would involve.

Therefore, I can only address the obvious "first step" issues that any development on the "northern properties" will encounter.

The term "*relationship to plans*" (per the Public Notice) suggests a very general theme. Consequently, I am going to offer input that I think fits this "request for comment" to make sure it is in the public record and available for reference, consideration and further research.

Input:

Why is the City of Walla Walla really applying to add land from the County of Walla Walla into the City of Walla Walla's UGA? What is the Big Picture?

It is my understanding that under the guidelines of the Growth Management Act (GMA) a city performs a "capacity study" that shows, among many statistics found in the documentation of a city's participation in and with the GMA, that a city either has-or-does- not-have sufficient land(s) defined by a city's UGA boundaries to allow for future growth.

Does the city of Walla Walla have on file an up-to-date "capacity study" to help in documenting their application for adding more land "into" their UGA?

4-1

In line with this, is their a <u>required</u> "direct relationship" between the release of UGA acreage on the south side (3rd and Langdon") and the addition of the "north properties" acreage?

I have looked around Washington State with regards to the relationship cities have with their UGA needs and existing boundaries and found that if and when a city shows an interest in expanding their UGA needs *unnecessarily*; public and private concerns (city and county) have spoken up and successfully addressed the

fact that UGA boundaries do not need to be extended simply because city management wants to.

In the Walla Walla application, it appears to me the boundaries do not need to be extended *(County Community Development has come to this conclusion)* consequently the "why" question falls under a bright spotlight.

When an application is made by an individual or individuals to do something/anything related to "development" (as suggested by the term "mixed-use development'), a primary question automatically is brought to the table - "who benefits". 4-1

With the city's application, and with no specific development project information being provided, the question of "who benefits" becomes very gray. Consequently, the question of "who benefits" must be replaced by "who *eventually will* benefit"?

Considering the question "who eventually will benefit"; logic directs that question be directed first towards adjacent land owners for further study and research.

Next Input:

In further studying the land(s) contained with the 329.4 acres of "Prime" farm land one finds there to be either (3) or (4) parcels of land. 4-2

One parcel contains acreage managed on behalf of the American Taxpayers by the Department of Natural Resources. This parcel is known as a "School Trust parcel".

4

(2) or (3) other parcels are owned, as defined by the terms of either one or two different trusts, by members of the Angell family.

I say there are (2) or (3) other parcels in the Angell family name as I found that by checking on their ownership (related to the "north properties" parcels) via the Walla Walla County Assessor's online "property records search", if one accesses this information from a personal home computer, the "property records search" site indicates there are (3) parcels (listed below) showing under the Angell name.

However, if one goes into the Walla Walla County Assessor's office directly and asks them to look up the same information, (the Angell family parcels contained within the "north properties" group) their information shows there are only (2) parcels listed and the last time I checked there was an indicator showing the Angell parcels at this location had recently been adjusted. 4-2

So, what does this mean? For an application by the City of Walla Walla to be complete doesn't the information regarding property parcel numbers have to be accurate, compatible and fully up-to-date?

42733

ANGELL JAMES L AND JAMES L & MARY ANGELL LIFE ESTATE & AMANDA ANGELL

Land Use Code 83

Legal Description: 16-7-36 TAX 29

Parcel Number: 360716120018

5537

ANGELL RESIDUARY CREDIT SHELTER TRUST

Land Use Code 81

5

Legal Description: 16-7-36 TAX 30 LESS CO RD

Parcel Number: 360716110019

42734

ANGELL JAMES L AND JAMES L & MARY ANGELL LIFE ESTATE & AMANDA ANGELL

Land Use Code 83

Legal Description: 16-7-36 TAX 31

Parcel Number: 360716120020

Next input:

It makes absolutely no sense for the city of Walla Walla to include the "School Trust Land parcel" in their UGA plans as stated.

5540

DNR

Land Use Code 67

Legal Description: 16-7-36 NW1/4

Parcel Number: 360716210001

4-3

The School Trust Land concept dates back to 1889 in Washington State.

Federally granted state trust lands support seven specific trusts, each with its own lands:

**Common School trust – supports construction of public kindergarten through 12th -grade public schools statewide*

**University trust – supports University of Washington*

6

**Normal School trust – supports 4 state universities (Western, Central, and Eastern Washington – former teacher colleges, and The Evergreen State College)*
**Agricultural School trust – supports Washington State University*

**Scientific School trust – also supports Washington State University*

**Capitol Building trust – supports state buildings at the Capitol in Olympia*

** Charitable, Educational, Penal and Reformatory Institutions (CEP&RI) trust – supports institutions managed by the state Departments of Corrections and Social and Health Services*

I want to focus on one of the seven points listed above, "*Common School trust*".

Growth is inevitable (*eventually*) and with growth comes the need for more schools. Why on earth would the City of Walla Walla attempt to encourage the use of a pre-existing "School Trust Land parcel" for a "mixed-use development" project as is suggested in their application?

4-3

The "School Trust Land parcel" should be left intact under the auspices of the DNR and left in agricultural production (income producing) until such time it is needed for a future school site north of Highway 12 or at such time it is needed for a protected Green Space/Park/Conservation Reserve should reasonable access by farm machinery to the property be limited by non-agricultural development of the surrounding privately-owned properties.

If the City of Walla Walla chooses not to help protect this parcel for school income or future school use then they should look very closely at what has to take place should they seek to assist in its becoming "commercially developable".

By the very definition of "Prime" agricultural land – which the "School Trust Land parcel" and the adjacent Angell family property parcels are (PA-40), conversion of

7

the "Best of the Best" (premium soil producing the highest of yields) is not something one does simply because one wants to.

No, to apply to take "Prime" agricultural land (Primary Agricultural/PA) out of production or potential production, one must approach such a request along the lines of a fiduciary responsibility. The application has to conform with higher standards than a normal land zoning change application.

4-3

Next Input:

Referring back to this as shared in the opening of this letter:

*"The lead agency has identified the following areas for discussion in the EIS: earth, water and natural resources, plants and animals, relationship to plans, policies and regulations, **transportation and traffic**, and public services and utilities."*

I have highlighted "transportation and traffic' for a very important reason.

In the City of Walla Walla's application to the County of Walla Walla, requesting the county approve the removal of specific county lands from full oversight of the county and placing those specific county lands within the city's oversight UGA zone, the city states the following regarding the "north properties":

4-4

"The existing and future development in this area has already led to Washington State Department of Transportation (WSDOT) changing the configuration of the intersection at Lower Waitsburg Road/Clinton and Highway 12 and WSDOT is planning for further changes to Highway 12/Clinton Intersection without considering the proposed addition to the UGA."

Hold on a minute!

Since December of 2014 I have been a participant in multiple development applications (of varying types and formats) located directly adjacent to the aforementioned Lower Waitsburg Road/Clinton and Highway 12 intersection; specifically, the Wenham, Evans, Bouchon Park Phase 1, Bouchon Park Phase 2 as well as (2) development applications (McDonald and the subsequent Hayden Homes ownership plat plan amendments) very nearby (approximately 2600' east on Middle Waitsburg Road).

When the City of Walla Walla states "*WSDOT is planning for further changes to Highway 12/Clinton intersection without considering the proposed addition to the UGA*" a great deal of pertinent reference/background material is missing.

At the time(s) of the (2) separate applications to develop submitted by the owner/developer of Bouchon Park, there were no WSDOT plans "in place" for changes to the Lower Waitsburg Road/Clinton and Highway 12 intersection. It has been known for many years that the intersection was in need of an overpass/underpass and that the intersection was dangerous, however there was no direct relationship in place between "need" and "real-time planning". 4-4

Subsequent to the first Bouchon Park application for development (Phase 1), **and subsequent** to the City of Walla Walla's recommendation to approve (per Development Services) that application, WSDOT issued a formal response (on file with Development Services) stating that Bouchon Park (Phase 1) would not receive its final permits for operation until the Bouchon Park owner/developer had paid for *specific Bouchon Park related* updates to the Lower Waitsburg Road/Clinton and Highway 12 intersection as defined by and installed by WSDOT.

In fact, since the City of Walla Walla had recommended to approve the Bouchon Park permit (without any significant upgrades to the Lower Waitsburg Road/Clinton/Highway 12 intersection) prior to receiving the WSDOT letter, the

City of Walla Walla had to go back and amend their approval of the Bouchon Park application to include and require what WSDOT required.

Furthermore, WSDOT specified that at such time a Bouchon Park Phase 2 development was built, *there would be further additional changes* to the Lower Waitsburg Road/Clinton and Highway 12 intersection and again these WSDOT defined changes would be paid for by the Bouchon Park owner/developer.

So, for the City of Walla Walla to officially state *"WSDOT is planning for further changes to Highway 12/Clinton Intersection without considering the proposed addition to the UGA"* – as I read it – is to imply that the "further changes" planned by WSDOT would serve "future development" (which could mean future development on property defined by an "expanded" UGA).

Nothing could be farther from the truth! 4-4

The "WSDOT planned further changes to Highway 12/Clinton Intersection" are specifically based on the official Traffic Study submitted for the Bouchon Park Phase 1 and Phase 2 development applications.

When the City of Walla Walla states "*without considering the proposed addition to the UGA*", I read that to say the City of Walla Walla is stating that WSDOT is thinking ahead (traffic handling wise) for future yet-to-be-proposed development.

No.

Those "planned needs" are not based on serving any development ***not yet on the books*** pertaining to nearby properties regardless of whether they are inside the

existing UGA boundary north of Highway 12 and served by Lower Waitsburg Road and Middle Waitsburg Road or outside of that existing UGA boundary.

The "planned needs" as defined by WSDOT for that location pertain directly to the Phase 1 and Phase 2 permits related to the Bouchon Park development and that is all. Period.

The City of Walla Walla, in their UGA application to Walla Walla County goes on to state:

"The City's Transportation Plan, which is being overhauled as part of this major update, has identified US Highway 12/Clinton intersection as an improvement project."

4-4

Wait a minute!

That official statement, as inserted into this application, makes it sound like the City of Walla Walla has taken a lead position in upgrading the US Highway 12/Clinton Intersection.

Nothing could be further from reality.

While that intersection has long been acknowledged as being under-designed and over-worked, and WSDOT has preliminary plans for an overpass at that location, those plans, prior to the Bouchon Park Phase 1 and Phase 2 applications, were simply plans for "sometime in the future" with no priority or funding attached to it whatsoever.

11

Thanks to (former) County Commissioner Perry Dozier; at first sight of the scale of the Bouchon Park Phase 1 initial site grading (when giant equipment was delivered onsite for that purpose) in early November of 2105, he went to the Port of Walla Walla and thanks to the Port's relationship with WSDOT, the County and the Port took the first "real time" steps that ultimately shifted the possibility of an overpass at that intersection from "sometime in the future" to a "legislative priority".

4-4

Please note that the City of Walla Walla was "late to the game", (their words as mentioned in the Union-Bulletin subsequent to the County and Port's significant homework) vis-à-vis the importance of actually going forward with safety design upgrades to that intersection.

Next Input:

Now as to "*affordable housing development*" (per the City of Walla Walla's application):

"Exhibit B delves into the city's argument for why this area should be added to the UGA and more deeply, but the main arguments can be summarized as: low cost of providing urban utilities, services, and transportation, allowing for affordable housing development, proximity to urban centers, proximity to increased development pressures, and a large County-wide supply of agricultural resource lands which are not immediately adjacent to UGA boundaries."

4-5

This UGA application does not relate to affordable housing development whatsoever. Hayden homes – known for building homes in the "more affordable" range is currently developing Blue Mountain Estates – directly adjacent to School Trust Land parcel and the Angell properties. Yet…the new Hayden homes at this location currently are priced between $325,126 (MLS # 117779) and $362,264 (MLS# 117770).

If one considers that Hayden Homes builds new homes in the "lower price ranges" *yet their properties adjacent to the "north properties" are currently listed between $325k and $363K*...logic dictates if more new urban sized lots are developed in subsequent new subdivisions within the proposed adjacent UGA expansion, those homes, being built on the best-of-the-best Prime Agricultural land(s) - with world class mountain views thanks to the fact that there are no preexisting structures to block views - and nearby expanding world class vineyards, those homes would NOT be priced under $400k.

If the lands within the proposed UGA addition were to be developed in the near future, it's guaranteed that any developer with a financial brain is going to build homes based on *location-location-location* and *view-view-view*. New homes built in that location would most assuredly not be priced in the low-to-mid $200,000 range (which by all local statistical accounts is where the current local "median" home price exists). 4-5

A recent real estate article in the Union-Bulletin included information from the local real estate community indicating that homes in the $200k range and under were snapped up immediately (suggesting what would be considered affordable in this area) while homes in the $400k range and up tend to "sit on the market" for a while.

I recommend the City of Walla Walla refrain from expanding their UGA unnecessarily northward at this time and focus on supporting the development of and/or the repurposing of properties already contained within the existing City Limits and existing UGA.

RL McFarland

3731 Middle Waitsburg Road, Walla Walla, WA 99362

Comment 5 – Steven Pao

Elizabeth Chamberlain
City of Walla Walla
Development Services Department
55 E. Moore St.
Walla Walla, WA. 99362

January 3, 2018

RECEIVED
JAN 04 2018

Steven Pao
334 Woodland Ave.
Walla Walla, WA. 99362
(509) 529-3471

Letter 5

Dear Ms. Chamberlain.

This letter is in regard to the City of Walla Walla's Comprehensive Plan update. It was stated that the city plans to rezone the current residentially zoned housing (primarily in the 300-500 block area) of Woodland Ave. to industrial. My concern for this proposed rezone is the cities' noise ordinance.

Currently the maximum noise allowed from an industrial zone to a residential zone is 60 db. However, the maximum noise allowed from an industrial zone to another industrial zone is 70 db. A ten decibel increase in sound is significant. I am concerned that this would then allow an industrial facility to emit more noise to the local houses that the homeowners would then have to endure without any recourse.

5-1

We have had problems in the past in an identical matter where Snow Distribution on Abadie St. (zoned industrial or commercial) would have as many as twelve diesel refrigeration units running all night which exceeded the residential noise limits. The nearby Walla Walla Foundry often operates two shifts, starting at 5:00 a.m. and operating until 10:00 p.m., and is often noisy. Especially with the operation of exhaust fans, (which whine like jet engines) sometimes 24 hours a day. (I am not formally complaining about the foundry, just pointing out facts. We, so far, have had a good relationship with the foundry.)

If the city proceeds with the rezoning of the residential housing to industrial, what guarantees would be in place to protect the homeowners from additional noise?

Thank you for your time in addressing my concerns in this matter.

Sincerely,

Steven Pao

Steven Pao

Exhibit 2-1 Responses to Comments

Comment Number	Response
Confederated Tribes of the Umatilla Indian Reservation	
1-1	Comment is noted. The Walla Walla 2040 plan carried forward the goals and policies from the *2008 Walla Walla Urban Area Comprehensive Plan* identified in the CTUIR letter. Goal 1 states that "Water, air, and soil resources are protected in Walla Walla" and ENR Policy 1.7 address this comment.
1-2	ENR Policy 1.10 states *"Develop a Mill Creek Corridor Plan with a focus on the opportunity to "daylight" Mill Creek through the downtown."* City will add an implementation item to the Environment and Natural Resources Element to address a Mill Creek Corridor Plan. Comment addressed.
1-3	Comment noted. The City's Shoreline Management Plan (SMP), recently updated in 2016 pursuant to the Shoreline Management Act (SMA), regulates land within 200 feet of Mill Creek which acts similar to an overlay district along Mill Creek within the city limits. The City's SMP address development within 200 feet of Mill Creek.
1-4	Comment noted. The City's SMP was recently updated in 2016 pursuant to the SMA. Streams were analyzed to determine if they fell within the threshold of shoreline jurisdiction (*see the Shoreline Analysis Report for Shorelines in Walla Walla County and the Cities of Walla Walla, Prescott, and Waitsburg, dated September 2014*). For the City of Walla Walla, Mill Creek is considered a shoreline of the state. Yellowhawk Creek within the city limits did not meet the cfs threshold for shoreline jurisdiction. The SMP calls for a 35 feet buffer from Mill Creek with an additional five foot building setback from the buffer for a total of 40 feet. Comments were addressed through the City's SMP update effort.
1-5	Comment noted. The City of Walla Walla's Critical Areas Ordinance (CAO) governs development when critical areas and buffers are present on properties.
1-6	Comment noted. The City's CAO was developed with Best Available Science in 2008. When the City updated its SMP, a review of the CAO was conducted and applicable amendments made to address any changes in state law. The City also conducted a review of the CAO as part of the periodic update and incorporated the CAO amendments from the SMP update process to apply city-wide.
1-7	Comment noted. Policy H-2.2 addresses property maintenance standards, although more specific to housing, could apply to other structures. Under the implementation action table, the City has identified the need to develop minimum property maintenance standards and code compliance program.
1-8	Comments noted. Critical areas have been addressed under comments 1-5 and 1-6. The comprehensive plan includes policies to support trail development along the Mill Creek Corridor. See PR Policy 1.6. City will add another policy regarding the Blue Mountain Region Trails Plan.
Department of Archaeology and Historic Preservation	
2-1	The plan has been amended to include historic preservation in LU Policy 1.4 as well as making sure the Policy Connection paragraphs in the other elements reference Historic Preservation where appropriate.
Washington State Department of Transportation - February 1, 2018 Letter	
3-1	Analysis of US Highway 12 and State Route 125 are referenced in the City's Transportation Plan. The City utilized information from the Walla Walla Valley Metropolitan Planning Organization 2040 plan for these facilities including traffic counts.

3-2	Comment noted. The Walla Walla 2040 Plan includes a transportation element meeting the requirements of RCW 30.70A. When WSDOT provided their comment letter on February 1, 2018 the draft transportation plan had not been completed.
3-3	The City's proposed North Urban Growth Area (UGA) Addition application to Walla Walla County was not moved forward to the County's final docket. The City has identified the North UGA as a future study area and is not included in the City's UGA.
3-4	The draft EIS looked at the potential increase in commercial and residential development within the Myra Road corridor. The analysis showed that the City's transportation network did not drop below a Level of Service standard "D" within the 20-year planning horizon.
Washington State Department of Transportation - March 30, 2018 Letter	
3A-1	Comment noted.
RL McFarland Comment Letter	
4-1	The City of Walla Walla completed a land capacity analysis that has been incorporated into the comprehensive plan update. Applying for the North UGA addition to Walla Walla County is related to a corresponding application the City submitted to Walla Walla County for removal of 198 acres from the UGA. However, Walla Walla County did not move forward the North UGA addition application to the final docket. Therefore this comment is no longer applicable.
4-2	Comment noted. Property ownership was obtained from the Parcel Records the City receives from Walla Walla County.
4-3	Comment noted.
4-4	Comment noted. The City's North UGA addition application was not moved forward to Walla Walla County's final docket. Therefore, the City has revised its draft comprehensive plan to show the North UGA as a future study area. The comments provided regarding "Bouchon Park" are not applicable to the draft comprehensive plan as "Bouchon Park" is an approved site development project in compliance with the City's development standards (Phase 1 approved June 1, 2015 and Phase 2 approved February 16, 2016). The transportation mitigation identified in the City's issued Mitigated Determination of Non-Significance (May 22, 2015) for Phase 1 and Phase 2 issued January 19, 2016 for the project was a result of the comments provided by the Washington State Department of Transportation to the City as part of Notice of Application comment period. In regards to US 12 and the interchanges along the corridor, the City has identified in its draft transportation plan the need for a interchange corridor study along US 12 from the interchange at 2nd Avenue to the interchange at Wilbur Avenue.
4-5	Comment noted.
Steven Pao Comment Letter	
5-1	The City's noise ordinance addresses noise impacts for non-residential zoned property when the receiving property is residential. See Walla Walla Municipal Code (WWMC) Chapter 8.13. Mr. Pao has also applied for a land use change of his property from Residential to Industrial. If approved, would permit Mr. Pao to apply for a potential rezone to Industrial and therefore could allow higher intensity uses on his own property similar to the request Mr. Pao is concerned about according to his comment letter.

Appendix VII. Engagement Report

Stakeholder Interviews

Introduction

As part of the regular update to the 2026 Comprehensive Plan, orientation interviews were conducted from January 28 to February 6, 2025. The interviews provided valuable insights from key stakeholders to inform the planning process. 20 stakeholders participated, representing a broad range of organizations, decision-making bodies, and community interests. Their input offers a balanced view of the opportunities, as well as challenges the community will most likely encounter in planning for the future. The topics covered various issues such as the creation of infrastructure, housing affordability, economic growth, active transportation, culture/ identity, and public facilities. The stakeholders also shared their opinions on policy priorities, community engagement strategies, and long-term visions that should be incorporated into the comprehensive plan update. The data gathered from these interviews will inform later phases of the planning process to ensure that the comprehensive plan will be an expression of the needs and desires of Walla Walla's residents and institutions.

Appendix VII Table 1. List of Interviewees

Organization	Title	Date of Interview
Walla Walla Valley Chamber of Commerce	Executive Director	30-Jan
City of Walla Walla	Mayor	4-Feb
Walla Walla Public Schools	Superintendent	28-Jan
Walla Walla Community Council	Executive Director	29-Jan
Walla Walla Community College	President	28-Jan
Blue Mountain Action Council	Executive Director	29-Jan
Providence St Mary Medical Center	Senior Manager, Community Health Investment	30-Jan
Port of Walla Walla	Executive Director	6-Feb
Bicycle and Pedestrian Advisory Committee	Chair	28-Jan
City of Walla Walla	Councilmember	29-Jan
Walla Walla Valley Chamber of Commerce	Executive Director	30-Jan
City of Walla Walla	Councilmember	28-Jan
Walla Walla Alliance for the Homeless	Executive Director	29-Jan
City of Walla Walla	Mayor Pro Tempore	30-Jan

Tri-State Steelheaders	Executive Director	29-Jan
Historic Preservation Commission	Chair	28-Jan
Walla Walla Realtors Association	President	4-Feb
Tarragon Northwest	President	4-Feb
Valley Transit	General Manager	28-Jan
Washington Trust for Historic Preservation	Chair	28-Jan
Walla Walla Immigrant Rights Coalition	Executive Director	6-Feb

Housing Key Takeaways

The feedback from interviewees showed that the most urgent concern in Walla Walla is housing. Participants felt that there is a dire shortage of housing, including student rentals, workforce housing, and affordable housing. Affordable housing is of particular concern to college graduates, first-time buyers, and low-income residents. Home prices and rent hikes have led to people living in inappropriate circumstances, including garages and cars. Homelessness prevention services are also increasingly needed, with special needs for pet-friendly shelters and services to the Spanish-speaking community.

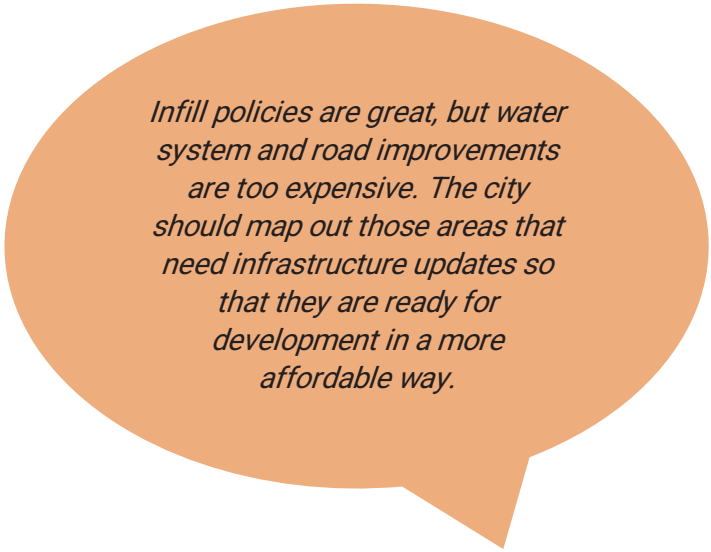
We don't have enough housing because we don't have a strong workforce; We can't attract the workforce because we don't have housing.

Challenges and Opportunities

- Housing is needed to attract more workforce.
- While Walla Walla has made improvements related to housing affordability and availability, relative to other towns, it is still not meeting the entire housing needs. The city has promoted higher density but has a strong Not in My Backyard (NIMBY) mentality among residents that generates mixed responses.
- Marketing and communication of the benefits of density and infill in the city has not been successful, and this has generated resistance from the population. Some view city policies as deterrents to growth, particularly developments involving annexation.
- There is a need for multi-family housing within city limits, but some believe it is discouraged by development policies and high infrastructure costs. Others suggest combining multi-family housing within historic districts to balance growth with the preservation of Walla Walla's character.
- Regulatory and zoning barriers also contribute to the housing crisis. Fewer building permits are being granted, and the high cost of water and street improvements make construction expensive.
- Another concern raised was the increasing gap in housing affordability, which makes it difficult for young and first-time families to enter the market. Housing costs have increased faster than wages, and this has forced many workers to live outside Walla Walla. Retirees who relocate from California and Seattle often pay cash for higher-end

homes, which further drives up prices. This process makes it difficult for many of the younger citizens to afford decent housing.

- Developers prefer to build single-family homes on large lots, but these are not always affordable, nor do they always meet demands. Annexing new land for housing is complicated by the expense of infrastructure.
- There is a need for more specific definitions and policies that relate to affordable housing.
- Other stakeholders who were interviewed feel that adding tax incentives and streamlining the permit process would be more effective in supporting affordable housing growth, particularly middle housing, and starter houses.
- Also on the horizon is the growing call for policies to regulate short-term rentals like Airbnb's to prevent "residential deserts" and keep long-term housing within reach. Loosening up multi-family zoning and encouraging garden-style developments would relieve the pressure. There is a call for additional permanent supportive housing (PSH) to aid the homeless. Walla Walla Housing Authority is currently constructing a 55-unit PSH facility.
- Infrastructure improvements would bring new development opportunities, particularly along the roads.
- Greater cooperation among developers, city government officials, and industries is needed to address the housing shortage effectively.



Transportation Key Takeaways

Transportation comments during the orientation interview both indicate positive trends and ongoing challenges within the region. Valley Transit was viewed as doing well with strong efforts to improve roads and increase public transport. Participants felt that the major improvements to infrastructure and completion of U.S. 12 to facilitate access to the Tri-Cities should improve the flow of vehicles. Air travel opportunities remain limited to two flights per day in and out of Walla Walla. Community members would prefer to see additional flights or another airline to increase travel opportunities because the closest alternate airport at Pasco is 50 miles away. Attempts to continue the service of Alaska Airlines in Walla Walla have been made, with community stakeholders playing a large role in continuing service.

Would love to see more daily flights to/from other major airports.

Traffic calming needed in high-speed areas like 9th Street

Challenges and Opportunities

- Availability of healthcare is also a major transport concern, as residents who need specialist healthcare services need to travel to the Tri-Cities or the City of Spokane. While organizations like People for People aid in the provision of transport, existing bus services, such as the one from Walla Walla to the Tri-Cities are not efficient and could take the entire day to make the return journey.
- There was support for extending infrastructure, such as the Myra Road extension, to accommodate growth while preserving agricultural lands and scenic views.
- Several of the participants emphasized the need for better public transport to eliminate the use of automobiles and address traffic. Specific needs include traffic calming in high-speed areas like 9th Avenue and more pedestrianized street closures within the downtown area. There is also a need for safer bike and pedestrian infrastructure.
- Feedback from some of the interviewees showed that the move towards sustainable transport is appreciated, and some public transport agencies are already investing in electric buses. However, Walla Walla still does not have charging infrastructure for electric vehicles.
- While roads have seen significant improvement, certain areas still need to be worked on, particularly as the city seeks to modernize infrastructure systems that are over a century old.

Economic Development Key Takeaways

Recruitment and retainment of the workforce needs to be the top priority.

The economic development feedback from the orientation interviews highlights the strengths and challenges of the economy of Walla Walla. Participants felt that while the region wasn't suffering from high unemployment, it still did not have the workforce to sustain large-scale manufacturing or industry employment. The economy is built on small businesses, entrepreneurship, and recruiting professionals to live in the region to take advantage of the high quality of life, which was seen as a key strategy for success.

- Participants believed that the economy needs family-wage jobs to sustain economic stability, but the employment that is offered, particularly in retail and tourism industries, does not meet that threshold. The wine industry has been the economic

force that has driven economic growth, redeveloped downtown, and helped to provide tourism opportunities. However, over-reliance on the industry is of concern. Diversification is needed to sustain the economy, particularly with seasonal challenges like inclement weather that affects agriculture and tourism.

Attracting new businesses and jobs is key to making Walla Walla more self-sustaining.

- A major barrier to economic growth is housing, making it difficult to attract and retain workers. While Walla Walla is gaining higher-income residents, young professionals and families are constrained by the issues of employment and affordability. Most college-educated workers want to stay in the area but leave due to the lack of employment opportunities. There are also employment shortages in the middle range, with a large gap between the low- and high-income levels.
- Concern that there is a shortage of skilled tradespeople, healthcare professionals, and middle management, and recruitment and retention of workers are issues.
- Economic growth is also impacted by infrastructure. More public transportation is required, along with more retail opportunities to keep residents from shopping in the Tri-Cities, and more co-working spaces to attract remote workers and tech professionals to the district. Downtown is described as quaint and tourist-oriented but is considered to be parking-constrained.
- Childcare is also a significant barrier, with not nearly enough affordable options to enable parents to fully participate in the workforce. A modification of the rules on in-home daycare businesses would mitigate this barrier.
- The Port of Walla Walla is an economic driver, but participants felt the City could collaborate with the Port and Chamber of Commerce to address business recruitment and local needs.
- Energy production is looming on the horizon as a growth industry, and the possibility exists to utilize inexpensive energy to attract Western Washington businesses.

Facilities Key Takeaways

The comments on facilities from the orientation interview reflect both the strengths and challenges of Walla Walla's community services and infrastructure. Walla Walla has a high level of support from the public for the schools that are served by excellent, well-maintained facilities.

- Whitman College and the community college contribute to the vitality of the area, providing educational opportunities and community engagement.
- Recreation facilities such as the YMCA, the gyms, the parks, and the art programs are in good health, and the airport is becoming increasingly busy, although flights to more destinations would be desired.
- Healthcare access is of concern. The town now only has one remaining hospital after another facility closed in 2018, and the stability of Providence St. Mary Medical Center the delivery of adequate medical services are questioned.
- Physicians are hard to hire, and many residents are required to travel to the Tri-Cities to access specialized services such as dermatology. Healthcare delivery in Walla Walla is described as unstable. There is also a recognized need within the City for a detox center to treat residents struggling with addiction.
- Other infrastructure concerns include insufficient wastewater treatment capacity, which could pose a challenge in attracting new businesses.
- While the City facilities are generally in good shape, the ability to sustain and build on essential services, particularly healthcare, is a concern to citizens.
- Coordination among the sectors could be required to enable facility development, such as the creation of art and community space, and the more pressing need to enhance access to healthcare in Walla Walla.

Parks and Recreation Key Takeaways

Walla Walla's parks system is both positively and critically reviewed. The city's park system is well developed, yet primarily sport-focused, resulting in a lack of areas of nature to observe wildlife and enjoy passive recreation. Recent additions, however, such as Heritage Square, which opened in early 2024, and Walawála Plaza, have been well-received, and public opinion is highly in favor of continued investment in parks and open space.

- The key improvements that were suggested by interviewees include better lighting in parks to provide greater safety.
- Other improvements suggested include the maintenance of walking paths and facilities well-interconnected to provide accessibility and the installation of a splash pad to provide additional family-friendly recreation. Such improvements would help to balance the parks system and be inclusive to address a wider range of community needs.

Culture and Identity Key Takeaways

The conversation about culture and identity in Walla Walla during the interview was centered on rich history, shifting demographics, and the need for increased representation. Walla Walla is culturally rich, yet concerns were raised regarding the way its history is represented. Additionally, public art and cultural icons in downtown Walla Walla do not necessarily reflect the full cultural history because there is little representation of the area's Hispanic, Native American, and migrant groups.

"Walla Walla has a plethora of art opportunities. It is a very talented community – that should be recognized and celebrated."

- The Hispanic population has grown immensely, with nearly one-quarter of the population. Solutions include greater interaction with the Latino population, having translators attend public hearings, and ensuring that their voices are heard when decisions are being made.
- Historic preservation remains a priority, and the wine and wheat industries remain the defining features of Walla Walla. The City is built as a tourist hub centered on wine, with concerns that it is becoming a monoculture that is obscuring its agricultural and tribal history. Many feel that more needs to be done to honor the region's tribal history, including placing educational signs in public areas and providing a stronger voice to the stories of migrants and Latinx populations.
- The city has cultural strengths. The Walla Walla Creative District fosters artistic innovation and multicultural events, and the library has received praise for its multicultural programming. Going forward, it will be important to make sure that Walla Walla's cultural identity reflects its multicultural population while still preserving its historic character in a way that will create a more representative, stronger future.

General Takeaways

This section represents general takeaways from the Walla Walla stakeholder interviews. These comments reflect a community that is collaborative, tightly knit, and deeply invested in preserving its quality of life while facing significant challenges. While the city is engaged in regional efforts and boasts a healthy volunteer population, demographic issues include an aging population, low birth rates, and dwindling students in the school system.

- Participants noted economic disparities with low-income areas having no internet access and a growing need for multicultural and bilingual providers. Housing affordability and the lack of availability of childcare and early education facilities are other issues confronting new families.
- Some felt growth has been sporadic, partly because of a culture of resistance to change on the part of long-term residents, particularly in agricultural areas, where maintaining productive land is paramount.
- Water preservation is an emerging issue, with creeks drying up and watershed management problems impacting wildlife.
- The city has developed culturally and recreationally, with restaurants, arts, and outdoor recreation improved, but industrial and economic development remains a challenge.

- Though the local economy has been buffered from major downturns due to its foundation in federal employment, there are still concerns regarding the long-term sustainability of industries, particularly tourism and higher education.
- Another concern centered on the lack of coordination among organizations within Walla Walla. Better outreach, involvement of respected community leaders, and greater ease of access to public information are some of the recommendations to address this lack of coordination. Walla Walla can address these issues as part of its collaborative nature so that it has a sustainable and inclusive future.

Written Comments

The city received several written comments from community members throughout 2025 as part of the Comprehensive Plan update process. These comments reflected interest in staying informed and involved, while also raising ideas and concerns related to housing, redevelopment, downtown parking, economic development, noise, air quality, and overall quality of life. Together, they offered helpful input on both community priorities and issues residents would like the plan to address.

City-Led Presentations

City staff led a series of presentations and briefings throughout the planning process to share updates, gather input, and keep decision-makers and the community informed. Early efforts focused on project kickoff and coordination with the Planning Commission and City Council, followed by regular workshops and a joint work session to review progress and draft materials.

Additional presentations were conducted with community groups, local organizations, and partner agencies, including service clubs, the development community, schools, and regional stakeholders. Targeted coordination included outreach to tribal governments, state agencies, and local organizations to share drafts and invite feedback.

Overall, these city-led efforts helped maintain consistent communication, expand participation, and ensure the plan reflects a wide range of perspectives.

Below are the groups that were presented to and shared input:

- Planning Commission
- City Council Orientation Interviews
- SEATech Skills Center
- Return to the River
- West Ward Town Hall
- Windermere
- City Leadership Team
- Hayden Homes
- Rotary Club of Walla Walla
- Walla Walla Sunrise Rotary
- Walla Walla High School Latino Club
- Walla Walla Senior Center
- Confederated Tribes of the Umatilla Indian Reservation
- Nez Perce Tribe
- Confederated Tribes of the Coville Reservation
- The Confederated Tribes and Bands of the Yakama Reservation
- Valley Transit

Open House Engagement Summary

Introduction

Event: City of Walla Walla Comp Plan Update: Open House

Date/Time: Thursday, July 10, 2025, from 4:30-6:30 p.m.

Location: Walla Walla Public Library
238 E. Alder St.
Walla Walla, WA 99362

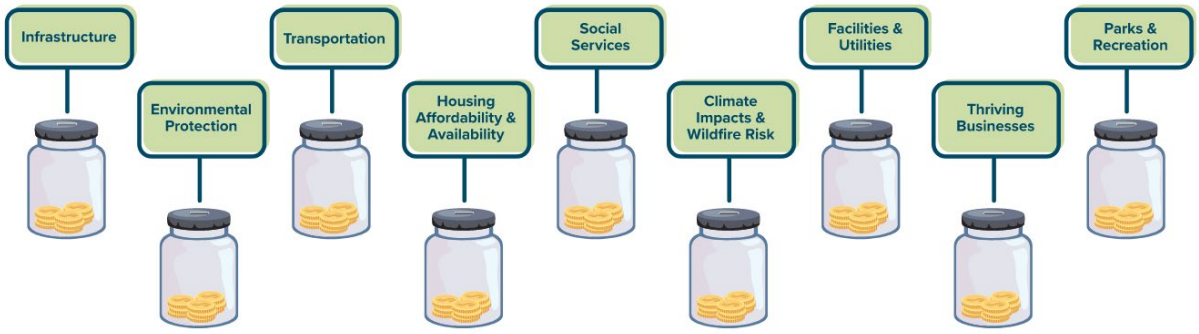


The City of Walla Walla held an open house on Thursday, July 10, 2025, from 4:30 p.m. to 6:30 p.m. at the Walla Walla Public Library, to share the comprehensive plan periodic update process with the community. The event provided an opportunity for the public to learn how the comprehensive plan guides decisions on growth, housing, transportation, land use, and other critical issues for the next 20 years. Survey and event flyers were made available in both English and Spanish to ease participation barriers and ensure broad participation from the community.

Attendees had the chance to watch a presentation about the update process and learn more about the timeline and opportunities for future involvement. This event was an important early opportunity to gather public feedback about community priorities. Participants were encouraged to share their ideas, concerns, and hopes for the future of Walla Walla. Three engagement activities were available to help collect input and better understand the values and vision of residents.

Activities

Activity One: Penny Poll – Community Priorities



Attendees participated in a "penny poll" to express what they value most for the future of Walla Walla. Nine jars were labeled with different aspects of the community, and each person was given three pennies to allocate toward the areas they felt were most important to focus on throughout the comprehensive plan update. This interactive activity gave residents a simple and visual way to prioritize local issues and opportunities. The distribution of pennies helped highlight which topics matter most to the community and will inform how the comprehensive plan update reflects local needs and aspirations.

The categories included: Social Service, Climate Impacts and Wildfire Risks, Thriving Businesses, Infrastructure, Parks and Recreation, Environmental Protection, Facilities and Utilities, Transportation, and Affordable Housing and Housing Availability.

Community Priorities (Based on Number of Coins)

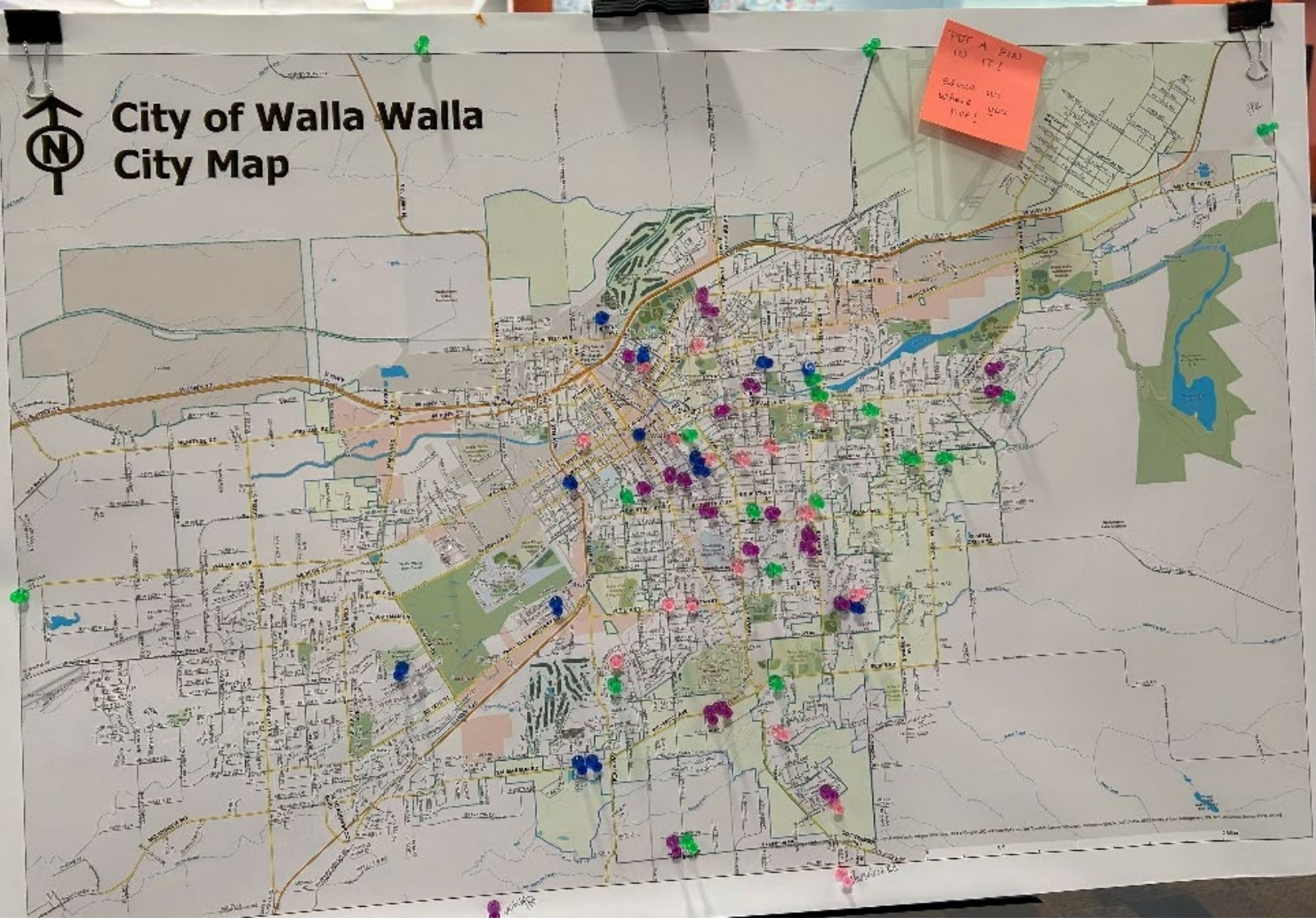
1) **Affordable Housing & Availability:** 62 coins
    a. *Note: Concern about skyrocketing housing prices; question raised about whether real estate speculation is contributing.*
2) **Social Services:** 34 coins
3) **Thriving Businesses:** 28 coins
    a. *Note: Suggestion to repurpose an old business building for indoor recreational activities across all age groups (e.g., pétanque, cornhole, pickleball, bowling).*
4) **Environmental Protection:** 25 coins
5) **Climate Impacts and Wildfire Risks:** 23 coins
6) **Parks and Recreation:** 23 coins
7) **Infrastructure:** 20 coins
8) **Transportation:** 17 coins
9) **Facilities and Utilities:** 8 coins

There was a total of **243 votes cast,** which means there were about **81 participants in 2 hours**.

The penny poll results from the July 10 Open House show that affordable housing is the community's top concern by a significant margin. Residents expressed frustration over rapidly rising housing prices and questioned whether real estate speculation is contributing to the trend. Social services, thriving businesses, and environmental protection also ranked highly, reflecting strong interest in community well-being and long-term resilience. One suggestion called for repurposing an old business building into an indoor recreational space for all ages. Additional feedback included concern for animal welfare and a desire for inclusive, accessible community services and infrastructure.







Activity Two: Community Map Displays

Along the perimeter of the event space, a series of large-format maps displayed key information about the Walla Walla community. Topics included economic activity areas, zoning, the comprehensive land use map, wetlands and surface water, the water distribution system, tree canopy and urban heat severity, the transportation plan, community facilities, and street classifications. Participants were encouraged to engage directly with the maps by adding sticky notes with comments, questions, and ideas. One particularly popular feature was located at the welcome table alongside snacks and the event sign-in sheet, which invited attendees to “Put a pin in it!” by placing a marker on a city map to show where they live and helped to visualize the geographic distribution of community input. Participants indicated they lived throughout Walla Walla, with representation from all parts of the city. There was a slightly higher concentration of participants from the downtown area and nearby neighborhoods.

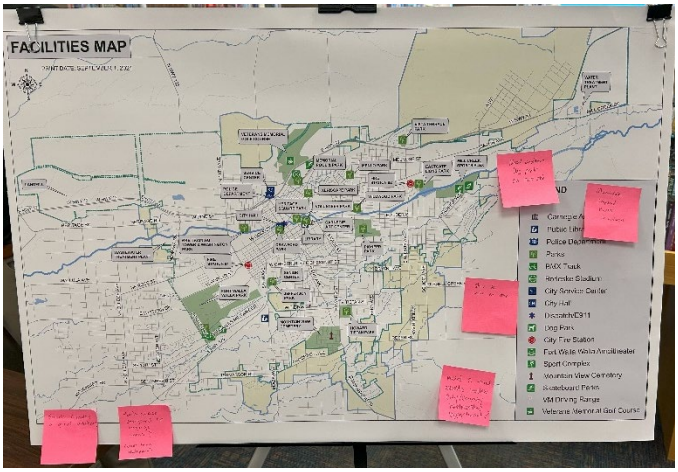
Engagement at this station was strong, with many thoughtful sticky notes submitted by the end of the event. All feedback gathered from the map displays has been collected and organized by topic. These comments are included at the end of this summary document to inform the Comprehensive Plan update and ensure that community voices are reflected in each thematic area.



Capital Facilities

“Sports Complex a great addition!”

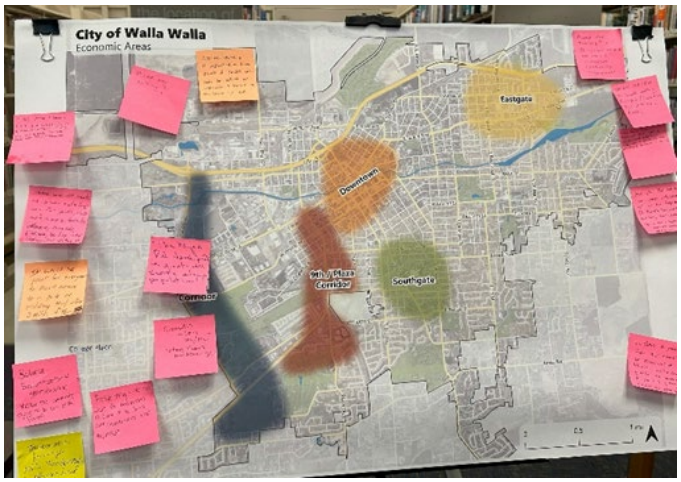
Community members expressed appreciation for existing investments, especially the sports complex, and proposed new capital projects to enhance services and amenities. Suggestions included developing an events center in partnership with the county, adding another park on the east side of the city, establishing a municipal animal impound facility, and ensuring water system infrastructure is accurately represented on maps.



Economic Development

*“Balance: Beautification & gentrification. *Allow the community there to be part of the process.”*

Participants emphasized the importance of diversifying Walla Walla’s economy beyond tourism and hospitality, supporting local businesses, and increasing access to services. Concerns about car dependency, mixed-use zoning, equitable development, and shelter for unhoused residents surfaced throughout. Many comments highlighted the need for walkable neighborhoods, indoor recreation spaces, and leveraging underutilized buildings for community benefit.



Environment / Shoreline / Climate Element

"No more development south of town."

Comments focused on urban tree canopy, equitable greening efforts, and questions around environmental planning tools like the Shoreline Master Program. Residents supported public-private partnerships for tree planting and expressed interest in integrating recreational and environmental enhancements, such as adding food trucks or sports areas at key sites. Some called for clarification on stream setback policies and Urban Growth Area (UGA) boundaries.



Housing

"Use empty buildings for affordable housing."

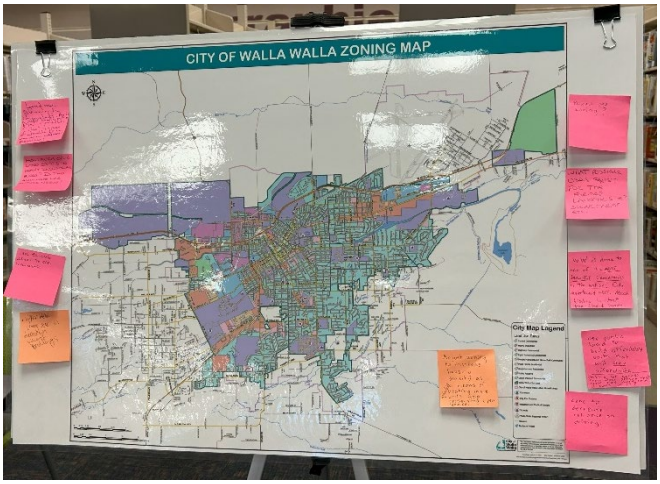
Housing concerns expressed by participants were wide-ranging and indicated a sense of urgency. Community members called for more affordable housing, especially for workers, seniors, and the unhoused. They suggested density increases, protections against corporate ownership, the use of public or vacant buildings, and a diversity of housing types to accommodate residents. There were also questions about who is driving new development and whether it reflects local income levels. Several participants stressed the importance of planning for infrastructure alongside housing growth.



Land Use

"Zone to decrease reliance on driving."

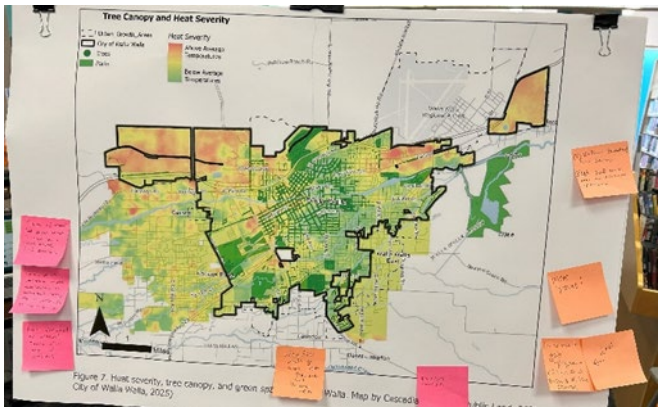
Land use comments showed concern about sprawl, equity, and planning transparency. Suggestions included expanding the UGA responsibly, preventing southside overdevelopment, encouraging infill, and considering land use impacts on transportation and affordability. Several comments advocated for mixed-use zoning, adaptive reuse of vacant buildings, and the use of public land for permanent affordable housing



Parks and Recreation

"More parks!"

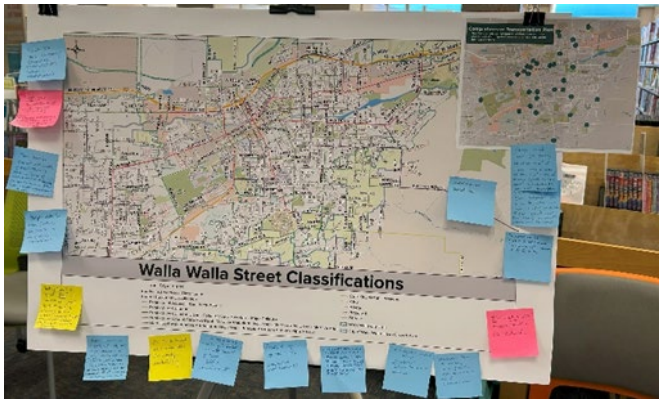
Feedback in this category is centered on the need for more parks and inclusive recreation opportunities, particularly for teens who are not drawn to traditional sports. Several participants voiced support for improving access to parks and trails, ideally within walking distance from neighborhoods, as a basic amenity for all residents.



Transportation

"Love the roundabouts at high traffic areas."

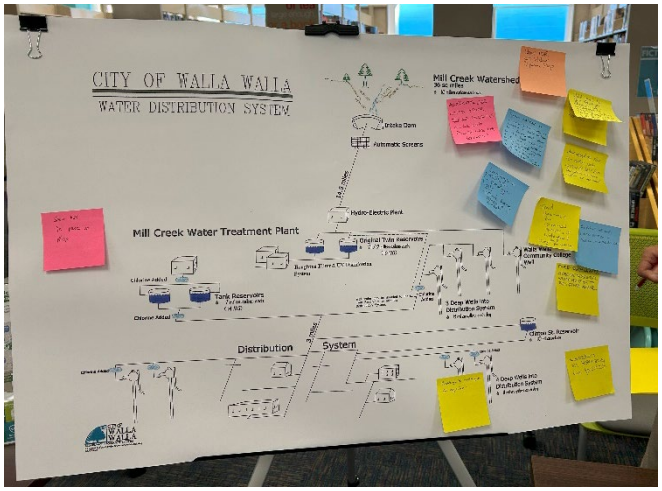
Transportation feedback reflected concerns about safety, access, and system efficiency. Suggestions included more sidewalks, roundabouts, bus and Dial-a-Ride service improvements, and better education on how to use traffic circles. Speeding, poor striping, and intersection design were also cited as community priorities. Equity was a recurring theme, with comments highlighting gaps in service for lower-income areas and calling for more trees and infrastructure investment across all neighborhoods.



Utilities

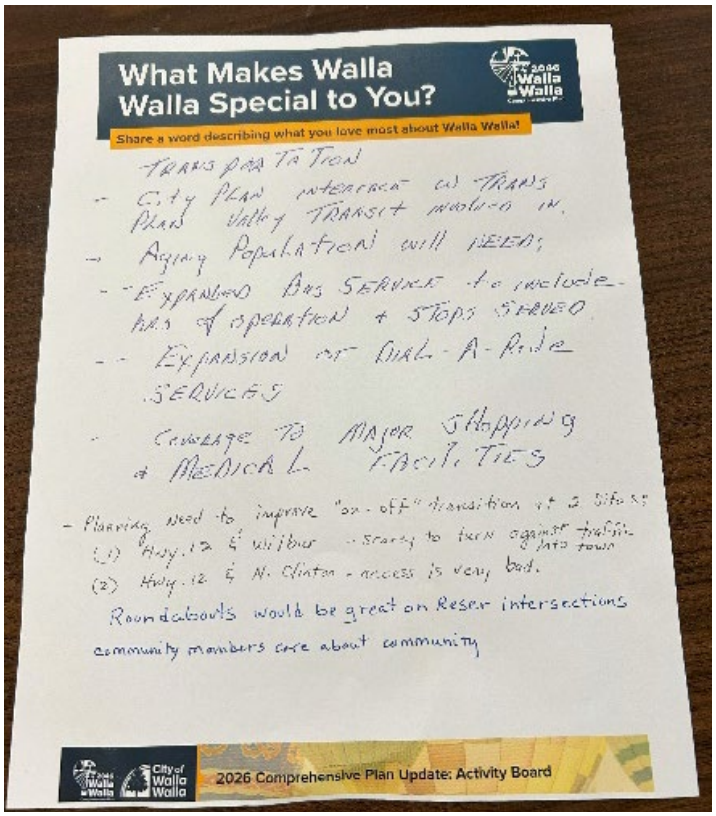
So proud of our water system & replenishing the aquifer."

Residents voiced strong support for the local water system and aquifer recharge efforts, with several expressing pride in existing projects. Suggestions included reducing residential water pressure, investing in system resilience, and planning for long-term water availability. There were also calls to preserve farmland, avoid waste, and ensure utility infrastructure keeps pace with development.



Activity Three: What Makes Walla Walla Special to You?

In addition to the interactive displays and penny poll, participants were invited to provide open-ended feedback by responding to the prompt: “Share a word describing what you love most about Walla Walla!” While some shared simple reflections, many used this opportunity to ask questions, offer specific suggestions, or highlight aspects of the community they value.



Responses were grouped by topic, with the full list provided at the end of this summary to help guide future planning decisions. The three main themes that emerged are:

Top 3 Themes

1) **Expand affordable and diverse housing** by increasing supply, protecting existing affordable options, and offering choices that meet the needs of different income levels and life stages.
2) **Encourage mixed-use development** that blends housing with retail or services while maintaining neighborhood character.
3) **Improve transportation access and safety** through expanded transit service, safer highway connections, and better intersection design.

Summary of Public Comments

Below are the full narrative responses received on sticky notes associated with the map display activity.

Capital Facilities

- Sports complex a great addition!
- Need a true events center city/ county partnership opportunity?
- Show ASR wells on the map
- Municipal impound facility for animals
- Need another Dos park on the east side

Economic Development

- Economic diversity is imperative to future growth and success. We won’t be reliant on hospitality & tourism to the level we are.

- This map shows why Walla Walla is a car-centric city. Not walkable to take care of daily needs.
- Where can we create an indoor activities area for youth, adults, and seniors? Activities: petanque, corn hole, pickleball, bowling, roller skating, ice skating, etc.
- Growth along Myra? Where should new homes go?
- Balance: Beautification + gentrification. Allow the community there to be a part of the process.
- Prospecting- Do not wait for businesses to come to us. Seek out opportunities and expansion.
- Mixed-use zoning? Decrease reliance on cars and increase community engagement.
- Do not continue to build south of Prospect/ Taumarson, move it to the east!
- This fails the popsicle test. That is can a child walk to a store, buy a popsicle, and go home before it melts?
- How can the town be more interconnected on the large scale. *(comment cut off in picture)*
- Is there a point when the goal of economic/biz district shifts from growth to maintaining or perhaps for-profit to growing... *(comment cut off in picture)*
- Include heat mitigation and non-car transportation in any expansion/ design.
- Indoor shelters. More shelters
- Tax breaks for small developers/less than 6 units *("seconded" by another participant)*
- Schools? New for
- health or people is important in planning
- Want everyone involved.
- Empty building, why? Shelters! (see Canada)
- I have questions about a large vacant building. Is it possible to make them into homeless centers? They would be covered, heated, cooled, a place to give support.
- I feel all of these concerns would include a togetherness-based community
- Why not have the ability to mix retail and housing? For example, a multi-story building with retail on the ground level. The only place I have seen that is on Rose where there is Mama Momacelli Bakery.
- I like that the added unit is in good proportion with the house. Sometimes the added unit... *(comment cut off in picture)*

Environment/Shoreline/Climate Element

- Increase canopy.
- Enhanced golf program at vets and events of the course. *("seconded" by another participant)*
- Why does clala go into UGA on the east and the South UGA
- public - private partnerships to plant trees/vegetation on business-owned property, esp. if the public right of way is lacking.
- Engage with home/landowners to partner to plant trees on private property. Avoid gentrification.
- Indoor basketball, Ice skating. Add a food truck area to Mill Creek Sportsplex. *(Comment was on the board at the environmental table)*
- What is the Shoreline master program?
- Why is the YellowhaWk creek setback 50' and every other stream (Mill Creek included) 35'?

Housing

- Housing: more development south N.E. Middle housing has ownership problems. Corporations own. Less autonomy. More multi-family housing
- More housing density- enough affordable housing for all who work here.
- More housing units overall, including for the working, poor, and the homeless.
- Affordable housing developed on with a long-term plan to keep housing affordable
- Multi-family housing in all neighborhoods tastefully developed!!
- More places for the homeless
- What's being planned to address rising rents? Is there a cap + incentives to achieve this?
- What protections exist to keep housing (esp affordable) locally owned? STRs, LTRs, corporate owners, etc.
- If extended affordable housing, where would go. (Comment was on the east side of the map)
- Use empty buildings for affordable housing
- Groups of 6? Tiny houses for seniors reduce loneliness. Centralized kitchen and conference room. Increase/maintain independence after downsizing family home.
- What's the plan for this planned community? *(comment was pointing at the map near Pine & Myra)*
- Who is buying the new housing in the developments when the median income is 58,000 and these new homes start around 350,000. Investors? Equity firms? Do we really need more housing developments?
- We need affordable housing so people (customers)(workers) can afford to live and purchase here. And have great lives!
- Affordable housing
- Protect manufactured home parks
- Townhouse style middle-income
- Single-level townhouse style low-income seniors
- We need affordable housing for all residents. Solve the scarcity problem.
- more multifamily units, including in existing neighborhoods
- We need more affordable housing + make sure intro.. Is built out to support new development. (roads, sewers..) *(comment cut off)*

Land Use

- Add Kendall Rd to the UGA. That is what should have been done 10 years ago.
- No more development south of town.
- Watershed and logging- where are we at with this? We would love a town hall-type opportunity.
- Who will provide affordable housing- the part industrial development.
- Mixed-use zoning?
- Land use planning is important. As is new housing priorities. Please consider "like" types of dwellings in an area whenever possible!
- How much open land exists in heavy industrial zones? Is it adequate for future needs?
- This zoning leads to car dependency
- Upper story development in downtown vacant buildings.
- Adjust zoning to increase housing density as a means of creating more affordable units and preserving open space.

- zone to decrease reliance on driving.
- Use public land to build affordable units that will stay affordable. Parking lot across from the post office that never has more than 3 cars in it?
- Walla Walla is home to one of the most beautiful cemeteries in the nation! City maintained well. Much history in that tree-shaded place.
- What possible uses exist for the former landfill site? Solar farm? Etc..
- Mixed zoning use
- How often is the UGA expanded/updated?

Parks and Recreation

- Park space designed to engage teens? (other than the skate park)
- more parks!
- Park designed to attract teens who are not athletes
- It would be great for everyone to have access to a park or walking trail within 3 miles of their home.

Transportation

- Aging population will need: Expanded bus service to include hrs of operation + stops served. Expansion of Dial - A- Ride services. Coverage to major shopping + medical facilities
- Planning needs to improve "on-off" transitions at 2 sites: 1) Hwy 12 & Wilber - scary to turn against traffic into town. 2) Hwy 12 & N. Clinton - Access very bad
- Roundabouts would be great on Reser intersections, community members care about the community.
- City Plan interface with the Trans Plan Valley Transit is involved in.
- South 3rd and Orchard/Cherokee intersection needs a roundabout.
- Love the roundabouts at high-traffic areas.
- Please prioritize sidewalks on every residential street.
- More trees in commercial areas, please. This is also an issue of environmental equity as lower-income folks live in more commercial areas
- People seem to need further education on navigating roundabouts.
- Valley transit is great, BUT it would be great to NOT have to always go through the transit center, transferring through there makes trips unnecessarily lengthy.
- Public transit is a gap, especially off major arteries/in more residential areas. Type diversity could increase (bus, dial a ride, etc.) Are there opportunities to ID community priorities for new stops?
- All streets should have sidewalks for safety & walkability.
- We are growing. Traffic gets backed up at Howard & Reser - add a roundabout.
- People driving too fast in the city. Wellington Ave + Middle Waitsburg Rd.
- Install flashing walk at Penrose and Isaacs. Provide regular info to the public about traffic circles. (How to Use!) Budget for residential street paving.
- Sidewalks needed along Blue St. Between Francis + Melrose.
- People are driving too fast - dangerous, need cameras.
- Bike routes with slower traffic. (see Portland)
- Developer should have paid for crossing (over Pan or ??) highway 12 at Division
- Sidewalks on School Ave

- Strips around town got poorly re-striped the last few weeks, and the hard work and money spent on the roads and sidewalks just went down the drain with the poor judgement on a couple who ran the striping machine. Please spend our tax money on quality people and machines.
- The Myra Rd development is great - will service a large population !!
- transportation: encourage public transportation to be efficient locally.
- Road designs have made WW less ambient and relaxed (poplar, rose)

Utilities

- Show ASR in procos on map
- Thank you for recharging the aquifer!
- education on watershed/fire tactics
- Forget green lawns! Decrease residential water pressure to the national average.
- So proud of our water system + replenishing the aquifer.
- Find reserves for concerned groups, ie. Watershed & forest practices.
- The house on 857 Wellington - ponding- check during a heavy rain event.
- Awesome job with your IRRP projects nice job plugging the leaks!
- System resilience as a priority for water is important + should continue as a focus. Forest mgmt in the west requires fire + the extent to which it can be introduced intentionally is preferred collab w/ CTUIR, Landowners, + anyone at highest risk of impact.
- We need to close the entire water system to loss & have the option for new water at the end. *(comment cut off)*
- Don't want to see any more farmland converted to housing. Who is buying the new houses?
- Show ASR on the water system map.

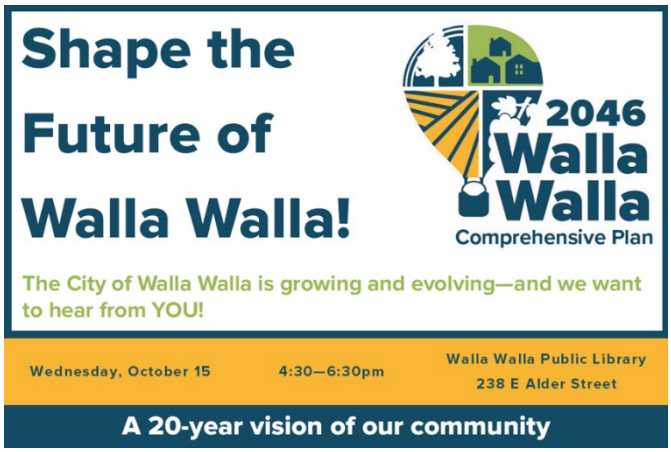
Fall Open House Engagement Summary

Introduction

Event: City of Walla Walla Comp Plan Update: Fall Open House

Date/Time: Wednesday, Oct. 15, 2025, from 4:30-6:30 p.m.

Location: Walla Walla Public Library 238 E. Alder St. Walla Walla, WA 99362



The City of Walla Walla held an open house on Wednesday, October 15, from 4:30 p.m. to 6:30 p.m. at the Walla Walla Public Library, to share the comprehensive plan periodic update process with the community. The event provided an opportunity for the public to learn how the comprehensive plan guides decisions on growth, housing, transportation, land use, and other critical issues for the next 20 years. All event materials were made available in both English and

Spanish to ease participation barriers and ensure broad participation from the community.

Attendees had the chance to hear a presentation about the update process and learn more about the timeline and opportunities for future involvement. This event was an important early opportunity to gather public feedback about community priorities. Participants were encouraged to share their ideas, concerns, and hopes for the future of Walla Walla. Three engagement activities were available to help collect input and better understand the values and vision of residents.

Community Priorities

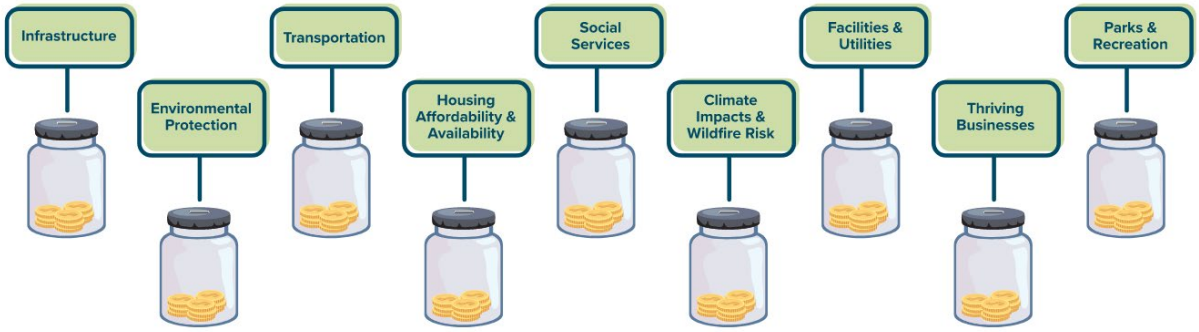
Community feedback from the Fall Open House revealed clear priorities. When both the penny poll results and written comments were considered together, housing affordability, transportation access, and parks and recreation emerged as the top three themes. These priorities highlight a shared community focus on improving affordability, mobility, and overall quality of life in Walla Walla.

Overall Top Three Themes:

1. Housing Affordability and Availability
2. Transportation Access and Safety
3. Parks, Recreation, and Open Space

Activities

Activity One: Penny Poll – Community Priorities



Attendees participated in a "penny poll" to express what they value most for the future of Walla Walla. Nine jars were labeled with different aspects of the community, and each participant was given nine pennies to allocate toward the areas they felt were most important to focus on throughout the comprehensive plan update. This interactive activity gave residents a simple and visual way to prioritize local issues and opportunities. The distribution of pennies helped highlight which topics matter most to the community and will inform how the comprehensive plan update reflects local needs and aspirations.

Community Priorities (Based on Number of Coins)

1. **Housing Affordability and Availability –** 25 coins
2. **Parks and Recreation –** 20 coins
3. **Climate Impacts and Wildfire Risks –** 19 coins
4. **Environmental Protection –** 18 coins
5. **Social Services –** 14 coins
6. **Transportation –** 13 coins
7. **Facilities and Utilities –** 13 coins
8. **Thriving Businesses –** 13 coins
9. **Infrastructure –** 12 coins

A total of **147 coins** were distributed during the activity, suggesting participation from **approximately 16 residents** over the course of the event.

The penny poll results show that housing affordability remains a leading community concern, with residents emphasizing the importance of accessible, attainable housing for all income levels. Parks, recreation, and environmental topics also ranked highly, highlighting the value residents place on outdoor spaces, natural resources, and climate resilience. The close grouping of several mid-ranking categories suggests that participants see many community needs as interconnected rather than isolated.





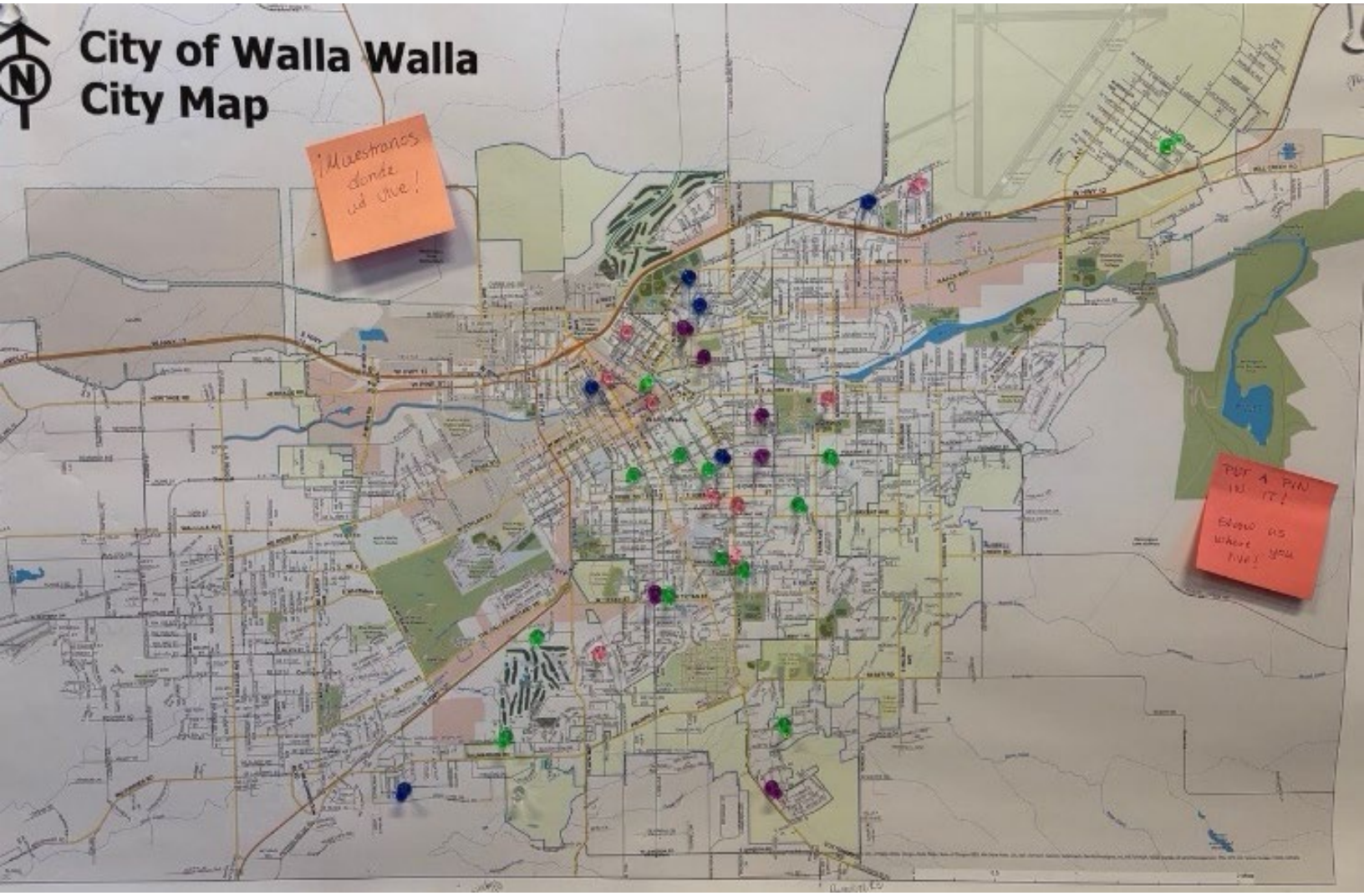


Activity Two: Community Map Displays

Along the perimeter of the event space, a series of large-format maps displayed key information about the Walla Walla community. Topics included economic activity areas, zoning, the comprehensive land use map, wetlands and surface water, the water distribution system, tree canopy and urban heat severity, the transportation plan, community facilities, and street classifications. Participants were encouraged to engage directly with the maps by adding sticky notes with comments, questions, and ideas. One particularly popular feature invited attendees to “Put a pin in it!” by placing a marker on a city map to show where they live, helping to visualize the geographic distribution of community input. Participants indicated they lived throughout Walla Walla, with representation from all parts of the city. There was a slightly higher concentration of participants from the downtown area and nearby neighborhoods.

Engagement at this station was strong, with many thoughtful sticky notes submitted by the end of the event. All feedback gathered from the map displays has been collected and organized by topic. These comments are included at the end of this summary document to inform the Comprehensive Plan update and ensure that community voices are reflected in each thematic area.

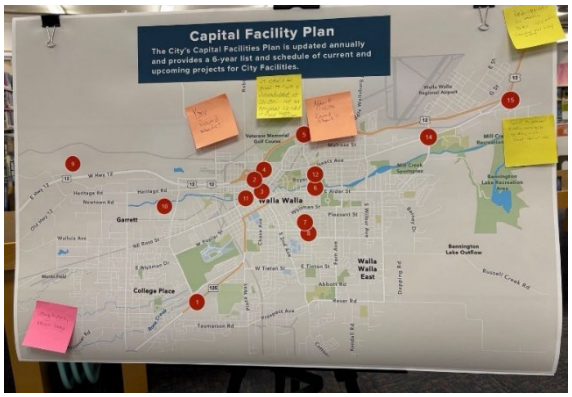
Map Display Feedback



At the open house event, community members shared their input through sticky notes placed on maps and displays, interactive stations, and open-ended prompts. All comments were reviewed and grouped by topic to reflect the full range of community perspectives. A summary of feedback, sorted by comprehensive plan category, is provided below.

Capital Facilities

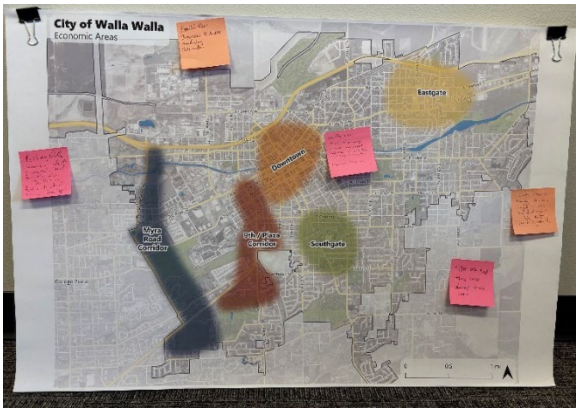
"Look into 'the end of the lines' success portal idea with a prototype incubator village!"



Community members emphasized the need for affordable and flexible housing options, with many suggesting small-scale, community-oriented solutions such as tiny home villages and modular units. There was also interest in creating spaces that combine housing, entrepreneurship, and neighborhood amenities, including ideas for year-round food truck pods and incubator-style villages. Several comments highlighted the value of improving the East Isaacs corridor to attract visitors and support local businesses.

Economic Development

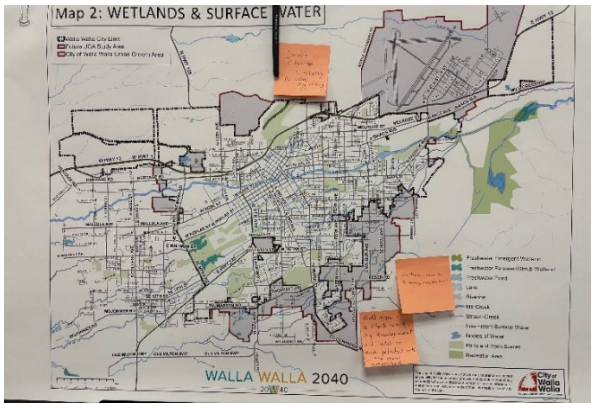
"Can there be a vacancy tax to encourage renting store fronts?"



Feedback focused on supporting both community well-being and local business vitality. Participants suggested initiatives that combine economic opportunity with social impact, such as mentoring programs for unhoused residents and strategies to reduce downtown vacancies. There was also interest in aligning agricultural and tourism efforts to showcase local products and heritage.

Environment/ Shoreline/Climate Element

"The South area is a flood zone - any development will add to flood potential within the entire watershed."

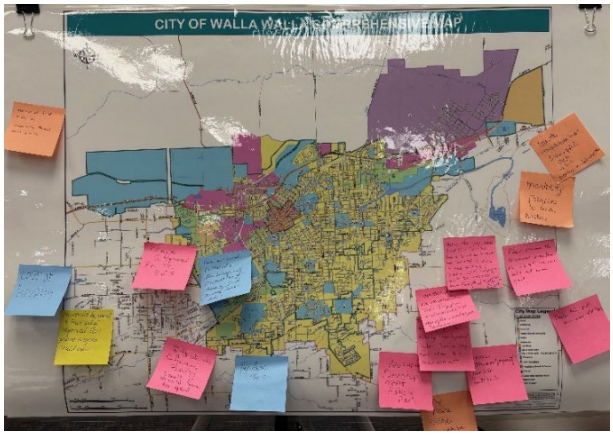


Participants expressed a strong interest in protecting floodplains, maintaining agricultural areas, and supporting environmentally sustainable practices. Several comments focused on reducing pollution, electrifying lawn equipment, and respecting watershed boundaries to minimize development impacts. Attendees also marked agreement with Climate Resilience policies that promote low-impact development, water efficiency, and habitat protection, indicating broad support for conservation and climate adaptation priorities.

Housing

"It would be great to have city-approved ADU plans anyone could use."

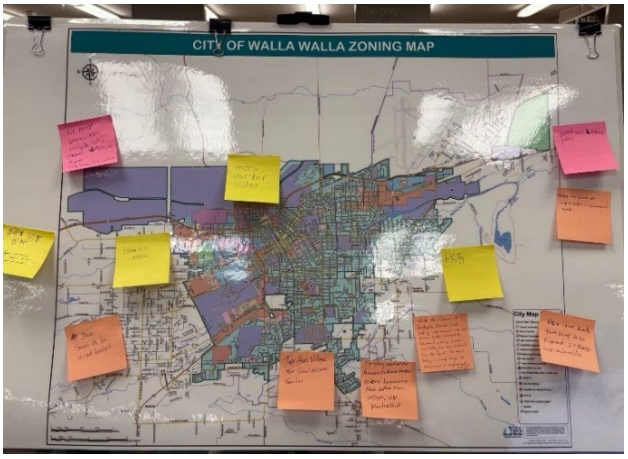
Comments centered on housing affordability, future growth areas, and the need for practical solutions to meet demand. Participants raised questions about how development in the South-Southeast area will align with infrastructure planning and expressed concern about the rising cost of housing. There was also interest in making it easier for residents to add accessory dwelling units (ADUs) through pre-approved design plans.



Land Use

"Please remove the Cottonwood area from the UGA! We need infill, not urban sprawl."

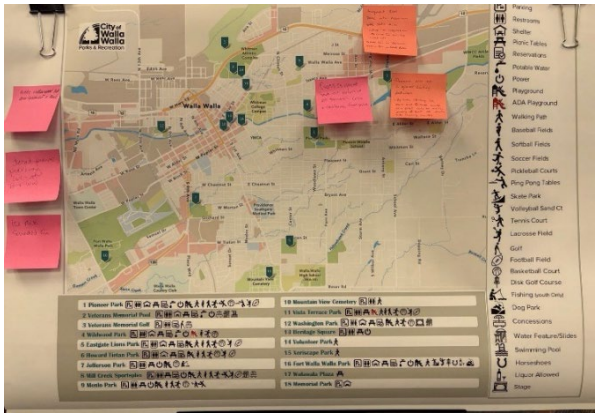
Participants voiced a strong preference for focusing growth within existing urban areas rather than expanding outward. Many comments called for removing the Cottonwood area from the Urban Growth Area (UGA) and prioritizing infill development, neighborhood-scale amenities, and mixed uses. Others raised issues of grocery access in South Walla Walla and the need for land use policies that support affordable housing and local employment opportunities.



Parks and Recreation

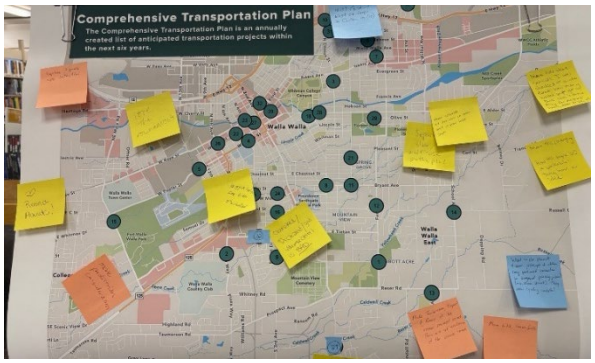
"Make Cottonwood Rd development a park!"

Feedback reflected broad community enthusiasm for recreation opportunities and open space. Many participants suggested creating new parks, trails, and bike facilities, with multiple comments supporting a park at the Cottonwood site and stronger trail connections along Mill Creek. Ideas also included developing cycling and mountain biking features, protecting existing hiking paths, and expanding amenities such as ice rinks and water slides to serve residents of all ages.



Transportation

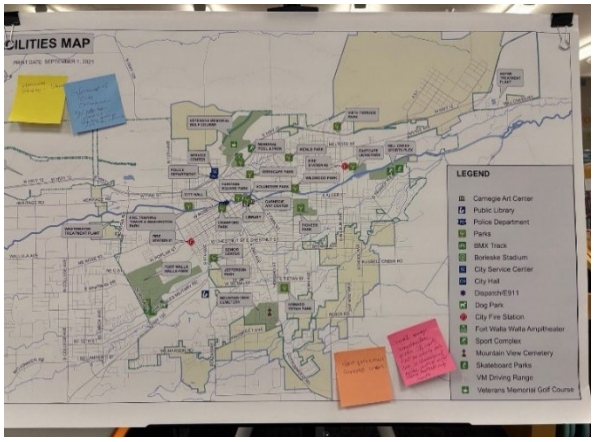
"Ped upgrades to match bike upgrades (upgrading bad sidewalks)."



Community members shared a mix of practical concerns and forward-looking ideas about the city's transportation network. Many comments focused on the need to repair existing roads and ensure new development aligns with infrastructure improvements. Roundabouts received strong support, along with calls for more bike lanes, pedestrian upgrades, and improved connections for public transit and rideshare services. Participants also highlighted the importance of traffic calming, EV charging, and better safety for cyclists and pedestrians.

Utilities

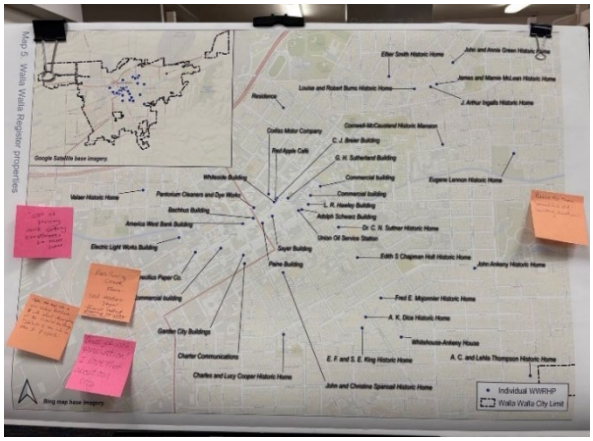
"Complete sewage infrastructure within City limits first so empty lots can be developed before putting infrastructure outside city limits."



Participants emphasized the importance of focusing infrastructure investments within city limits before extending service to surrounding areas. Several comments highlighted the need to complete sewer and water systems that would enable infill development and better use of existing vacant lots. The feedback reflected a broader desire to manage growth efficiently while maintaining reliable public utilities.

Historic Preservation

"Make this map into a WW history brochure & with short descriptions of the historical buildings."



Community members expressed pride in Walla Walla's historic character and encouraged continued preservation and reuse of existing structures. Several participants proposed creating educational materials to share the city's history, such as brochures and maps highlighting notable buildings. Others emphasized the importance of restoring and occupying vacant historic properties to maintain downtown vitality and celebrate the city's heritage.

Other

Targeting marked for businesses to rehab people. Mixed businesses teach better than colleges. Use mentorship."

These comments did not align with a single topic area but reflected a variety of individual perspectives and observations. Several participants discussed enforcement of local ordinances, while others emphasized the role of businesses in providing rehabilitation and job training opportunities. Feedback also reflected individual interest in city economic development efforts.



Summary of Public Comments

Below are the full narrative responses received on sticky notes associated with the map display activity.

Capital Facilities

- We need spaces for people who (make less than $50k?) a year tiny home/ RU/ modular
- Tiny home village - the end of the line
- Year-round food truck pod! Maybe using the Farmer's market pavilion
- Tiny house villages
- Look into "the end of the lines" success portal idea with a prototype incubator village
- Tiny house village for low-income families
- Beautify East Isaacs to encourage visitation and support businesses like Bike Barn, Livit, Green Lantern, etc. Lampposts, trees, etc

Economic Development

- Mentoring programs to teach the homeless
- Can there be a vacancy tax to encourage renting storefronts?
- Ross Spring Creek Farm- Old Milton Highway should reflect produce neighborhood tourism.

Environment/Shoreline/Climate Element

- Don't change anything no more ag. Areas
- The South area is a flood zone - any development will add to flood potential within the entire watershed
- Eliminate gas "so-called" leaf blowers. Reduce pollution and noise!
- Mandate electrifying all lawn equipment. No more 2-stroke engines.
- Grass is great, but its excessive at times - cost + carbon footprint
- Flood areas need to be respected. Don't develop in the water-sheds.
- No developments on South side w/o traffic improvement + aquifer recharge studies
- **1 checkmark next to CR 3.5** – Encourage new development and retrofits to pursue green building standards and explore incentives that prioritize low-impact development, sustainable design, climate-conscious materials, and environmentally friendly landscaping, especially for climate-impacted multifamily and low-income housing communities.
- **1 checkmark next to CR 3.6** – Continue efforts to enhance water use efficiency and upgrade water and wastewater infrastructure to better adapt to future climate conditions.
- **1 checkmark next to CR 4.1** – Prioritize the protection and restoration of critical habitats such as floodplains, wetlands, and riparian ecosystems and other critical areas to reduce the severity of climate impacts, support long-term ecosystem health, and improve climate adaptability.
- **1 checkmark next to CR 4.**5 – Promote local and regional conservation, open space, and land management planning efforts that explicitly consider and address climate change risks

Historic Preservation

- Make this map into a WW history brochure & with short descriptions of the historical buildings.
- Distribute @ WW info on Main St. & airport.
- Great job with preservation! I love that about our city.
- Please fill those beautiful old buildings downtown!
- Using historic, vacant buildings

Housing

- How do you see housing in the South-South East move to SR 125 & US 12 in the future? Where will improvement be needed? Are they tied to Capital Facilities and STIP?
- Cost of housing and selling employees to move here
- Cost of housing
- It would be great to have city-approved ADU plans anyone could use

Land Use

- Make the block at 228 E Poplar a commercial zone.
- With the closure of Southgate market (and taking into account the new market under construction Downtown), grocery access & availability has been reduced for the South & SW areas. Perhaps a zoning change to encourage a neighborhood market?
- Please remove the Cottonwood area from the UGA! We need infill, not urban sprawl.
- Remove Cottonwood from the U6
- I think the Cottonwood property should be removed from the UGA.
- Can we work to develop the neighborhood properties for housing, parks, (illegible), etc.
- Remove Cottonwood property from UGA. Build North.
- Don't piecemeal annexed areas
- Homeless area
- More space for low-income families
- Establish new businesses to the area of manufacturing. Intermodel.
- I'd like to see more infill to come- consolidation- we don't need sprawl.

Parks and Recreation

- Make Cottonwood Rd development a park
- Don't pave parking lot at Fort WW
- Ice rink sounded fun
- Promote WW as a gravel cycling destination
- Augment BMX park with mountain bike skills area: drop line progression; skinnies for balance; rock roll. Dutwie Hill in Issaquah, Family Man in Hood River
- Railway starting on Main and Palouse would be a great rails to trails, jumping off point to the North side cycling routes
- Buy unused parking lots and turn them into pocket parks
- Develop trails, public areas along Mill Creek
- No Cottonwood development make a park
- More warder (water?) slides

- Protect our hiking paths
- Big bike (with drawing of a bike on a road)

Transportation

- FIX the roads that need to be repaired. It damages our automobiles
- Improve transportation routes prior to allowing development rather than a long time after the development
- Repair our road, they cause damage to our cars
- Make Tamarason, Prospect & Reeser all the same named road. They are all sections of the same road.
- Yay roundabouts!
- It would be great to have a roundabout at Clinton - not an overpass. We need it fixed faster, cheaper.
- Alder & Division Round about?
- Ped upgrades to match bike upgrades (upgrading bad sidewalks)
- Speed mitigation/ traffic calming to go along with speed reductions
- Reduce signals w/o detection
- (heart) Roundabouts!
- Love the roundabouts
- More pedestrian consideration
- Trigger light for bikes 9th & Chestnut
- Cherokee/ Orchard/ 3rd intersection is BAD
- Must construct West onramp on Clinton to (12)
- Bike lane Cottonwood Rd
- More rideshare services. I was shocked at a wine event how many wasted people got in their cars & drove. Also for airport runs, older people, etc
- Ensure sidewalks are available in areas where we have bike lanes
- Separated bike/ multi-use paths, pls!
- More EV charging. Also tell people W2 is walkable! They have no idea!
- What to do about 4-door pickups + other long personal vehicles in diagonal parking places (e.g. Main Street). They make cycling unsafe!
- More bike lanes/ paths

Utilities

- Complete sewage infrastructure within City limits first, so empty lots can be developed before putting infrastructure outside city limits.

Other

- Homeless sleeping in the library
- PS5
- Rodney Outlaw cares about economic development. for the city- the part is for individual econ. develop.
- Enforcement of City Ordinance, e.g., Chalk man, homeless, smoking & drugs on city sidewalk
- Targeting marked for businesses to rehab people. Mixed businesses teach better than colleges. Use mentorship



Walla Walla Comprehensive Plan Survey and Mini Poll Results

Public Outreach Survey

The Walla Walla Comprehensive Plan Survey was open for 168 days and received 281 complete responses and 185 partial responses. Most respondents (71.9%) live in Walla Walla, with 42.7% residing in the West Ward and 28.6% in the Central Ward. Most participants (88.2%) live in single-family homes, and 85.1% are homeowners. All age groups were represented, with respondents aged 60-69 comprising the largest share (24.3%) and those aged 20-29 the smallest (6.5%). Most participants (76.5%) do not have dependent children living at home. Survey respondents were predominantly Caucasian/White (92.1%), with fewer than 5% identifying with other racial or ethnic groups. Nearly all respondents (95.7%) primarily speak English at home, while 3.5% most often speak Spanish.

Mini-Polls

To increase participation, a series of mini polls were also conducted in January and February 2026. Four mini polls—focused on community vision, community character, economic development, and housing—were released sequentially and remained open for one week each. Each poll received between 200 and 300 responses, for a total of 1,127 responses.

The data presented below reflects the combined results from the full survey and the mini polls. These results provide a comprehensive snapshot of community perspectives and will directly inform the direction of the Comprehensive Plan update.





Key Takeaways

Community Character

- The pace of life (23.4%), community identity (19.8%), and access to nature and green spaces (19.7%) are most important to respondents.
    - Write-ins emphasized affordability, public safety, parks and trails, a vibrant downtown, and maintaining a high quality of life while managing growth and preserving community character.
- Increased demand for services (19.4%), housing affordability (17.0%), and traffic congestion (16.2%) are the top growth concerns, followed by environmental impacts and loss of small-town character (15.5%).
    - Write-ins highlighted rising costs and taxes, loss of farmland, crime and homelessness, healthcare access, and concerns about both unmanaged growth and lack of growth.
- Desired industry expansion includes agriculture (19.6%), retail (18.6%), and healthcare (16.7%), with education also noted.
    - Write-ins called for economic diversification, including technology, skilled trades, healthcare specialties, arts, and family-oriented industries that provide living-wage jobs.
- Key priorities to retain young people include affordable housing (26.1%), jobs (20.5%), and local businesses (20.3%).
    - Write-ins emphasized better wages, lower cost of living, reduced barriers to development, expanded arts and entertainment, and more opportunities for young professionals.
- Business support priorities include amenities that attract business (17.2%), training programs (15.6%), and incubators (15.2%).
    - Write-ins focused on lower taxes, streamlined permitting, affordable commercial space, and addressing vacant storefronts and high downtown rents.
- Top park improvements include accessibility (14.3%) and natural areas and trails (13.8%), though 24.3% say current parks meet their needs.
    - Write-ins called for safer, cleaner parks, better connectivity, more shade and seating, and balancing new amenities with preservation of quieter spaces.

Community Vision

- The 2018 vision reflects Walla Walla “Well” (40.2%) or “Spot On” (15.9%) for most respondents.
- Top-aligned statements are preserving identity while adapting to change (29.1%) and inclusivity (21.3%).
- Least aligned are government transparency (21.8%) and inclusivity (19.7%), suggesting mixed perceptions.
- 78.5% say supporting locally owned businesses is very important, while 37.1% say the same for transportation access.

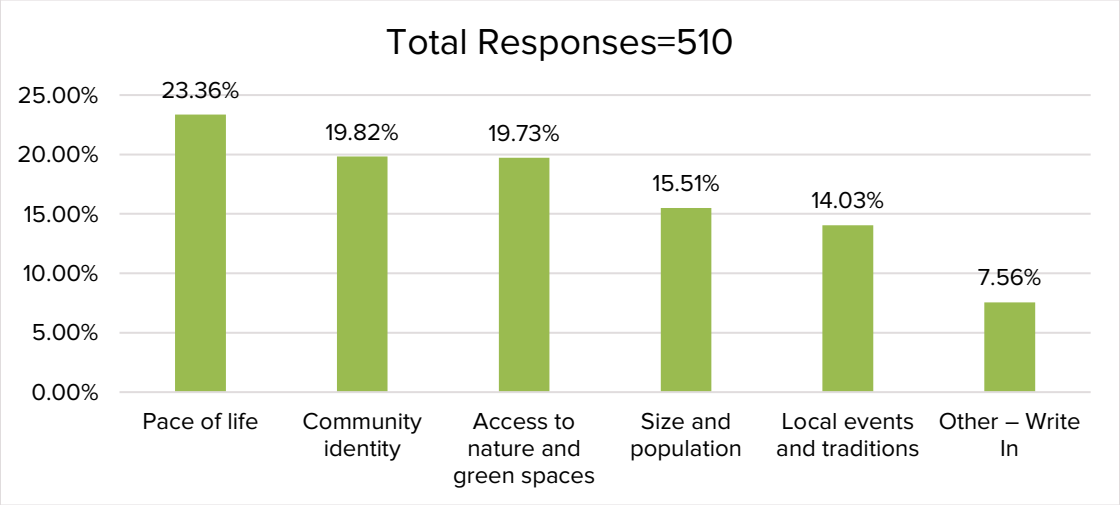
Housing in Walla Walla

- 65.0% have purchased a home; 31.2% have rented.

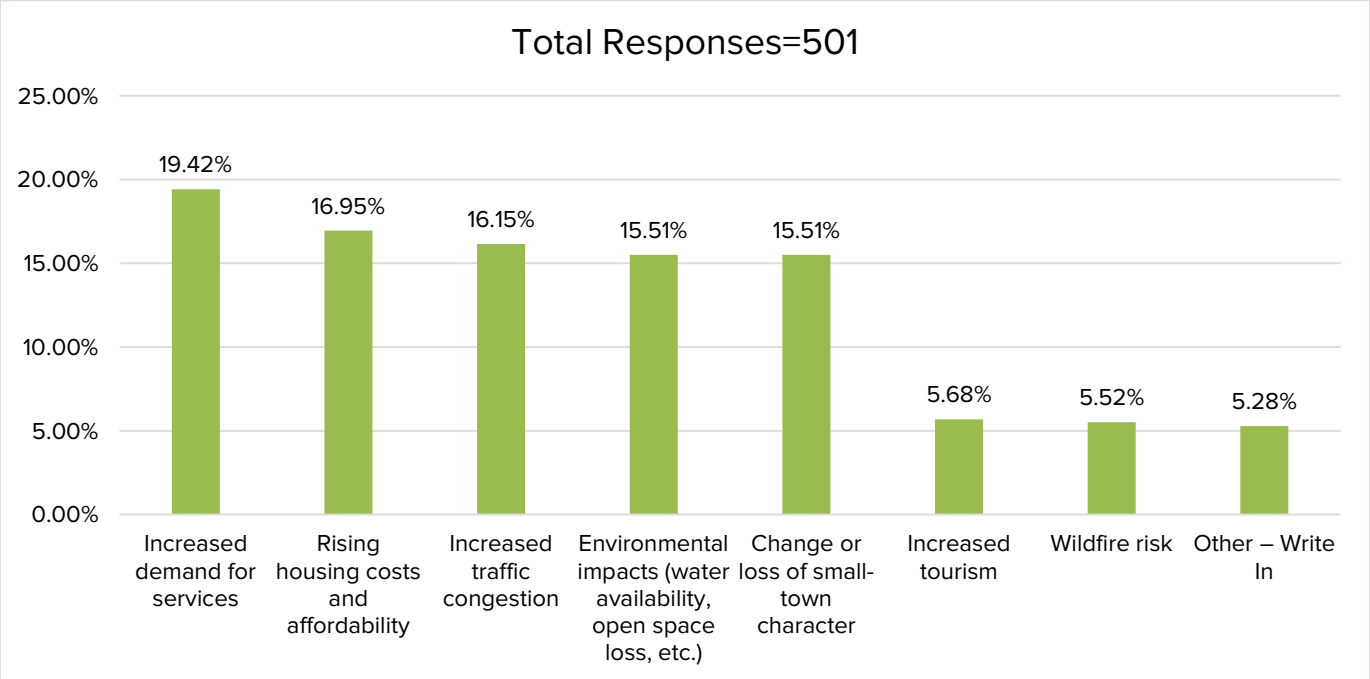
- Top rental challenges are finding housing (21.5%) and poor quality (17.5%).
    - Write-ins emphasized high costs, limited availability, and lack of suitable or pet-friendly options.
- Most respondents say there are not enough rental (62.5%) or ownership (68.7%) options for a range of incomes.
- Housing preferences are split: 31.0% support all housing types, while 29.5% prefer limiting growth in existing neighborhoods.
    - Write-ins cited high prices, limited supply, and regulatory barriers, with a need for more attainable housing options.



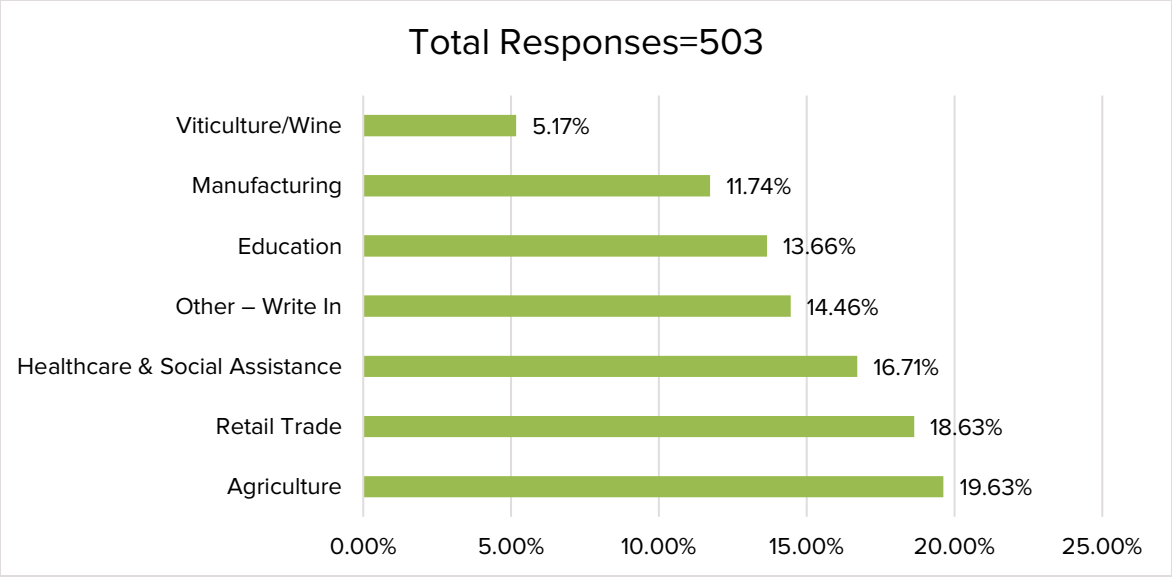
Survey Results



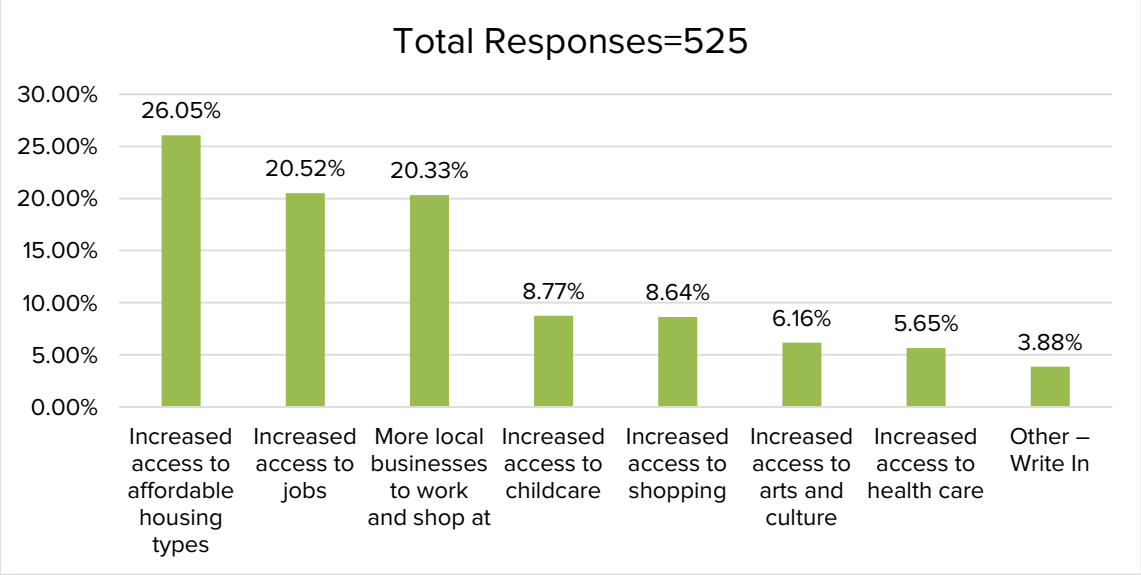
Appendix VII Figure 1. Which aspects of Walla Walla's atmosphere are most important to you? Select your top 2.



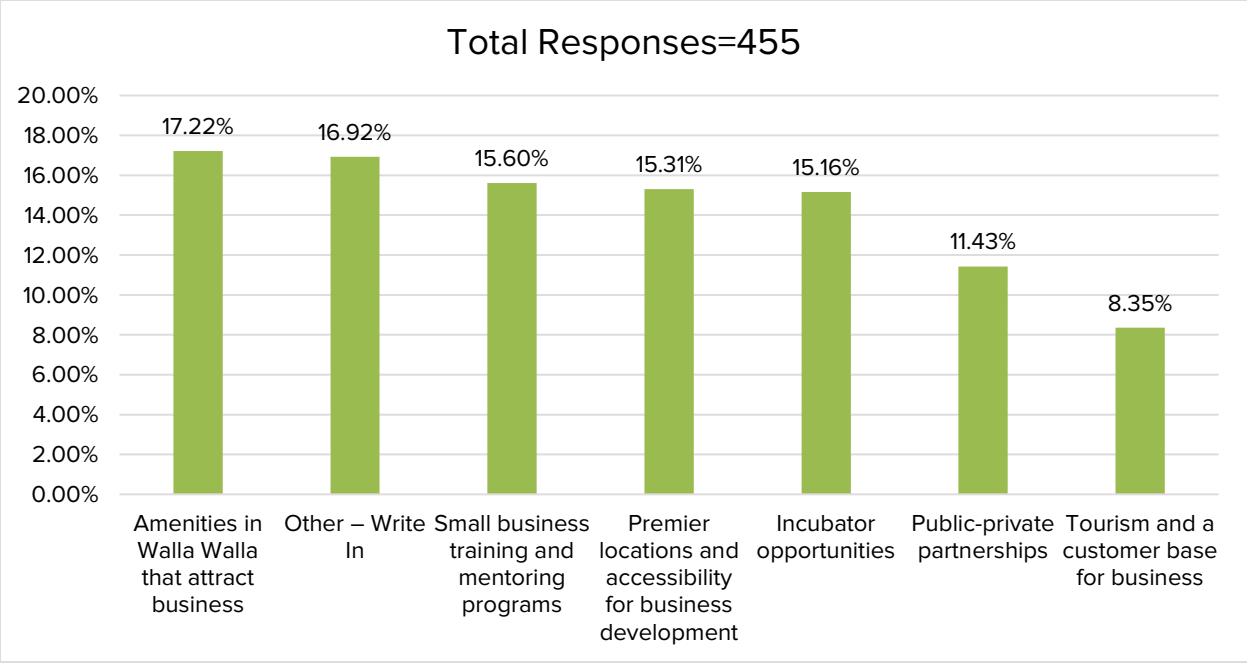
Appendix VII Figure 2. What are your biggest concerns regarding growth in Walla Walla? Select up to 3.



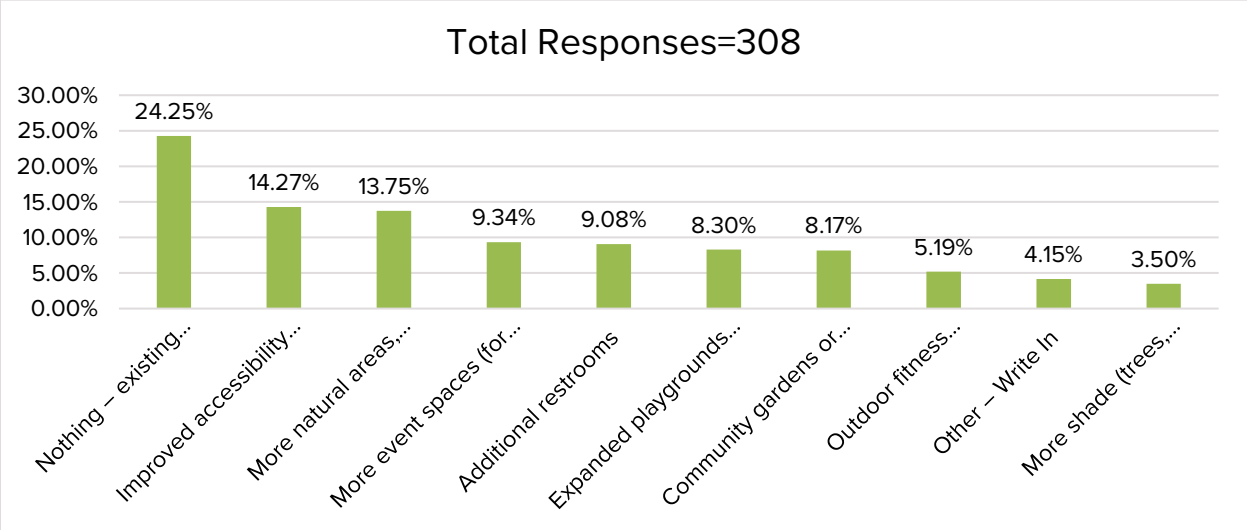
Appendix VII Figure 3. What industries would you like to see expanded in Walla Walla? Select any that apply.



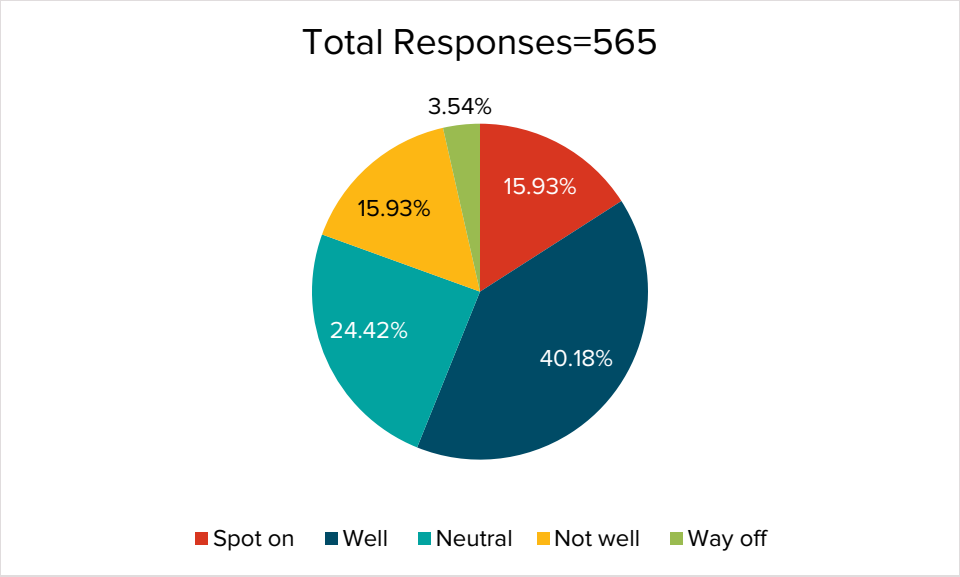
Appendix VII Figure 4. What would best foster economic growth and retain young people in the Walla Walla community? Select up to 3.



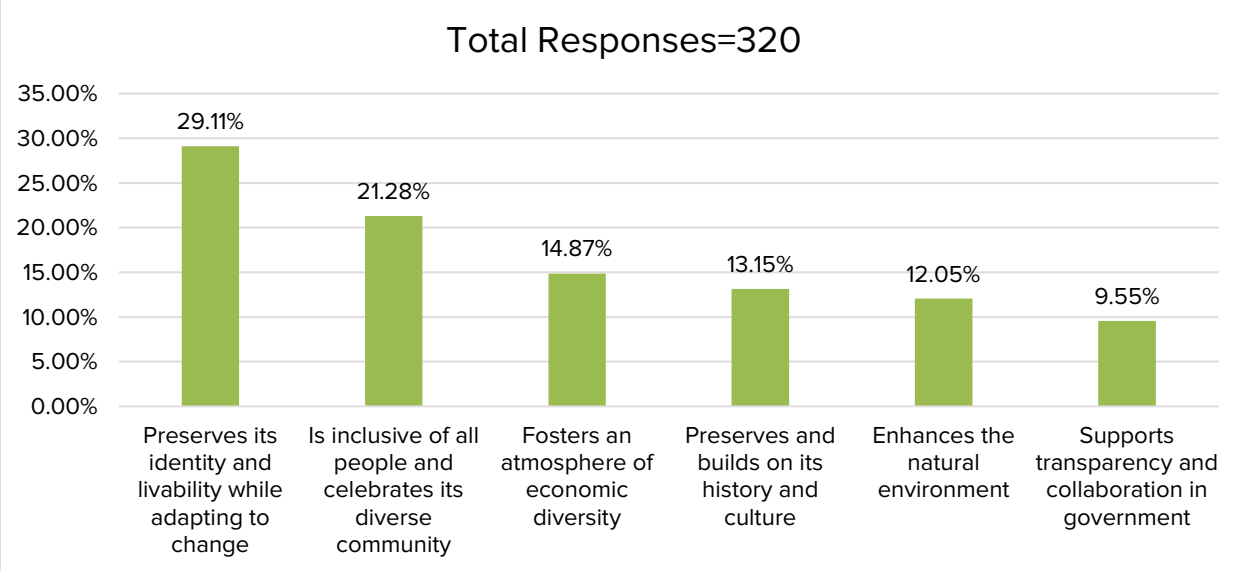
Appendix VII Figure 5. What would best support business development and retainment in Walla Walla? Select up to 3.



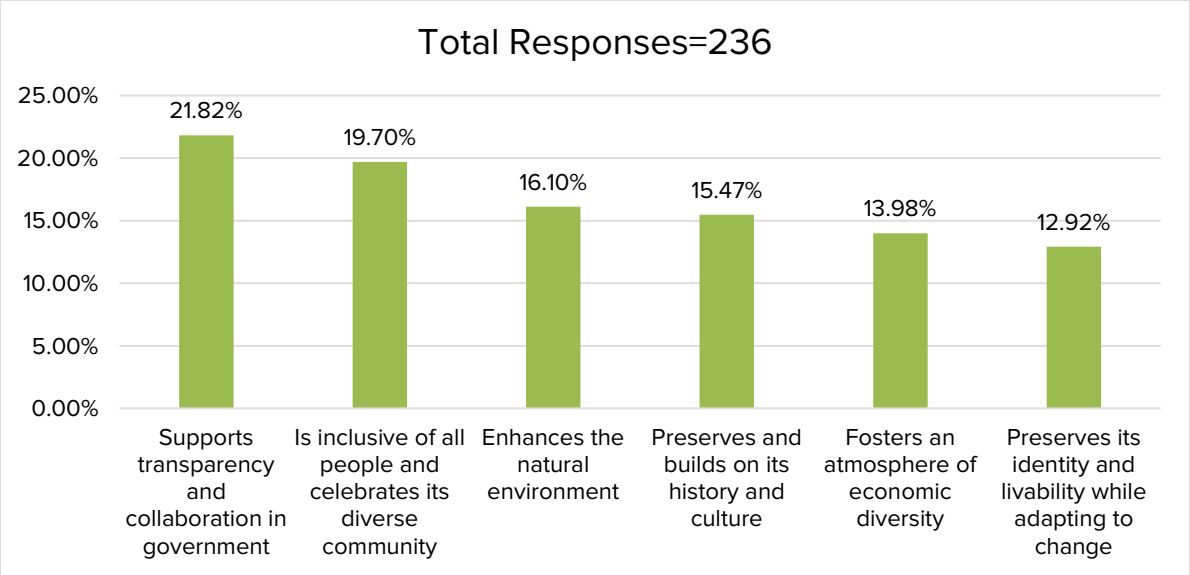
Appendix VII Figure 6. Thinking about parks and recreation in our community, what types of improvements or features would most enhance your experience when visiting parks, trails, or recreational facilities? Select up to 3.



Appendix VII Figure 7. How well does the 2018 vision statement represent Walla Walla in 2025 and your hopes for its future?



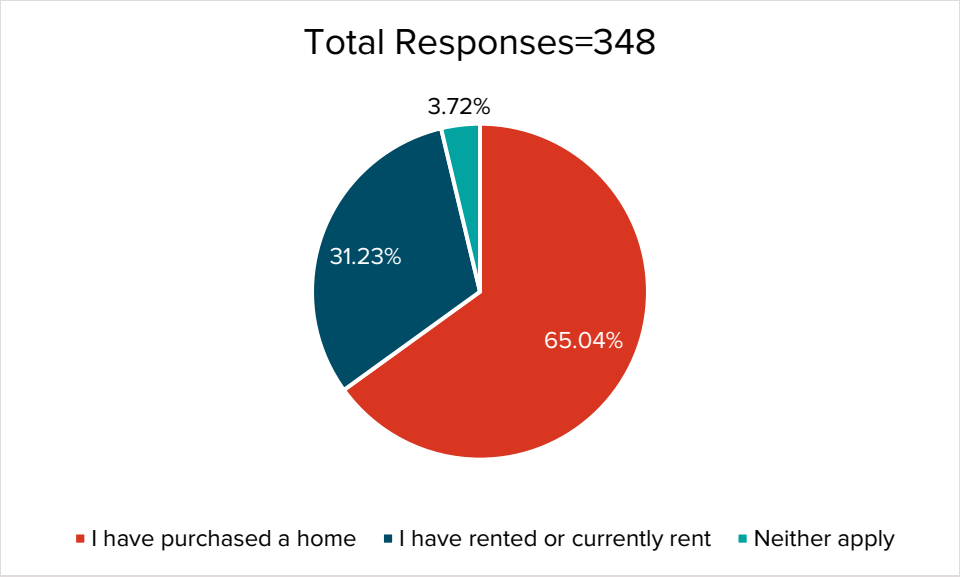
Appendix VII Figure 8. Which points in the 2018 vision statement represent your vision for Walla Walla the most? Select your top 2.



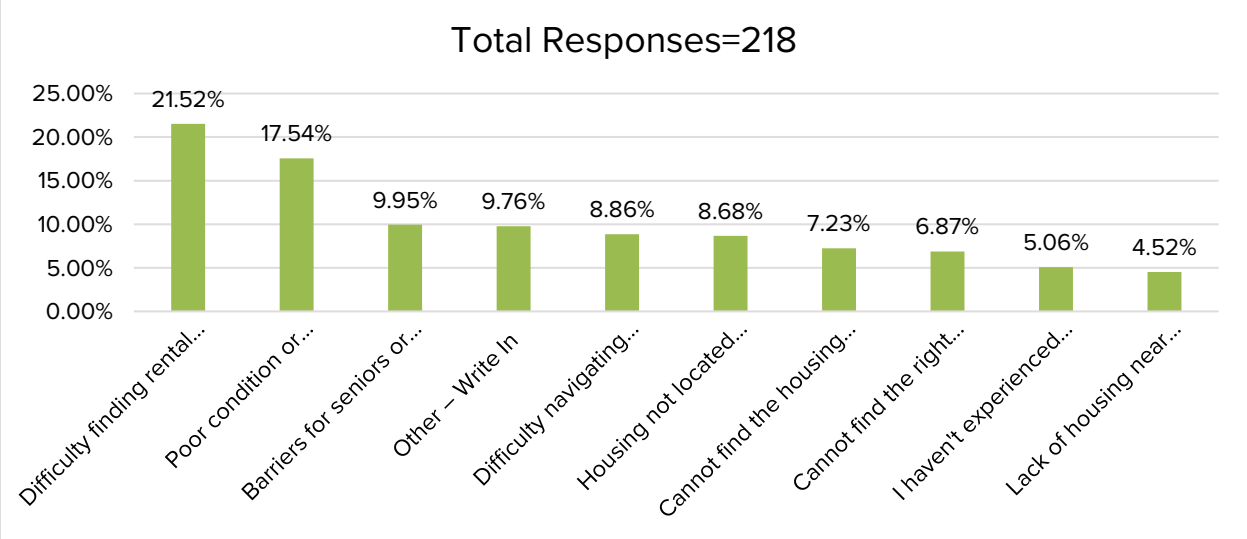
Appendix VII Figure 9. Which points in the 2018 vision statement represent your vision for Walla Walla the least? Select your top 2.

Appendix VII. Table 2. How Important is it to you that Walla Walla: Total Responses = 497

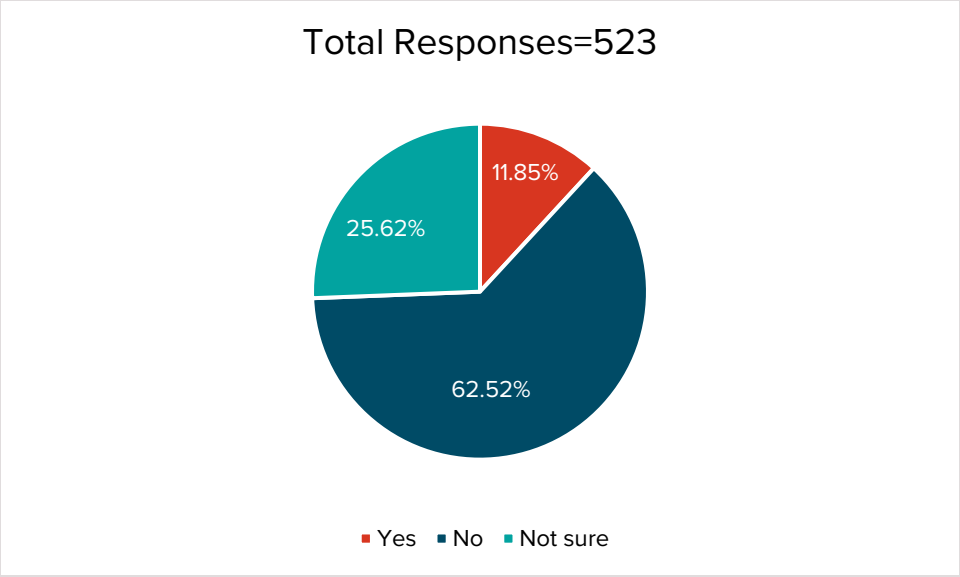
	Very important	Somewhat important	Neutral	Not important	I don't want this
be a diverse, welcoming, and family-friendly community	68.90%	19.30%	8.30%	3.00%	0.60%
preserves its historical heritage	42.20%	43.10%	11.80%	2.50%	0.50%
cultivates an inviting, vibrant, and walkable downtown	66.30%	25.50%	3.90%	3.20%	1.10%
enables locally owned businesses to successfully establish and thrive	78.50%	17.60%	3.60%	0.40%	0.00%
has a housing mix that serves a broad array of incomes and age groups	67.50%	18.60%	9.20%	3.00%	1.80%
has equitable access to parks, open space, trails, and other recreational opportunities	50.40%	34.50%	11.00%	3.10%	1.20%
has public transportation and non-motorized modes of travel that are easily accessible and available	37.10%	40.80%	14.50%	5.30%	2.30%



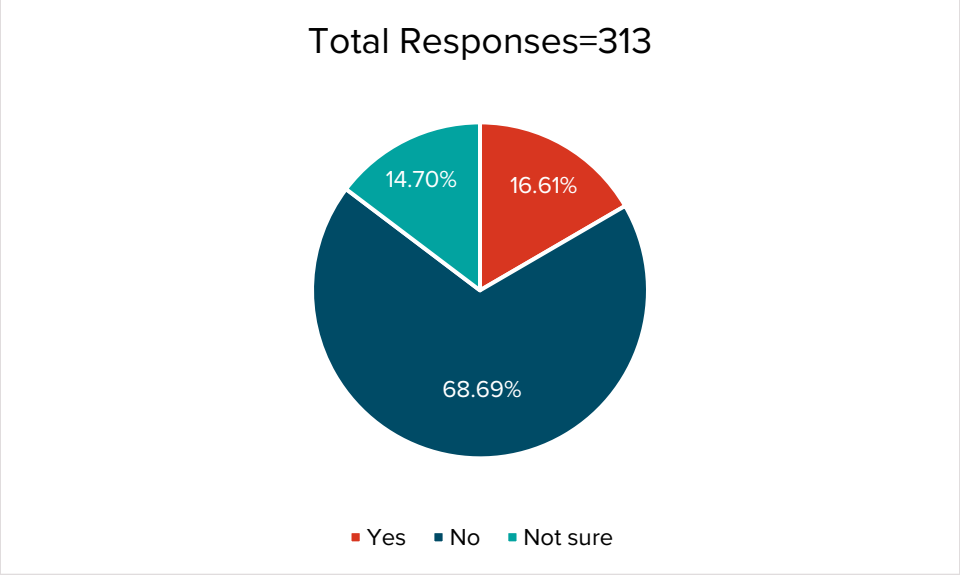
Appendix VII Figure 10. During your time in Walla Walla, have you rented or purchased housing? Select all that apply.



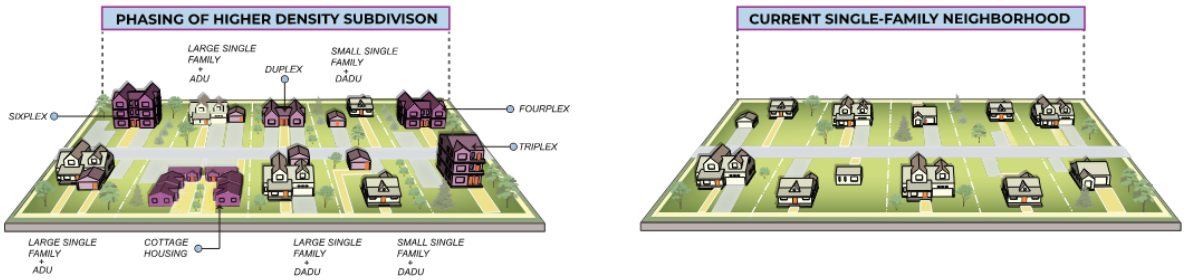
Appendix VII Figure 11. When it comes to rental housing, what specific housing challenges have you or someone you know experienced in Walla Walla? Select all that apply.



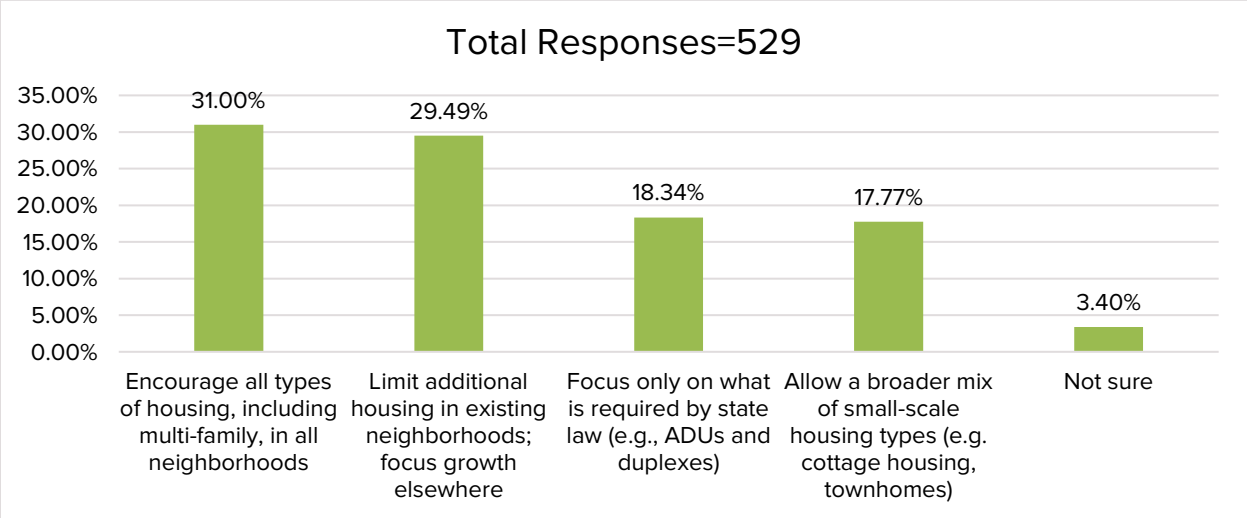
Appendix VII Figure 12. Do you believe there are enough rental housing options available in Walla Walla for people with a range of incomes and family sizes?



Appendix VII Figure 13. Do you believe there are enough housing options for ownership available in Walla Walla for people with a range of incomes and family sizes?



Appendix VII Figure 14. Reference Image for Appendix Figure 15.

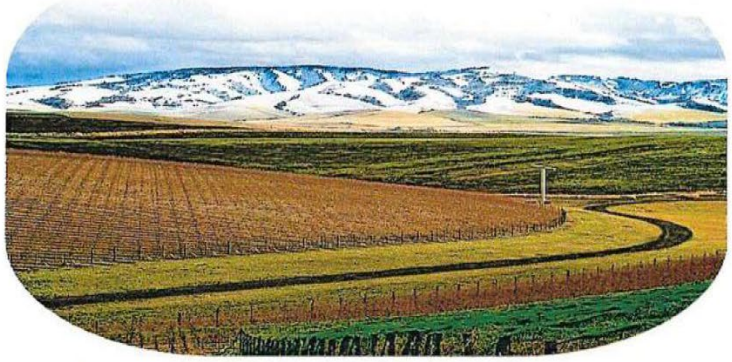


Appendix VII Figure 15. How should Walla Walla plan for new housing development in existing neighborhoods? Select one option that best reflects your values. Use the image below for an example of what housing types may look like in a current single-family neighborhood.

Appendix VIII. Countywide Planning Policies (CWPP)

Walla Walla

Countywide Planning Policies



Town of Prescott

Passed this 29th day of December, 2025 by Board members as follows: 3 Present or 0 Participating via other means, and by the following vote: 3 Aye 0 Nay 0 Abstained 0 Absent.

Attest:

Diane L. Harris, Clerk of the Board

Gunner Fulmer Chairman, District 3

Todd L. Kimball, Commissioner, District 2

Bertha J. Clayton, Commissioner, District 1

Constituting the Board of County Commissioners of Walla Walla County, Washington

ADOPTION

April 7, 2025, Walla Walla County Board of Commissioners

Todd Kimball

Gunner Fulmer

Bertha Clayton

Approval

January 22, 2025, Walla Walla City Council

Mayor Tom Scribner

Mayor Pro Tempore Steve Moss

Brian Casey

Rick Eskil

Monte A. Willis

Jeffrey Robinson

Gustavo Reyna

February 19, 2025, Waitsburg City Council

Mayor Martin Dunn

Mayor Pro Tempore Kevin House

Court Ruppenthal

Jillian Henze

Jennifer Bishop

Jim Romine

January 28, 2025, College Place City Council

Mayor Norma Hernandez

Paul Jessup

Michael Cleveland

Tito Espinoza

Loren Peterson

Melodie Williams

Heather Schermann

Monica Boyle

Prescott City Council

Kristin Du Brille

Karen Gleason

Jason Norris

Kathleen Oliver

Nathan Stueckle

Doug Venn

INTRODUCTION

The Growth Management Act (GMA or Act) was created in part to foster coordination and cooperation among units of local and state government. Cities and counties must engage in a collaborative planning process under the requirements of the Act.

Specifically, the Act states that:

> "The Legislature finds that uncoordinated and unplanned growth [...] pose a threat to the environment, sustainable economic development, and the health, safety, and high quality of life enjoyed by residents of the State. It is in the public interest that citizens, communities, local governments, and the private sector cooperate and coordinate with one another in comprehensive land use planning." (RCW 36.70A.010)

To guide the development of comprehensive plans and development regulations, the GMA sets forth planning goals (RCW 36.70A.020) in 15 areas:

1. Urban Growth
2. Reduce Sprawl
3. Transportation
4. Housing
5. Economic Development
6. Property Rights
7. Permits
8. Natural Resource Industries
9. Open Space and Recreation
10. Environment
11. Citizen Participation and Coordination
12. Public Facilities and Services
13. Historic Preservation
14. Climate Change and Resiliency
15. Shorelines of the State

The GMA also states that:

> "[A] countywide planning policy is a written policy statement or statements used solely for establishing a countywide framework from which county and city comprehensive plans are developed and adopted [...] (to) ensure that city and county comprehensive plans are consistent [...] as required in RCW 36.70A.100. Nothing in this document shall be construed to alter the land use powers of cities." (RCW 36.70A.210(1))

Further, "Federal agencies and Indian Tribes may participate in and cooperate with the countywide planning policy adoption process." (RCW 36.70A.210(4)) These policies may also be used for other purposes requiring collaboration and cooperation in addition to the development and adoption of comprehensive plans.

Walla Walla County's current countywide planning policies were originally adopted in 1993. Since that time, the GMA has been repeatedly amended and expanded and the communities in Walla Walla County have changed as well.

2023-2024 Collaborative CPP Review and Update

In 2023, Walla Walla County and the Cities within the county (City of Walla Walla, College Place, Waitsburg, and Prescott) adopted an interlocal agreement[1] to update and amend the Walla Walla Countywide Planning Policies (CPPs). These policies have been revised and adopted in accordance with the procedures contained in that interlocal agreement. County and City comprehensive plans shall be consistent with the adopted CPPs. They may be amended from time-to-time hereafter in accordance with procedures established by the communities through ongoing coordination as part of a regional planning advisory council as established in these CPPs.

How to read the Countywide Planning Policies

Each chapter of this document begins with a description of the planning and policy context for the issue or issues covered in the chapter. After the context, each chapter defines a set of planning goals for the policies that follow.

The policies within the CPPs have equal importance and each should be understood in the context of the entire document. The CPPs specify how directive a policy is. The policies use one of three different operator words to do this: shall, should, and may. These operators are defined as follows:

- "Shall" means implementation of the policy is mandatory and imparts a higher degree of substantive direction than "should". "Shall" is used for policies that repeat State of Washington requirements or where the intent is to mandate action. However, "shall" cannot be used when it is largely a subjective determination of whether a policy's objective has been met.
- "Should" means implementation of the policy is expected, but its completion is not mandatory. The policy is directive with substantive meaning, although to a lesser degree than "shall" for two reasons. 1) "Should" policies recognize the policy might not be applicable or appropriate for all jurisdictions due to special circumstances. The decision not to implement a "should" policy is appropriate only if the implementation of the policy is either inappropriate or not feasible. 2) Some "should" policies are subjective; hence, it is not possible to demonstrate that a jurisdiction has implemented them. For example, some "should" policies encourage jurisdictions to support various programs or initiatives, but because "support" is a subjective term, implementation could take an array of forms.
- "May" means the actions described in the policy are either advisable or allowed. "May" gives permission and implies a preference. Because "may" does not have a directive meaning, there is no expectation that the described action will be implemented.

The last two chapters of the document provide framework for implementation of the CPPs and ongoing planning work. Chapter 9 establishes an advisory council to coordinate and collaborate on

[1] Walla Walla County Resolution 23-060, March 27, 2023
City of Walla Walla Resolution 2023-22, February 22, 2023
College Place City Council approved February 28, 2023
Waitsburg City Council approved
Prescott City Council approved

implementation of the CPPs and future amendments. Chapters 9 and 10 contain policies and an implementation matrix (Chapter 10) designed to assist the jurisdictions of Walla Walla County with prioritization and implementation of policies from each chapter that require specific and ongoing action and coordination.

1. URBAN GROWTH AREAS AND CONTIGUOUS AND ORDERLY DEVELOPMENT

1.A Urban Growth Areas

Context

Urban Growth Areas (UGAs) are "...areas within which urban growth shall be encouraged and outside of which growth can only occur if it is not urban in nature" (RCW 36.70A.110). Urban growth is defined as "...growth that makes intensive use of land for the location of buildings, structures, and impermeable surfaces to such a degree as to be incompatible with the primary use of land for the production of food, other agricultural products, or fiber, or the extraction of mineral resources...".

This chapter sets goals and policies focused on shared principles as the County and Cities work together on planning for future growth, facilitating growth in Urban Growth Areas, and transitioning these areas when annexations occur.

Goals

Goal 1 - Walla Walla County and the Cities will utilize a consistent methodology for completing a Land Capacity Analysis.

Goal 2 - Walla Walla County and the Cities will work together to distribute population, housing, and employment growth prior to updating comprehensive plans.

Goal 3 - Walla Walla County and the Cities will utilize a consistent process and criteria for expanding or adjusting UGA boundaries.

Goal 4 - Walla Walla County and the Cities will coordinate growth within unincorporated UGAs prior to annexation.

Goal 5 - Walla Walla County and the Cities will encourage higher density residential development in closer proximity to jobs, commercial services, transit, schools, and parks.

Goal 6 - Walla Walla County and the Cities will promote infill and redevelopment of existing areas to utilize services most efficiently and economically.

Goal 7 - Walla Walla County and the Cities will consider possible impacts to critical areas, greenbelts and open space, aquifer recharge areas, and both rural and resource lands when an expansion to a UGA is proposed.

Goal 8 - Where applicable, the County, Cities, and/or other services providers should coordinate on providing utilities and capital facilities within UGAs.

Goal 9 - Walla Walla County and the Cities will provide predictability for investors, landowners, and residents regarding types of land use, development standards, and zoning intended.

Goal 10 - Walla Walla County and the Cities will provide an adequate supply of industrial and commercial property and infrastructure to support economic development and employment projections.

Urban Growth Area Policies

1.1 Land Capacity (RCW 36.70A.115 and WAC 365-196-325): The County and Cities shall ensure that, taken collectively, adoption of and amendments to their comprehensive plans and/or development regulations provide sufficient capacity of land suitable for development within their jurisdictions to accommodate their projected population, housing, and employment growth.

a. The County and Cities shall jointly coordinate, through the process outlined in Chapter 9, a Land Capacity Analysis methodology to provide a consistent estimate of the land supply available to accommodate future population and employment growth and projected housing needs. This includes setting a reasonable market factor. Once developed, the methodology will be attached to these CPPs as an Appendix.
b. In the event of a dispute among jurisdictions relating to inconsistencies in collection and analysis of data, the affected jurisdictions shall meet and discuss methods of resolving the dispute. If a resolution cannot be achieved, representatives from the County and Cities via the Walla Walla County Growth Management Advisory Council shall work together to review and, if possible, facilitate any disputes between parties.

1.2. Policies for the distribution of 20-year population, housing, and employment growth:

a. The County and Cities shall jointly coordinate, through the process outlined in Chapter 9, a methodology for distributing the forecasted population, housing, and employment growth (growth targets) consistent with the requirements of the Growth Management Act. Once distributed, growth targets will be attached to these CPPs as an Appendix.
b. The County and Cities, as part of their Comprehensive Plan periodic updates, shall reflect those growth targets in their Comprehensive Plan.

1.3 Adopt a process and criteria to ensure regional coordination when establishing, expanding, and adjusting Urban Growth Areas:

a. Sufficient capacity must be included in the Urban Growth Areas to accommodate the 20-year population, housing, and employment (commercial and industrial) targets.
b. Urban Growth Area expansions shall not result in new areas being included for population, housing, or employment capacity that exceed what is necessary to accommodate the growth management planning projections, plus a market factor.

c. Except for UGA modifications under subparagraph "g", an expansion of the boundary of an individual UGA that results in a net increase of residential, commercial, or industrial land capacity shall not be permitted unless the UGA expansion is supported by a land capacity analysis completed consistent with the Land Capacity Methodology. (See Policy 1.1)
d. The County, City, or other interested party may initiate an amendment to an existing Urban Growth Area boundary through the Walla Walla County annual comprehensive plan amendment docketing process. The County has discretion to determine their annual comprehensive plan amendment process, including the schedule and review types.
e. The County should adopt specific procedures for filing comprehensive plan amendments which will be processed concurrently with the state-required Periodic Update.
f. Any expansion of an Urban Growth Area shall result in zoning that will ensure urban growth patterns and densities consistent with the Growth Management Act.
g. The County shall adopt procedures and criteria for considering UGA boundary revisions consistent with the requirements in RCW 36.70A.130(3)(c). Such 'swap' amendments must comply with applicable GMA criteria and shall not increase land capacity within the UGA.
h. When an Urban Growth Area boundary is proposed to be established, expanded, contracted, or adjusted the County and appropriate City should coordinate together to conduct early and continuous public involvement.
i. All Urban Growth Areas shall be reflected in County and respective City comprehensive plans.
j. Possible impacts to critical areas, greenbelts and open space, and both rural and resource lands shall be evaluated when an expansion to a UGA is considered.
k. UGAs should be designated where:
    a. Areas are already characterized by urban growth;
    b. Infrastructure exists or is planned, as identified in an approved capital improvement program, or can be reasonably and economically extended; and
    c. It is environmentally appropriate for growth to occur.
l. UGAs may provide for the inclusion of greenbelts and open space, some of which may be critical areas.

1.4 Coordinated growth management in Urban Growth Areas:

a. Adopted City and County comprehensive plans shall reflect the intent that all land within unincorporated Urban Growth Areas, where feasible, will either annex to a City or incorporate within the 20-year planning horizon.
b. To maximize the efficient use of urban lands, uses and densities permitted in unincorporated Urban Growth Areas should be consistent where feasible with the associated jurisdiction's zoning densities and uses.
c. Cities are the primary provider of municipal services and facilities in their Urban Growth Areas, responsible for demonstrating within their comprehensive plans and capital facilities plans the capacity to provide all urban services within their associated unincorporated Urban Growth Area(s). This may be accomplished through a collaborative process with the County and/or other service providers.

d. The County and Cities should establish procedures to facilitate the smooth transfer of governance for associated Urban Growth Area(s).
e. The County should plan with associated Cities and local communities to address land use, zoning, infrastructure needs, and other issues as needed.
f. The County and each City, where appropriate, should consider utilizing Interlocal Agreements (ILAs) as a mechanism to facilitate urban growth within unincorporated UGAs. An ILA could be utilized to coordinate on common development regulations and standards and permit review processes within these areas, resulting in development more closely aligning with adopted regulations within cities. This process could also be utilized to encourage the extension of urban services to these areas given urban growth typically requires urban governmental services.

1.B Contiguous and Orderly Development

Context

These policies facilitate the cost-effective provision of urban services by minimizing differences in urban development regulations and standards between the County and Cities in shared UGAs. These policies focus on specific topics where coordination is essential, including topics also covered by other chapters of the Countywide Planning Policies such as housing, transportation, and public capital facilities. These policies ensure the goals and policies specific to those topics are implemented in a consistent and orderly way. In contrast with the policies for UGAs, which are focused on coordination as projected growth is planned for, these policies are intended to coordinate development and transition when annexation occurs.

Goals

Goal 11 - Walla Walla County and each City will work to ensure that urban services in shared Urban Growth Areas (UGAs) serve development in an orderly and cost-efficient manner.

Goal 12 - Walla Walla County and the Cities will ensure the provision of urban governmental services in the Urban Growth Area and applicable capital improvement plans.

Goal 13 - Walla Walla County and the Cities will coordinate with each other and with special districts, where applicable, in the provision and financing of utilities and capital facilities.

Goal 14 - Walla Walla County and the Cities will work together to ensure that permitting in unincorporated urban growth areas is well coordinated.

Policies

1.5 The County and the Cities shall prioritize urban growth within Urban Growth Areas (UGAs) as follows:

a. First in areas already characterized by urban growth that have existing public facility and service capacities to serve such development;
b. Second, in areas already characterized by urban growth that will be served by a combination of both existing public facilities and services and any additional needed public facilities and services that are provided by either public or private sources; and
c. Third, in the remaining portions of the urban growth areas.

1.6 Non-urban development in the UGA should be discouraged. Non-urban development in the UGA should only be allowed if urban development is not feasible and if it will be compatible with future urban development.

1.7 The timing of capital improvements shall be consistent with the adopted capital facilities plan(s) of the purveyor(s).

1.8 Existing and future level of service standards shall be established within the appropriate capital facilities plan(s).

1.9 The County and Cities should coordinate the development and implementation of long-range planning between fire protection, police services, schools, transportation, and parks and recreation facilities.

1.10 The County should not encourage fully contained communities.

1.11 Service boundaries for urban governmental services shall not be extended past existing adopted service area boundaries.

1.12 Cities should be the purveyors of urban services, except in cases where an Urban Growth Area is not associated with a city.

1.13 To adequately plan for growth and implement the policies of the GMA, the County, the Cities, and special districts in the county, should establish ongoing mechanisms, such as the advisory council established in Chapter 9, to improve communication, information sharing, and coordinated approaches to common problems.

1.14 Walla Walla County should coordinate with adjacent and/or nearby counties and cities on issues of growth and delivery of urban services that cross county or state boundaries.

2. PUBLIC CAPITAL FACILITIES AND ESSENTIAL PUBLIC FACILITIES

State Context

The Growth Management Act (GMA) requires that Countywide Planning Policies address the siting of public capital facilities of a countywide or statewide nature, including transportation facilities of statewide significance (RCW 36.70A.210(3)(c)). The term, "capital facilities of countywide or statewide nature" is not defined in state law but is synonymous with essential public facilities, which are defined in the GMA. Essential public facilities include facilities that are typically difficult to site, such as airports, state education facilities and state or regional transportation facilities, regional transit authority facilities, state and local correctional facilities, solid waste handling facilities, group homes, and secure community transition facilities (RCW 36.70A.200). The policies in this chapter focus on areas where coordination is necessary for the siting of public capital facilities and essential public facilities where coordination is necessary.

Local Context

Each county and city are also required to have a capital facilities plan. Capital facilities include, but are not limited to, water systems, sanitary sewer systems, stormwater facilities, reclaimed water facilities, schools, parks and recreational facilities, and police and fire protection facilities. Coordination between the County and Cities, in the form of sharing details, objectives, and locations with affected jurisdictions during the planning and design phase, for these facilities can improve service to the public and protect the environment and public health. Coordination on levels of service, in the form of communication and alignment of levels of service standards for public facilities and services between jurisdictions, helps ensure consistent service. Public services and facilities in Urban Growth Areas are expected to be provided at service levels to support urban densities and development intensity while reflecting the realities of limited resources and prioritization between those services and facilities. Public services and facilities in rural areas of Walla Walla County are expected to be provided at service levels reflecting lower densities and more dispersed patterns of development. This chapter also provides policies on public capital facilities.

Public Services and Facilities Goal

Walla Walla County and the Cities will coordinate on, develop, and provide adequate and efficient public facilities and services to ensure the health, safety, conservation of resources, and economic vitality of all communities and all residents.

Policies for All Capital Facilities

2.1 The County and the Cities should consider including impacts upon historically marginalized communities and disproportionately burdened communities when siting or expanding capital facilities.

2.2 Some regionally significant public capital facilities and essential public facilities may be located outside Urban Growth Areas. The County should permit or approve capital facilities or essential public facilities beyond Urban Growth Areas only if they are self-contained or to be served by services in a manner that will not promote sprawl.

2.3 Location of public capital facilities and essential public facilities:

a. If the primary population served by the facility is urban, the facility should be located in a city or unincorporated Urban Growth Area, where feasible.
b. Public capital facilities that generate substantial travel demand should be located along or near major transportation corridors and existing public transportation routes.
c. The design of capital facilities and utilities located within and serving rural and/or resource areas should be at a size and scale appropriate to rural locations to not increase development pressure in those areas.

Policies for Public Capital Facilities

2.4 Identification of needed capital facilities: The County and the Cities shall each prepare a capital facilities plan as part of the comprehensive plan periodic update as established in RCW 36.70A.130. The jurisdictions may also update their capital facilities plan yearly as part of each jurisdiction's budget amendment process. Where facility expansions or new facilities may impact another jurisdiction, the jurisdiction proposing the expansion or new facility shall provide data about proposed facilities expansions to impacted jurisdictions.

2.5 Uses shall adhere to local health district or state agency rules regarding commercial or industrial use of on-site sewage systems.

2.6 The County and the Cities should consider multiple uses for rights-of-way and easements related to public capital facilities, including multi-modal transportation.

2.7 In Urban Growth Areas, the County and the Cities shall coordinate on changes to or differences between levels of service (LOS) standards when development is proposed that would have LOS impacts across jurisdictional boundaries.

2.8 The County and the Cities should, where appropriate, integrate probability, vulnerability, and risk assessment information from the Walla Walla County Hazard Mitigation Plan, as may be amended, into capital facilities planning.

2.9 The County and the Cities should encourage the location of new human services facilities near access to transit.

2.10 The County and the Cities shall promote connection to sanitary sewers for residents and businesses within Urban Growth Areas as the preferred alternative to resolving failing septic systems.

2.11 The County and the Cities should support planning for the provision of broadband infrastructure.

2.12 The County and the Cities shall permit schools, institutions, and other community facilities that serve primarily urban populations within Urban Growth Areas in locations where they will support local comprehensive plans, except as provided by RCW 36.70A.211. Considerations should include recent growth, projections of population and student enrollment growth, adopted comprehensive plans and capital facilities plans, and the growth allocations once attached as an Appendix.

Policies for Essential Public Facilities

2.13 The County and the Cities shall not preclude the siting of essential public facilities as defined in RCW 36.70A.200 in their comprehensive plans and development regulations.

2.14 The County and the Cities may also generate standards to ensure that reasonable compatibility with other elements of the plans can be achieved.

2.15 When a proposed essential public facility could impact another jurisdiction in Walla Walla County, it is important that opportunities for communication are provided when an essential public facility permit application is received. Therefore, when essential public facilities are proposed to be located within Walla Walla County, the local government(s) involved shall:

a. Send notice to each jurisdiction as part of the notice of application comment period. This will ensure there is time to communicate and coordinate early in the permit process;
b. Encourage public involvement through public comment periods, newspaper notices, and public meetings and hearings as authorized through adopted permit processes and procedures; and
c. Consider factors for minimizing effects upon the health, safety, and welfare of residents around or near the facility when siting essential public facilities.

2.16 Essential public facilities may be identified by the state Office of Financial Management, other state agencies, or by local government.

2.17 The County and the Cities should not locate essential public facilities in designated resource lands or critical areas unless they are compatible with those lands and comply with critical areas and development regulations.

3. RURAL AND RESOURCE LANDS

Context

Rural and resource lands are important to our economy and community. It is a high priority to preserve the features and character of these areas. Under the Growth Management Act (GMA), the County is responsible for designating and regulating rural and resource lands through its comprehensive plan. However, preservation of rural and resource lands is a regional issue, and it is important to establish countywide planning policies so there is harmony and consistency between uses on rural lands and resource lands and those occurring in cities and unincorporated Urban Growth Areas (UGAs). All jurisdictions are responsible for designating and protecting critical areas; but, where open space corridors and habitat areas cross jurisdictional boundaries, countywide planning policies can ensure jurisdictions work together to protect these environmental resources.

While the GMA does not require countywide planning policies for these land use categories, the County and the Cities desire to coordinate planning for these areas.

Rural Lands

The GMA characterizes rural development as, "development outside the urban growth area and outside agricultural, forest, and mineral resource lands designated pursuant to RCW 36.70A.170. Rural development can consist of a variety of uses and residential densities, including clustered residential development, at levels that are consistent with the preservation of rural character and the requirements of the rural element. Rural development does not refer to agriculture or forestry activities that may be conducted in rural areas." RCW 36.70A.030(36).

Walla Walla County's rural lands are characterized by lower levels of service; mixed residential, agricultural, and open space uses; broad vistas; parcels of varying sizes; a variety of housing types; and small unincorporated communities.

Resource Lands

Goal 8 of the GMA states that an objective of the Act is to "[m]aintain and enhance natural resource-based industries, including productive timber, agricultural, and fisheries industries. Encourage the conservation of productive forestlands and productive agricultural lands and discourage incompatible uses." RCW 36.70A.020(8). Resource lands are further defined in the GMA as consisting of agricultural land, forestland, and mineral resource land. These lands are distinguished from rural lands by the commercial significance of these resources, and the County comprehensive plan designates these lands and establishes densities and allowed uses that are more restrictive than in rural lands to protect these resources.

Walla Walla County has a unique climate, topography, and land use mix. Resource lands in Walla Walla County are those lands defined as agricultural and mineral resource lands of long-term commercial

significance. Additionally, there are lands used for agricultural, mineral, and timber purposes that do not have long-term commercial significance but nevertheless support the rural economy and provide ecosystem services.

Rural and Resource Lands Goals

Goal 1 - Walla Walla County and the Cities are focused on supporting traditional lifestyles, rural-based economies, and opportunities to live, work, and recreate in rural areas and retain the rural and agrarian character of the county.

Goal 2 - Rural lands serve as a buffer between urban lands and resource lands in order to retain open spaces and bank land for possible future urban expansion where needed.

Goal 3 - Walla Walla County and the Cities will maintain resource-based industries through the conservation of productive agricultural, forest, and mineral resources while retaining open spaces and recreational opportunities.

Rural and Resource Lands Policies

3.1 The County and the Cities may use buffering and other land use techniques to retain the separation between rural lands and urban lands, as well as between rural lands and resource lands, to mitigate the impacts of permitted rural and urban uses on adjacent resource lands.

3.2 The County should consider input from Cities on establishing appropriate land use designations and development regulations for rural lands that are expected to be included within an Urban Growth Area and be annexed in the future to ensure eventual orderly inclusion.

3.3 The County and the Cities should work together early in the planning process to identify and designate greenbelts and open space corridors within and between urban growth areas. These areas may include recreation, fish and wildlife habitat, trails, and connections of critical areas and buffers.

3.4 The County and the Cities shall continue to utilize the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP) for floodplain management.

3.5 The County shall protect the "right to farm" in agricultural areas in its Comprehensive Plan and development regulations.

3.6 The County and the Cities should support rural and resource land uses that preserve the rural character and deliver economic benefits for all communities in the county.

4. TRANSPORTATION

Context

The Growth Management Act (GMA or Act) requires that transportation planning and improvements be coordinated among jurisdictions and be consistent with the land use elements of local comprehensive plans. The Act also places special emphasis on transportation because a jurisdiction may not approve development unless an adequate level of service is available or planned to accommodate the development. The countywide transportation policies address areas of mutual interest when more than one jurisdiction is affected by or involved in a transportation policy program or project. In Walla Walla County, this includes all jurisdictions since all incorporated cities and the county have a portion of the State Highway System within their boundaries and the cities' streets connect to county roads. These policies then apply to transportation related impacts, policies, programs, and projects involving more than one jurisdiction.

Transportation facilities in Walla Walla County consist of airports and airfields, commercial water transportation facilities, highway and road systems, transit systems, bridges, rail systems, truck routes, specialized transportation for the elderly and persons with disabilities, and bike and pedestrian routes.

Transportation planning policies and programs include the Walla Walla Valley Metropolitan Planning Organization (MPO) Regional Plan, transportation improvement programs, six-year road programs, transportation components of jurisdictions' capital facilities plans, and other transportation financing strategies. The Walla Walla Valley MPO has served as the Sub-Regional Transportation Planning Organization (SRTPO) in accordance with the GMA since 2013.

Goals

Goal 1 - Walla Walla County and the Cities shall provide a balanced countywide transportation system that allows for the efficient, clean, safe, well connected, context-sensitive, multi-modal movement of people, goods, and services.

Goal 2 - Walla Walla County and the Cities shall reduce sprawl, conserve land and natural resources, and make more efficient use of transportation infrastructure.

Goal 3 - Walla Walla County and the Cities shall develop transportation plan elements, investment decisions, and regulations that are consistent with and reinforce land use and economic development policies.

Goal 4 - Walla Walla County and the Cities will work together through the Walla Walla Valley Metropolitan Planning Organization (MPO) to provide effective and efficient transportation facilities and strategies.

Goal 5 - Walla Walla County and the Cities will work together to eliminate traffic deaths or serious injuries caused by traffic crashes involving any mode of transportation through the use of a data-driven, multi-disciplinary, and Safe System Approach that increases safe, healthy, and equitable mobility for all.

Goal 6 - Walla Walla County and the Cities will work together to enhance transportation accessibility and inclusivity for all individuals, ensuring that every member of the community can navigate the transportation system safely and independently, regardless of age, ability, or socioeconomic status.

Policies

4.1 Walla Walla County and the Cities should maintain participation in the MPO/SRTPO to ensure transportation planning is consistent, local needs are reflected in the Regional Plan, and to avail themselves of transportation planning technical services.

4.2 Each comprehensive plan adopted pursuant to the Growth Management Act shall contain a transportation element consistent with the Regional Plan's land use and economic development policies as well as those of jurisdictions in the planning area.

4.3 The County and the Cities should consider including impacts upon historically marginalized communities and disproportionately burdened communities when siting or expanding transportation facilities, including transportation facilities of a statewide nature.

4.4 The County and the Cities should work toward establishing multi-modal levels of service that are sensitive to differences between UGAs and rural areas and that are consistent across jurisdictions when facilities cross jurisdictional boundaries.

4.5 The County and the Cities should adopt a cooperative process for early coordination of public and private capital projects that may impact the transportation system in the county or a neighboring jurisdiction. This process should include an early referral and response mechanism and appropriate criteria for use in evaluating the impacts of a proposal. This process should also apply to any transportation improvements contemplated by one jurisdiction that will impact an adjacent jurisdiction.

4.6 The County and the Cities should develop policies in their comprehensive plans to support Target Zero/Vision Zero, Complete Streets, and Context Sensitive Solutions as appropriate to circumstances.

4.7 The County and the Cities should coordinate with the MPO to collect non-motorized activity data that can be standardized countywide.

4.8 The County and the Cities should cooperate early in the permitting and design process for trails where they cross jurisdictional boundaries.

4.9 The County and the Cities should coordinate with the MPO and Valley Transit to conduct regular assessments of existing transportation facilities to identify barriers to accessibility. Incorporate feedback from community members, particularly those with disabilities, to inform improvements.

5. HOUSING

Context

The Growth Management Act (GMA) requires that Countywide Planning Policies consider the need for affordable housing, such as housing for all economic segments of the population, and parameters for its distribution. Furthermore, the GMA requires cities and counties to encourage the availability of housing that is affordable for all income levels at a variety of housing densities. Local jurisdictions are also encouraged to preserve existing housing resources in their communities and to provide an adequate supply of housing with good access to employment centers to support job creation and economic growth.

Housing affordability and availability is a major challenge facing Walla Walla County and its Cities. Housing shall mean housing intended for a full range of household incomes. These income levels are defined as follows (WAC 365-196-410(2)(e)(i)(C) and RCW 36.70.030):

- Extremely low-income shall mean those households that have incomes that are at or below 30 percent of the countywide median household income (median income), adjusted for household size.
- Very low-income shall mean those households that have incomes that are within the range of 31 to 50 percent of the median income, adjusted for household size.
- Low-income shall mean those households that have incomes that are within the range of 51 to 80 percent of the median income, adjusted for household size.
- Moderate-income shall mean those households that have incomes that are within the range of 81 to 120 percent of the median income, adjusted for household size.
    - The Department of Commerce (Commerce) provides guidance for demonstrating capacity for income band allocations that further breaks moderate-income households into 81 to 100 percent and 101 percent to 120 percent of the median income, adjusted for household size.

The housing goals and policies in the Countywide Planning Policies are connected to goals and policies in other chapters. For example, providing housing that is affordable and available to all economic segments of the community, which is the focus of this chapter, is only possible if the County and the Cities coordinate successfully on Urban Growth Areas, Public Facilities and Utilities, and Transportation as well as other topics.

Goals

Goal 1 - Walla Walla County and the Cities focus higher density residential developments, as needed to accommodate housing targets, near jobs, transit, schools, parks, and other daily needs and services.

Goal 2 - Walla Walla County and the Cities promote infill and redevelopment of existing residential areas and rehabilitation of existing housing stock.

Goal 3 - Walla Walla County and the Cities plan for and accommodate sufficient capacity of affordable housing units to meet the housing needs of all economic segments of the community, including extremely low, very low, low, and moderate-income households as well as the need for manufactured homes, manufactured home parks, group homes, foster care facilities, emergency shelters, emergency housing, and permanent supportive housing.

Goal 4 - Walla Walla County and the Cities promote preservation of existing housing as a means of providing housing choices affordable to all income levels.

Goal 5 - Walla Walla County and the Cities ensure that their permitting processes are timely, predictable, and fair.

Goal 6 - Walla Walla County and the Cities promote programs that support homeownership for new and established residents.

Policies

5.1 The County and the Cities shall plan for and accommodate a wide range of housing development types and densities throughout the county to meet the needs of a diverse population.

5.2 The County and the Cities shall encourage affordable housing through innovative land use techniques, including but not limited to: financial incentives, clustering, planned unit development, maximum lot size provisions, infill housing incentives, retaining existing housing, and density bonuses.

5.3 The County and the Cities should encourage and support financial incentive programs for homeownership.

5.4 The County and the Cities should pursue partnerships with nonprofit agencies, such as Blue Mountain Action Council, public corporations, such as Walla Walla Housing Authority, and others, to ensure that housing needs are being met.

5.5 The County and the Cities shall each identify specific policies and implementation strategies in their respective comprehensive plans and shall enact implementing regulations to provide a mix of housing types for housing at all income levels, considering easy access to employment centers.

5.6 The County and the Cities should provide appropriately zoned lands and location criteria to assure the inclusion of multi-family housing and manufactured home parks within UGAs.

5.7 The County and the Cities should share data and methodology for the housing needs assessments in their comprehensive plans to ensure consistency.

5.8 The County and the Cities shall include housing elements in their comprehensive plans that comply with the provisions of RCW 36.70A.070(2) and that are consistent with adopted growth allocations.

5.9 The County and the Cities may create or support a registration program with a consolidated database of available government-supported affordable housing units in the region including inventory, availability, conditions, and price structure, which should also link to a website providing tenants information on application and screening. (See pages 26-27 of the adopted Regional Housing Action Plan.)[2]

5.10 The County may permit high density housing within an unincorporated urban growth area which is not contiguous to a municipal boundary provided it meets the criteria for contiguous and orderly development per RCW 36.70A.020(1).

5.11 The County and the Cities should evaluate the impact of any new ordinance or regulation that may affect housing affordability with regard to the provision of housing options prior to adoption.

5.12 The County and the Cities should support reducing or eliminating minimum lot size requirements within Urban Growth Areas to promote the development of greater diversity of housing types where feasible.

5.13 The County and the Cities should ensure the vitality of established residential neighborhoods that:

a. Include consideration of senior and accessible housing needs;
b. Provide avenues to homeownership for moderate-income households; and
c. Provide support for institutions and services that serve historical and cultural communities and lower-income households in areas with displacement risk.

5.14 Physical, economic, and cultural displacement of low-income households may result from planning, public investment, private development and redevelopment, and market pressure. The County and the Cities should employ a range of strategies to mitigate displacement impacts as planning for future growth occurs, including the strategies and actions identified in the adopted Regional Housing Action Plan. [2]

---

[2] Regional Housing Action Plan Adopted by:
City of Walla Walla Resolution 2021-23, August 11, 2021
City of College Place Ordinance 21-013, September 14, 2021
City of Waitsburg Resolution 2021-732, August 18, 2021

5.15 The County and the Cities should periodically review permit processes to ensure permits are processed in a timely and fair manner.

6. COUNTYWIDE ECONOMIC DEVELOPMENT AND EMPLOYMENT

Context

The Growth Management Act (GMA) requires that communities "[E]ncourage economic development throughout the state that is consistent with adopted comprehensive plans, promote economic opportunity for all citizens of this state, especially for unemployed and for disadvantaged persons, promote the retention and expansion of existing businesses and recruitment of new businesses, recognize regional differences impacting economic development opportunities, and encourage growth in areas experiencing insufficient economic growth, all within the capacities of the state's natural resources, public services, and public facilities." (RCW 36.70A.020(5))

Countywide planning policies are required to include policies for countywide economic development and employment, including consideration of future development of commercial and industrial facilities.

Goals

Goal 1 - Walla Walla County and the Cities will support and encourage a sustainable, healthy economy and adequate employment opportunities that are vitally important to the long-term health of Walla Walla County.

Goal 2 - Walla Walla County and the Cities will collaborate in planning for economic development that benefits our region.

Goal 3 - Walla Walla County and the Cities will provide predictability in private investment decisions through land-use, zoning, development regulations, and permit processes.

Policies

6.1 The County and the Cities shall support and encourage economic development that is consistent with the preservation of Walla Walla County's quality of life and environment and that is within the capabilities of the county's natural resources, public services, and public facilities.

6.2 The County and the Cities should coordinate the economic development element of local comprehensive plans with other elements of those plans, with particular attention being given to coordination with the land use and capital facilities elements.

6.3 The County and the Cities should ensure an adequate supply of industrial property throughout the county based on needs identified in the economic development elements of their comprehensive plans and should support the development of infrastructure to service lands designated as industrial.

6.4 The County should recognize the importance of industrial zoned property on the Columbia/Snake River system for the efficient transportation of local commodities to world

markets and support efforts to protect and encourage industrial zoned property on the river system.

6.5 Areas designated for future commercial and industrial uses should have infrastructure capacity, transportation, and housing, or the ability to provide the forementioned.

6.6 The economic development elements of all jurisdictions should encourage inter-jurisdictional coordination and cooperation on economic development issues, particularly those that affect the size and diversity of the economic base. Comprehensive plans should encourage coordination between local economic development organizations.

6.7 The County and the Cities should collaborate with the Port of Walla Walla, tribes, and special districts to encourage economic growth consistent with comprehensive plan policies for land use, transportation, and capital facilities and services, among other topics.

6.8 The County and the Cities should coordinate with federal and state resource agencies and economic development groups concerning their land use plans that may impact economic development activity.

6.9 The County and the Cities should work to retain those enterprises and industries that have created the economic base of the county and promote their continued growth.

6.10 The County and the Cities should continue to support and develop agriculture-based industries through continued innovations in production, marketing, and technology as well as increased investment in value-added processing.

6.11 The County and the Cities should contribute to an overall climate where business opportunities are provided and where regulations protect the public health, safety, and welfare.

6.12 The County and the Cities should ensure that all building permits, planning regulations, and procedures are clear and concise and administered in a fair and timely manner.

6.13 When more than one jurisdiction is involved in planning and permitting a business development, the jurisdictions involved should collaborate to provide consistent development regulations and permitting to the greatest degree feasible.

6.14 The County and the Cities should support and encourage economic development efforts to diversify and expand basic manufacturing, construction-related, and service-related jobs.

6.15 The County and the Cities should encourage the recruitment of new employers to meet the county employment projections.

6.16 The County and the Cities should work together to facilitate and promote a range of job opportunities throughout the county to create a balance between jobs and housing.

6.17 The County and the Cities should work together, in coordination with business owners, schools, and skill centers, to promote training programs that give people opportunities to learn, maintain, and upgrade skills necessary to meet regional job needs.

6.18 The County and the Cities should foster appropriate and targeted economic growth in areas with low and very low access to opportunity to improve access to employment opportunities for current and future residents of those areas.

7. FISCAL IMPACT

Context

To preserve and maintain quality of life and level of governmental services, jurisdictions in Walla Walla County are expected to fully evaluate their financial capacity to provide the full range of urban services, as described in Chapter 1 within Urban Growth Areas (UGAs). The policies in this chapter focus on opportunities for coordination that would have a positive fiscal impact for the region.

Goals

Goal 1: Walla Walla County and the Cities will provide a means for assessing the cost of providing public services in conformance with their respective comprehensive plans.

Goal 2: Walla Walla County and the Cities will creatively pursue all means of financing required public improvements.

Goal 3: Walla Walla County and the Cities will work together, where feasible, on the fiscal impact of providing services within unincorporated Urban Growth Areas. This includes consideration of innovative tactics which could provide a positive fiscal impact for communities.

Policies

7.1 Where capital improvement, utility, and land use plans involve lands within or adjacent to the UGA, the County and the Cities, individually and jointly, shall routinely conduct fiscal analysis, consistent with capital facility and utility planning requirements in RCW 36.70A.070(3) and (4), that identifies the most cost-effective means of providing and locating public services and infrastructure over the long term.

7.2 Each capital improvement plan should include:

a. Plans for cooperation between the public and private sectors to ensure coordination of those plans with emphasis on the effective provision of services at the adopted level of service concurrent with demand;
b. Inventory of existing capital facilities; and
c. Assessment of future needs.

7.3 The County and the Cities should consider the use of innovative financing strategies for capital improvements that minimize the costs to taxpayers and provide for equitable assignment of costs between existing and new development.

7.4 The County and the Cities should consider the imposition of impact fees to ensure that new development pays its fair share for improvements necessitated by growth and contributes to

the overall financing of capital improvements. Changes in or impositions of new impact fees should be accompanied by an analysis consistent with statutory requirements.

7.5 The County and the Cities may develop a process for use by the jurisdictions to facilitate the identification, analysis, and disclosure of the fiscal impacts of major development proposals and governmental actions. The process shall establish a formula to address fiscal impacts, including tax revenues and service cost implications of the following:

a. Proposed changes in municipal boundaries;
b. Proposed changes in UGAs;
c. Proposed master planned resorts; and
d. Proposed large-scale residential, commercial, and industrial developments.

8. COORDINATION WITH TRIBAL GOVERNMENTS

Context

The Confederated Tribes of the Umatilla Indian Reservation – Cayuse, Umatilla, and Walla Walla – the Nez Perce Tribe, and the Yakama Nation all have treaty rights and ceded lands in Walla Walla County. These Tribes have authorities, responsibilities, interests, and treaty rights within their respective reservation boundaries as well as Usual and Accustomed Areas (the latter applies to Walla Walla County). Since future growth and land use decisions in Walla Walla County affect all governmental entities, governmental agencies (including the Tribes) must be well informed and continuously involved in regional and local planning.

The Growth Management Act (GMA) requires that "federal agencies and federally recognized Indian tribes whose reservation or ceded lands lie within the county shall be invited to participate in and cooperate with the countywide planning policy adoption process." (RCW 36.70A.210(4))
In addition, Countywide policies are required to address the protection of tribal cultural resources in collaboration with federally recognized tribes as above, provided that a tribe or multiple tribes choose to participate in the process. (RCW 36.70A(3)(i))

The Tribal coordination chapter is being provided as a placeholder if federally recognized Indian tribes, whose reservation or ceded lands lie within the county, choose to participate in the process to amend or update the Countywide Planning Policies in the future. This could provide a process to strengthen coordination and communication on permitting and planning processes utilized by the County and cities and enhance processes for protection of cultural resources.

Goals

Goal 1 - Walla Walla County and the Cities will invite federally recognized Tribes with ceded lands in the county to participate in planning and development activities and decisions.

Goal 2 - Walla Walla County and the Cities will protect natural and cultural resources in partnership with the Tribes.

Policies

7.6 The County and the Cities should provide meaningful and substantial opportunities for early and continuous tribal government participation in regional and local planning activities.

7.7 Local jurisdictions should work with the Tribes to develop agreements that ensure that the Tribes are consulted on issues within their interest early in the periodic update process. The parties to these agreements will jointly determine the appropriate contents of the agreements and a schedule for completing them.

7.8 The County and the Cities shall include Tribal government agencies in public notice and comment procedures and keep them informed of matters of interest to them.

7.9 The County and the Cities should ensure that their development regulations provide processes for inadvertent discovery of cultural resources during development activity.

9. ADVISORY COUNCIL, POLICY REVIEW AND AMENDMENT

Context

This document is meant to be a living document which guides coordination between the County and the Cities. As such, it is expected that it will undergo amendments periodically. This chapter outlines the process for future review and amendment of the Countywide Planning Policies (CPP) and appendices, and roles and responsibilities for implementation.

In 2023, Walla Walla County and the Cities within the county (City of Walla Walla, College Place, Waitsburg, and Prescott) adopted an interlocal agreement to jointly review and update and the Walla Walla Countywide Planning Policies (CPPs). The interlocal agreement established a group to lead the update with representatives of each jurisdiction, called the Project Management Team. Through the 2023-2024 update, the jurisdictions identified a need to continue the work of the Project Management Team. This chapter establishes a new advisory council, modeled after the 2023 team, to lead implementation and future amendments of the CPPs.

Goals

Goal 1 - An advisory council shall ensure that the Countywide Planning Policies are maintained and implemented and that planning between Walla Walla County and the Cities is accomplished in a coordinated, consistent manner.

Goal 2 - Maintain the Countywide Planning Policies consistent with the Growth Management Act.

Goal 3 - Ensure the Countywide Planning Policies reflect local circumstances accurately.

Goal 4 – Ensure adequate public notification and opportunity for involvement for updates to the Countywide Planning Policies.

Walla Walla County Growth Management Advisory Council

9.1 The jurisdictions hereby establish the Walla Walla County Growth Management Advisory Council. The primary responsibility of the council is to ensure that the Growth Management Act requirements are coordinated within the County, its Cities, and the region.

9.2 The Walla Walla County Growth Management Advisory Council shall:

a. Provide a forum, as necessary, for coordination and consensus in the development of local plans and plan implementation issues that are common among jurisdictions.
b. Promote coordination and consistency among local plans and between local plans and the Countywide Planning Policies and the Growth Management Act to the extent necessary to achieve regional policies and objectives.
c. Serve as a forum to amicably work together and address differences when they occur on important planning issues impacting Walla Walla County.

d. Coordinate the review, revision, and monitoring of the Land Capacity Analysis which aids in developing comprehensive plans.
e. Define and implement procedures that ensure opportunities for early and continuous public involvement in policy discussions facilitated by the Walla Walla County Growth Management Advisory Council.

9.3 Membership, Administration, and Decision-Making

a. Each jurisdiction, Walla Walla County, City of Walla Walla, City of College Place, City of Waitsburg and City of Prescott, may appoint a maximum of three members to the advisory council and may make provision for an alternate member to serve in the event that its appointed member(s) is unavailable or unable to serve.
b. Decision making by the advisory council should be collaborative and by consensus. However, in the event of impasse or disagreement, a decision may be made by a majority of the members of the advisory council.
c. The Community Development Department Director for Walla Walla County (Department) is designated as the administrator for the advisory council.
d. The Department and advisory council will communicate via in-person meetings, telephone, or email to relay information, answer questions, or raise concerns. All members will respond promptly to communications. The Department will ensure that information related to matters coming before the council is provided to the members in a timely manner.
e. The Department will keep the official council records and make them available to council members and the jurisdictions. Records shall be made available for public inspection in accordance with law.
f. The advisory council through the Department shall coordinate and cooperate with the Washington State Department of Commerce Growth Management Services.

Countywide Planning Policies Review and Amendment

9.4 The Walla Walla Countywide Planning Policies should be dynamic and regularly monitored for applicability and effectiveness.

a. The adopted Countywide Planning Policies should, at a minimum, be reviewed through the advisory council before each required comprehensive plan periodic update as required by RCW 36.70A.130.
b. The County or a city, or the advisory council, may propose amendments to the Countywide Planning Policies at any time.
c. The advisory council shall review and discuss the merits of the proposed amendment, revise the language as agreed to by the advisory council members via their bylaws, and make a recommendation on the amendment to the Board of County Commissioners.

9.5 County Review. Walla Walla County shall take action to consider and adopt amendments or revisions to the Countywide Planning Policies following a recommendation from the advisory council.

a. The County should conduct SEPA environmental review and public notice as required after receiving recommended amendments from the advisory council.
b. The County may ask the advisory council to respond to SEPA agency and public comments.
c. The Board of County Commissioners will invite the advisory council to a public meeting to discuss the proposed countywide planning policy amendments.
d. After this review, the Board of County Commissioners will vote on whether or not to send the draft amendments to the cities for review and ratification.
e. If the Board of County Commissioners does not vote to send the draft amendments to the cities for review, the Board should provide a written statement to the advisory council documenting their concerns or reasons for not doing so to facilitate further review.
f. The Board of County Commissioners may amend the final draft countywide planning policy amendments after consultation with the advisory council prior to sending the amendments to the cities for review.

9.6 City Approval Process. Within 60 days of the Board of County Commissioners' vote, the respective city legislative authorities must act by resolution to adopt the recommended amendment.
a. City approval means a vote by the legislative authority to approve or disapprove the proposed amendments (up or down vote). Draft amendments may not be modified during the city approval process.
b. If a city does not act, it shall be presumed that the city approves of the amendments.
c. If a city does not act, or does not vote to approve the amendments, their City Council should provide a written statement of its concerns or reasons for not doing so to the advisory council to facilitate further review.

9.7 County Approval Process. After the 60-day city review period has ended, or all four cities ratify the amendments or vote to not approve the amendments, the Board of County Commissioners shall hold a public hearing and may adopt or not adopt the proposed policy amendments. Draft amendments may not be modified during the county approval process.
a. If the Board of County Commissioners does not vote to approve the amendments, they should provide a written statement of their concerns or reasons for not doing so to the advisory council to facilitate further review.

9.8 The jurisdictions, through the advisory council, shall strive for ratification by all four cities and adoption by the County during these review processes.

Countywide Planning Policies Appendices

9.9 Appendices. As provided in Chapter 1, Countywide Planning Policies appendices will be added containing methodologies for conducting the Land Capacity Analysis, establishing countywide population, employment, and housing projections, and allocating those projections between the jurisdictions.

a. The jurisdictions will primarily rely on the advisory council's expertise for coordinating this technical planning work within the bounds of the adopted countywide planning policies. Each jurisdiction will be able to appoint representatives to the council and it is expected that council members are concurrently and separately consulting internally with other departments and officials as appropriate.
b. The appendices may be adopted and later amended by the Walla Walla County Board of Commissioners without going through the policy amendment adoption process listed above based on a recommendation of the advisory council if they are consistent with the countywide planning policies.
c. These appendices should be reviewed, along with the policies, by the advisory council before each required comprehensive plan periodic update as required by RCW 36.70A.130.

10. IMPLEMENTATION

Context

Countywide Planning Policies, to be effective, must be able to be implemented. While many countywide planning policies will be implemented by the county and cities through comprehensive plans, development regulations, and other programs, many policies will require ongoing coordination. In addition to the responsibilities defined in other countywide planning policy chapters, this section further clarifies the planning roles and responsibilities of the advisory council and member agencies.

Goals

Goal 1 - Walla Walla County and the Cities will coordinate at the staff level and via the Walla Walla County Growth Management Advisory Council on an ongoing basis to implement the countywide planning policies and address other planning issues as they arise.

Policies

10.1 Walla Walla County is the regional government within the county providing various services within unincorporated and incorporated areas as required and specified by law and by legal agreements. Walla Walla County shall:

a. Be responsible for the development, adoption, and implementation of comprehensive plans and development regulations for the unincorporated portions of the county.

b. Be responsible for coordinating water quality planning in multi-jurisdictional watersheds and for other environmental planning activities as agreed to by all affected and interested jurisdictions.

c. Be responsible for administering the federal Endangered Species Act in multi-jurisdictional watersheds as agreed to by all affected and interested jurisdictions.

d. If agreeable, consider executing interlocal agreements with each City as appropriate to address joint issues identified in the Countywide Planning Policies and other matters agreed to be of mutual interest.

e. Define and implement procedures that assure opportunities for early and continuous public involvement through short- and long-range planning efforts.

10.2 Cities within Walla Walla County provide a variety of services primarily to residents within their respective municipal boundaries. Cities shall:

a. Provide urban governmental services identified in the Growth Management Act and adopted interlocal agreements.

b. Be responsible for developing, adopting, and implementing comprehensive plans and development regulations within the incorporated boundaries of their respective city.

c. Participate with other agencies in multi-jurisdictional planning activities, including but not limited to environmental planning, transportation planning, and growth management planning.

d. If agreeable, consider executing separate interlocal agreements with Walla Walla County as appropriate to address issues identified in the Countywide Planning Policies and other matters agreed to be of mutual interest.

10.3 The Walla Walla County Growth Management Advisory Council will ensure that the Growth Management Act requirements are coordinated within the County, its Cities, and the region and monitory implementation of the Countywide Planning Policies as established in Chapter 9.

Implementation Table

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
Chapter 1: Urban Growth Areas and Contiguous and Orderly Development				
1.1.a. The County and Cities shall jointly coordinate, through the process outlined in Chapter 9, a Land Capacity Analysis methodology to provide a consistent estimate of the land supply available to accommodate future population and employment growth and projected housing needs. This includes setting a reasonable market factor. The adopted methodology will be attached as an Appendix.	Develop, agree to, and adopt and land capacity analysis methodology	County lead, in partnership with Cities	Prior to beginning 2026 comp plan update process (jurisdictions will need the methodology in order to establish capacity for growth targets)	Advisory Council and process established in Chapter 9
1.2.a. The County and Cities shall jointly coordinate, through the process outlined in Chapter 9, a methodology for distributing the forecasted population, housing, and employment growth (growth targets) consistent with the requirements of the Growth Management Act.	Coordinate the process for distributing population, housing, and employment growth among all jurisdictions/UGAs	County lead, in partnership with Cities	Prior to 2026 comp plan update	Population, housing, and employment growth targets reflected in Comprehensive Plans
1.2.b. The County and Cities, as part of their next Comprehensive Plan periodic updates, shall reflect those growth targets in their Comprehensive Plans, as adopted in an Appendix.	Adopt growth targets into comprehensive plan	All jurisdictions individually	During 2026 comprehensive plan update (and all those following)	Land use changes sufficient to accommodate growth targets
1.3.e. The County should adopt specific procedures for filing comprehensive plan amendments which will be processed	Adopt procedures for filing comp plan amendments	County	Prior to 2026 update	County code as well as supportive policy in comp plan update

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
concurrently with the state-required Periodic Update.	processed concurrently with periodic update cycle			
1.3.g. The County shall adopt procedures and criteria for considering UGA boundary revisions consistent with the requirements in RCW 36.70A.130(3)(c). Such 'swap' amendments must comply with applicable GMA criteria and shall not increase land capacity within the UGA beyond what is needed to accommodate the growth planned for the succeeding 20-year planning period and a reasonable market factor.	Adopt procedures and criteria for considering UGA boundary revisions (UGA "swap" amendments)	County	During 2026 periodic update	Procedures and criteria in comprehensive plan update for UGA boundary revisions consistent with new state law
1.4.a. Adopted City and County comprehensive plans shall reflect the intent that all land within unincorporated Urban Growth Areas, where feasible, will either annex to a City or incorporate within the 20-year planning horizon.	Stated intent within comprehensive plans that all land within unincorporated portions of UGAs should be annexed into a City or should incorporate within the planning horizon	Cities	During 2026 comprehensive plan update	Policy language to this effect adopted into comprehensive plans.
1.4.d. The County and Cities should establish procedures to facilitate the smooth transfer of governance for associated Urban Growth Area(s).	Establish procedures to transfer governance of UGAs	County and Cities	Long-range (during the planning period)	Interlocal agreements, Advisory Council
1.4.f. The County and each City, where appropriate, should consider utilizing Interlocal Agreements (ILAs) as a mechanism to facilitate	Establish interlocal agreements to facilitate growth within UGAs	County and each City	Long-range (after 2026 comp plan update)	Interlocal Agreements

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
urban growth within unincorporated UGAs. An ILA could be utilized to coordinate on common development regulations and standards and permit review processes within these areas. This could result in development more closely aligning with adopted regulations within cities. This process could also be utilized to encourage the extension of urban services to these areas given urban growth typically requires urban governmental services.				
1.13 To adequately plan for growth and implement the policies of the GMA, the County, the Cities, and special districts in the county, should establish an ongoing mechanisms, such as the advisory council established in Chapter 9, to improve communication, information sharing, and coordinated approaches to common problems.	Establish an ongoing mechanism to improve communication, information sharing, and coordinated approaches to common problems	All jurisdictions – advisory council and other similar mechanisms	Medium term – after adoption of updated CPPs	Growth Management Advisory Council
1.14 Walla Walla County should coordinate with adjacent and/or nearby counties and cities on issues of growth and delivery of urban services that cross county or state boundaries.	Coordinate with adjacent counties and cities outside county boundaries	County	Long-range	Likely to be informal dialogue in the case of cross-state boundaries. Benton-Franklin COG could be a venue for engaging with counties to the west on planning issues.
Chapter 2: Public Capital Facilities and Essential Public Facilities				

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
2.1 The County and the Cities should consider including impacts upon historically marginalized communities and disproportionately burdened communities when siting or expanding capital facilities.	Develop criteria for consideration of impacts on historically marginalized and disproportionately burdened communities for capital facilities decisions	Advisory Council, any community could take the lead on this policy and then workshop with counterparts	During comprehensive plan periodic update	Comprehensive plan policies on capital facilities
2.8 The County and Cities should, where appropriate, integrate probability, vulnerability, and risk assessment information from the Walla Walla County Hazard Mitigation Plan into capital facilities planning.	Update of Hazard Mitigation Plan	County	Currently in progress, expected adoption late 2024	County should include cities and service providers in Hazard Mitigation Plan update process
2.11 The County and Cities should support planning for the provision of broadband infrastructure.	Identification of areas lacking broadband access in comprehensive plan; installing conduit for future broadband cable where possible; pursue grants from state and federal sources to fund construction of fiber optic or other broadband infrastructure	All jurisdictions	Identify areas lacking access in 2026 comprehensive plan update. Other provisions as needed	Policy and capital facilities planning
Chapter 3: Rural and Resource Lands				

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
3.2 The County should consider input from Cities on establishing appropriate land use designations and development regulations for rural land that is expected to be included within an Urban Growth Area and be annexed in the future to ensure eventual orderly inclusion.	Input from cities on appropriate designations for rural land that may be suitable for inclusion in the UGA	County	During County comprehensive plan update	Meetings led by County with each City to establish land use designations for areas that may be suitable for inclusion in UGAs
3.3 The County and the Cities should work together early in the planning process to identify and designate greenbelts and open space corridors within and between urban growth areas. These areas may include recreation, fish and wildlife habitat, trails, and connection of critical areas and buffers.	Designate greenbelts and open space corridors within and between UGAs	County and Cities	During next comprehensive plan update	Work of the advisory council
3.5 The County shall protect the "right to farm" in agricultural areas in its Comprehensive Plan and development regulations.	Confirm that development regulations protect right to farm or develop new code	County	Annual code amendment process	Buffers and use regulations
4.1 Walla Walla County and the Cities should maintain participation in the MPO/SRTPO to ensure transportation planning is consistent, local needs are reflected in the Regional Plan, and to avail themselves of transportation planning technical services.	Maintain staff participation in MPO	All jurisdictions	Ongoing	Annual work plans/budgets
4.2 Each comprehensive plan adopted pursuant to the Growth Management Act shall contain a transportation element consistent with the Regional Plan's land use and economic	Adopt transportation element consistent with the regional transportation plan's land use and	All jurisdictions	During 2026 comprehensive plan update	Comprehensive plan drafting – assess transportation element's

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
development policies as well as those of jurisdictions in the planning area.	economic development policies			consistency with 2045 Plan.
4.3 The County and the Cities should consider including impacts upon historically marginalized communities and disproportionately burdened communities when siting or expanding transportation facilities, including transportation facilities of a statewide nature.	Develop criteria for consideration of impacts on historically marginalized and disproportionately burdened communities for transportation facilities decisions	Advisory Councils, any community could take the lead on this policy and then workshop with counterparts	During comprehensive plan periodic update	Comprehensive plan policies on transportation. Also, the jurisdictions should develop criteria in code or directors' decisions for evaluating transportation projects that incorporates this.
4.4 The County and the Cities should work toward establishing multi-modal levels of service that are sensitive to differences between UGAs and rural areas and that are consistent across jurisdictions when facilities cross jurisdictional boundaries.	Establish multi-modal levels of service in comprehensive plan	County leads	During comprehensive plan updates	Comprehensive plan levels of service in transportation element
4.5 The County and the Cities should adopt a cooperative process for early coordination of public and private capital projects that may impact the transportation system in the county or a neighboring jurisdiction. This process should include an early referral and response mechanism and appropriate criteria for use in	Adopt cooperative process for early coordination of capital projects that may impact the transportation system in the county or a neighboring jurisdiction	County leads, including drafting early referral and response	During comprehensive plan update cycle	County should consider adopting a process into its comprehensive plan, and cities should adopt policies to participate.

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
evaluating the impacts of a proposal. This process should also apply to any transportation improvements contemplated by one jurisdiction that will impact an adjacent jurisdiction and should allow for mitigations across jurisdictional boundaries.		mechanism, cities provide feedback.		
4.6 The County and the Cities should develop policies in their comprehensive plans to support Target Zero/Vision Zero, Complete Streets, and Context Sensitive Solutions as appropriate to circumstances.	Adopt policies in comprehensive plans that support Target Zero/Vision Zero, Complete Streets, and Context Sensitive Solutions as appropriate	All jurisdictions	During 2026 comprehensive plan update cycle	Each jurisdiction will have to determine during policy development in the comp plan update the appropriate circumstances for these programs or priorities.
4.7 The County and the Cities should coordinate with the MPO to collect non-motorized activity data that can be standardized countywide.	Collect non-motorized activity data in a way that is standardized in coordination with MPO	All jurisdictions (MPO lead)	Ongoing	Public works work programs. Staff assigned to work with MPO should coordinate with the MPO staff.
5.1 The County and the Cities shall plan for and accommodate a wide range of housing development types and densities throughout the county to meet the needs of a diverse population.	Housing allocations by income bracket; needs assessment and gap analysis and adequate provisions documentation in individual comprehensive plans	County (leads Housing Allocations by income bracket); County and Cities lead needs	During 2026 comprehensive plan update	Comprehensive Plans for individual jurisdictions

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
		assessment and gap analysis and adequate provisions documentation in individual plans. Coordination via Advisory Council.		
5.2 The County and the Cities shall encourage affordable housing through innovative land use techniques, including but not limited to financial incentives, clustering, planned unit development, maximum lot size provisions, infill housing incentives, and density bonuses, including to retain existing housing.	Development of codes to implement these tools as deemed appropriate by jurisdictions	Cities primarily (County not expected to plan for housing below 50% AMI re: Commerce guidance)	Concurrent with 2026 comprehensive plan periodic updates (some may go longer depending on what is needed to demonstrate adequate provisions being made for all economic segments)	Development regulations updates necessary as part of becoming consistent with 2026 comprehensive plan updates
5.3 The County and the Cities should encourage and support financial incentive programs for homeownership.	Develop and implement programs to incentivize homeownership for households making below	Mostly cities	Long-range (will likely require establishing funds or fee programs that	Various mechanisms, including development agreements with organizations like Habitat

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
	100% AMI (potentially targeted at 50-80% and 80-100%)		may take time to fully fund or implement)	for Humanity, impact fee or other fee waivers for single-family homes or townhomes with affordability covenants
5.4 The County and the Cities should pursue partnerships with nonprofit agencies, such as Blue Mountain Action Council and others, to ensure that housing needs are being met.	Engage with BMAC and other nonprofit organizations to provide input on housing needs	County lead, Cities participate	Begin with housing needs assessment partnership during early phases of 2026 comprehensive plan update	County representative attend BMAC meetings or vice versa; invitations from all jurisdictions to have BMAC or other staff prepare material and brief councils/commission on housing needs
5.5 The County and the Cities shall each identify specific policies and implementation strategies in their respective comprehensive plans and shall enact implementing regulations to provide a mix of housing types for housing at all income levels, considering easy access to employment centers.	Develop implementation strategies in individual comprehensive plans	All jurisdictions individually	During 2026 comprehensive plan update	Develop implementation strategies or tools during policy writing phase of comprehensive plan periodic update process
5.6 The County and the Cities should share data and methodology for the housing needs assessments in their comprehensive plans to ensure consistency.	Share data and methodology for housing needs assessments	Cities lead (City of Walla Walla probably has the most robust data so it	Early stages of 2026 periodic update process	Housing Needs Assessments (appendices in comprehensive plans)

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
		might make sense for them to lead)		
5.8 The County and the Cities may create or support a registration program with a consolidated database of available government-supported affordable housing units in the region including inventory, availability, conditions, and price structure, which should also link to website providing tenant information on application and screening. (See pages 26-27 of the adopted Regional Housing Action Plan.)	Create or support a consolidated database of government-supported affordable housing units.	All jurisdictions and/or external partners	Long-range (post-2026 update)	Secure database for jurisdictions to use with public-facing website providing tenant information and screening
5.10 The County and the Cities should evaluate the impact of any new ordinance or regulation that may affect housing affordability with regard to the provision of housing options prior to adoption.	Evaluate proposed ordinances' or regulations' effects on housing affordability	All jurisdictions individually	Medium- to long-range (2026 and beyond)	Add criteria to internal staff report templates or requirements
5.11 The County and the Cities should support reducing or eliminating minimum lot size requirements within Urban Growth Areas to promote the development of greater diversity of housing types where feasible.	Reduce or eliminate minimum lot size requirements within UGAs	All jurisdictions	Any annual code amendment docket	Code amendments in individual jurisdictions
5.14 The County and the Cities should periodically review permit processes to ensure	Periodic review of permit processes	All jurisdictions individually	Every year during code cleanup process (or however	Preparation of permit data reports to Commerce should be followed by

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
permits are processed in a timely and fair manner.			frequently this is done). Annual reports on permit process are required of jurisdictions	presentation to or discussion with decision making bodies about the results to ensure accountability for timely and fair permit processing.
Chapter 6: Countywide Economic Development and Employment				
6.2 Walla Walla County and the Cities should coordinate the economic development element of local comprehensive plans with other elements of those plans, with particular attention being given to coordination with the land use and capital facilities elements.	Ensure economic development elements are coordinated with other elements, especially land use and capital facilities	All jurisdictions individually	During 2026 comprehensive plan updates	Policy consistency review between land use and capital facilities and economic development elements
6.3 The County and the Cities should ensure an adequate supply of industrial property throughout the county based on needs identified in the economic development elements of their comprehensive plans and should support the development of infrastructure to service lands designated as industrial.	Periodically assess supply of industrial land in response to development that occurs and ensure supply is adequate on regular basis.	County lead, coordinate with cities and economic development agencies, Advisory Council	During comp plan update and at regular intervals (perhaps every year or every five years)	Periodic updates and 5-year check-in should include assessment of industrial land supply taking into account pipeline projects, at a minimum. Individual jurisdictions could choose to assess supply more frequently depending on development trends.

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
6.4 The County should recognize the importance of industrial zoned property on the Columbia/Snake River system for the efficient transportation of local commodities to world markets and support efforts to protect and encourage industrial zoned property on the river system.	Comp plan policy or policies recognizing importance of industrial-zoned property on the Columbia/Snake River system	County	Part of 2026 comprehensive plan update	Policy analysis and writing to properly incorporate this CPP
6.6 The economic development elements of all jurisdictions should encourage inter-jurisdictional coordination and cooperation on economic development issues, particularly those that affect the size and diversity of the economic base. Comprehensive plans should encourage coordination between local economic development organizations.	Adopt one or more policies that encourage interjurisdictional cooperation and coordination on economic development issues	All jurisdictions	During 2026 comprehensive plan update	Policy language could likely be shared between jurisdictions.
6.12 The County and the Cities should ensure that all building permits, planning regulations, and procedures are clear and concise and administered in a fair and timely manner.	Periodic review of permit processes	All jurisdictions individually	Every year during code cleanup process (or however frequently this is done). Annual reports on permit process are required of jurisdictions	Preparation of permit data reports to Commerce should be followed by presentation to or discussion with decision making bodies about the results to ensure accountability for timely and fair permit processing.
Chapter 7: Fiscal Impact				

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
7.1 Where capital improvement, utility, and land use plans involve lands within or adjacent to the UGA, the County and the Cities, individually and jointly, shall routinely conduct fiscal analysis, consistent with capital facility and utility planning requirements in RCW 36.70A.070(3) and (4), that identifies the most cost-effective means of providing and locating public services and infrastructure over the long term.	Develop or update fiscal analysis standards located in comprehensive plans or capital improvement plans in line with RCW 36.70A.070(3) and (4).	All jurisdictions individually	Capital improvement plan updates as required in each jurisdiction; land use changes as part of annual docket requests as well as periodic updates	Advisory council or similar body should jointly develop standards for fiscal analyses that are consistent with RCW 36.70A.070 and meet needs of all jurisdictions.
7.2 Each capital improvement plan should include: d. Plans for cooperation between the public and private sectors to ensure coordination of those plans with emphasis on the effective provision of services at the adopted level of service concurrent with demand; e. Inventory of existing capital facilities; and f. Assessment of future needs.	Ensure capital improvement plans meet the standards enumerated in this policy.	All jurisdictions	Next update to each jurisdictions' capital improvement plan.	Capital improvement plan text.
7.4 The County and the Cities should consider the imposition of impact fees to ensure that new development pays its fair share for improvements necessitated by growth and contributes to the overall financing of capital improvements. Changes in or impositions of	Introduce discussion of impact fees with decision making bodies in each jurisdiction as appropriate	Staff at each jurisdiction	After 2026 comprehensive plan update	Annual work program for city councils/board of county commissioners.

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
new impact fees should be accompanied by an analysis consistent with statutory requirements.				
7.5 The County and the Cities may develop a process for use by local government to facilitate the identification, analysis, and disclosure of the fiscal impacts of major development proposals and governmental actions. The process shall establish a formula to address fiscal impacts, including tax revenues and service cost implications of the following: e. Proposed changes in municipal boundaries; f. Proposed changes in UGAs; g. Proposed master planned resorts; and h. Proposed large-scale residential, commercial, and industrial developments.				
Chapter 8: Coordination with Tribal Governments				
8.2 Local jurisdictions should work with the Tribes to develop agreements that ensure that the Tribes are consulted on issues within their interest early in the periodic update process.	Work with tribes to develop agreements that ensure Tribes are consulted early in the periodic update process	Each jurisdiction	Early in the 2026 comp plan update process (late 2024)	Letter from mayor/other chief executive or elected official to appropriate Tribal official formally

Policy requiring one or more jurisdictions to take tangible action	Action(s) needed	Responsible party(ies)	Timeline	Implementation mechanism
Policy Prioritization Key	"Shall" policy (required, usually related to statutory requirements)	"Should" policy (implementation expected, but completion is not mandatory)		"May" policy (either advisable or allowed)
The parties to these agreements will jointly determine the appropriate contents of the agreements and a schedule for completing them.				inviting participation in the comp plan process. Should be done in early stages of public engagement and scoping so information can be provided with Tribes about opportunities to participate.
8.3 The County and the Cities shall include Tribal government agencies in public notice and comment procedures and keep them informed of matters of interest to them.	Public notice and comment procedures specifically include Tribal government agencies	Each jurisdiction individually	Early 2025 at the latest to ensure notice is being provided appropriately during early phases of comp plan update	Municipal/county code and SEPA distribution lists (annual work program)
8.4 The County and the Cities should ensure that their development regulations provide processes for inadvertent discovery of cultural resources during development activity.	Review or develop inadvertent discovery language into code	Staff from all jurisdictions	2025	Annual work program

Appendix IX. Climate Vulnerability Assessment

Walla Walla Climate Element

Climate Vulnerability Assessment



The City of Walla Walla Climate Element is supported with funding from Washington's Climate Commitment Act. The CCA supports Washington's climate action efforts by putting cap-and-invest dollars to work reducing climate pollution, creating jobs, and improving public health. Information about the CCA is available at www.climate.wa.gov.

GLOSSARY

- **Adaptive Capacity:** The ability to moderate the damage of, cope with, or adjust to climate change. An example of this is having access to a vehicle and health insurance which increases people's ability to manage health impacts from extreme heat, smoke, and any injuries related to climate hazards.
- **Climate Change:** The long-term shifting of environmental conditions and a change in predicted weather patterns. Climate change shows itself in many ways, including changes in rainfall, droughts, increasing floods, and heat waves.
- **Climate Hazards:** The climate-related physical events or trends that may cause damage and loss, such as floods, extreme heat, and wildfire.
- **Climate Risks**: The potential impacts that climate change could have on a system, which depend on its exposure to climate factors and its sensitivity to those changes.
- **Exposure:** The degree to which a system is exposed to climate hazards. For example, areas in towns and cities that are in a 100-year floodplain will have higher exposure to flooding impacts.
- **Sensitivity:** The degree to which that system is likely to be affected by climate change. For example, older adults are less able to regulate their body temperatures and thus more physically sensitive to extreme heat than younger people.
- **Frontline Communities:** Communities that will be disproportionately impacted by climate change; these are the populations that face historic and current inequities, often experience the earliest and most acute impacts of climate change and have limited resources and/or capacity to adapt.
- **Overburdened Communities:** Geographic areas where vulnerable populations experience multiple, compounding environmental harms and health risks. In Washington State, these communities have historically faced systemic health, social, and environmental inequities, leading to disproportionate exposure to pollution, climate hazards, and limited access to resources that support well-being.
- **Urban Heat Island Effect:** Urban areas that are significantly warmer than surrounding rural areas. They form where there is limited greenery and a high density of heat-absorbing urban materials, such as concrete, asphalt, and buildings. Heat islands can occur in small or large cities and suburban areas, or anywhere with large extents of heat-absorbing surfaces and fewer trees.
- **Vulnerability**: The state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of the capacity to adapt.

EXECUTIVE SUMMARY

The Climate Vulnerability Assessment (CVA) is a foundational component of Walla Walla's Climate Element (CE) for the 2026 Comprehensive Plan update. This document provides an overview of current and projected climate risks affecting the city's infrastructure, ecosystems, and residents, serving as a critical resource for climate resilience and adaptation planning. The purpose of this document is to guide the development of CE measures to enhance climate resilience and integrate climate considerations into future planning and development.

Climate Impacts: Today and Tomorrow

The City of Walla Walla ("Walla Walla") has already experienced climate impacts and will continue to be affected by climate hazards, such as rising temperatures, periods of poor air quality, and reduced winter snowpack leading to drought. The Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report highlights the need to reduce emissions and prepare for climate impacts. Without action, these impacts will grow more intense, and adaptation will be necessary across multiple sectors to avoid ever-worsening outcomes (IPCC, 2023). Without investments into climate action at the global scale and adaptations to current and future climate risks, the city is expected to face increasingly severe climate impacts, including:

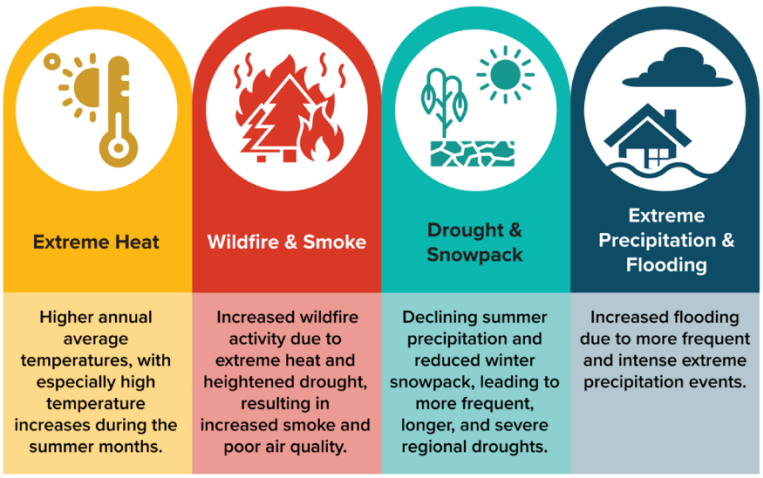


Figure 1. Key Climate Impacts in the City of Walla Walla

As part of Walla Walla's update to its Comprehensive Plan, the City is developing a Climate Vulnerability Assessment to provide an overview of current and future climate risks that are affecting Walla Walla's social, economic, environmental, and physical systems. This CVA will be used to develop and prioritize Climate Resilience Element goals and policies to enhance climate resilience in the city.

Assessing Vulnerability

The CVA focuses on key climate risks and hazards affecting Walla Walla's assets and sectors aligned with the Comprehensive Plan. The risk assessment examines climate risks in terms of exposure and sensitivity and assesses the ability of a sector to respond by examining the adaptive capacity. **Exposure** refers to the extent a system encounters climate hazards, **sensitivity** assesses the system's likelihood of being affected, and **adaptive capacity** reflects the system's ability to cope with or adjust to climate impacts.

The CVA analysis draws on extensive research from municipal, county, state, federal, Tribal, and peer-reviewed sources, supplemented by input from the City's Climate Policy Advisory Team (CPAT). This collaborative planning process included one community survey, one staff listening session, and three CPAT meetings to address climate and hazard risks and inform resilience policies.

Key Findings

Key findings for each of the three sectors analyzed in this CVA are summarized here, with an overall climate vulnerability ranking. The overall vulnerability score for each sector combines the climate risk and adaptive capacity scores to provide a broad understanding of vulnerability to climate change impacts, ranging from low to high. A "high vulnerability" rating signifies both a high level of climate risk and a low level of adaptive capacity. Whereas a "low vulnerability" rating indicates a low level of climate risk and a high level of adaptive capacity. The ranking tables below include icons to indicate the degree of climate risk, adaptive capacity, and overall vulnerability. Further details on this scoring, methodology, and rationale are in the Approach and Methodology and Appendix 1. Climate Risk and Adaptive Capacity Scoring Matrix section.

The CVA is divided into three main sectors: Community Health and Well-Being, Natural Environment and Water Resources, and Built Infrastructure. These sectors were identified in collaboration with City staff and CPAT. Assessing infrastructure and assets impacted by climate hazards using sectors aligns with Commerce guidance. The sector structure enables city staff to quickly identify information relevant to their departmental operations. Additionally, each sector has three sub-sectors. While some sub-sectors and their assets may align with other sectors or sub-sectors, the designations represent the most relevance and connection within the sector.

Community Health and Well-being

Walla Walla's community health and well-being is vulnerable to extreme heat, flooding, and wildfires. These climate hazards will be especially impactful to vulnerable populations including the elderly, disabled, unhoused, and those living with chronic health conditions. More frequent and severe heatwaves, floods, and wildfires can strain emergency services as more people may be needing care and resources. Outdoor workers, including those in construction and agriculture, face risk of poor air quality and heat stress during wildfires and extreme heat days. The City has some plans including a Community Wildfire Protection Plan to increase wildfire emergency responses, but additional planning is needed to address public health impacts from extreme heat and flooding.

Table 1. Community Health and Well-being Climate Vulnerability Ranking

Sector	Climate Risk	Adaptive Capacity (Ability to Adapt)	Vulnerability
Physical and Mental Health	 High	 Moderate	 Moderate/High
Emergency Management	 Moderate	 Low	 Moderate
Community Services	 Moderate	 Low	 Moderate

Natural Environment and Water Resources

Walla Walla's natural environment and water resources face significant risks from climate change, including extreme heat, drought, and wildfires, which threaten ecosystems, agriculture, and water quality. Rising temperatures and reduced snowpack are putting stress on water resources, impacting agriculture, fisheries, and habitats, while increasing wildfire frequency threatens timber, water quality, and vulnerable watersheds. Drought and declining snowpack further stress water supplies, with the potential for long-term impacts on agriculture, water infrastructure, and streamflow. Although some measures are in place, such as water conservation and wildfire protection, more comprehensive planning is needed to address the increasing risks to agriculture, ecosystems, and cultural resources from climate change.

Table 2. Natural Environment and Water Resources Climate Vulnerability Ranking

Sector	Climate Risk	Adaptive Capacity (Ability to Adapt)	Vulnerability
Ecosystems, Parks, and Open Space	Moderate/High	Moderate/High	Moderate/High
Water Supply and Quality	Moderate/High	Moderate	Moderate/High
Resource Lands	Moderate/High	Moderate/Low	Moderate/High



Built Infrastructure

Housing and transportation infrastructure in Walla Walla faces significant heat, wildfire, and flooding risks due to the urban heat island effect, wildfire and smoke occurrence in the region, and numerous streams and creeks throughout the city. Extreme temperatures will damage the city's transportation and housing infrastructure, leading to higher maintenance and repair costs, as well as increased financial strain and public health risks for residents. Walla Walla also faces a high risk of short-duration, high-volume flooding from Mill Creek, driven by intense rain or rapid snowmelt. While the Mill Creek flood control project has reduced flood impacts in the city, aging infrastructure and recurring floods highlight ongoing vulnerabilities, especially upstream and downstream of the flood control channel. Walla Walla has undertaken several projects to increase stormwater resilience including street trees, bioswales, and additional pipe capacity. While some structures face direct and indirect wildfire exposure risk, the most significant impact from wildfire might be decreased air quality during fire season. Additional planning is needed to increase weatherization in current and new housing, and to properly determine climate hazard risks to housing, roads, and other key infrastructure.

Table 3. Built Infrastructure Climate Vulnerability Ranking

Sector	Climate Risk	Adaptive Capacity (Ability to Adapt)	Vulnerability
Transportation	 Moderate	 Low	 Moderate
Housing	 Moderate/High	 Moderate	 Moderate/High
Water Infrastructure	 Moderate	 Moderate	 Moderate/Low

Next Steps

The results of the CVA will be used to inform policy development for the City Climate Element as part of the Comprehensive Plan update.

INTRODUCTION

Report Goals

To ensure that resilience measures address the climate impacts that are most relevant to the City of Walla Walla, Cascadia Consulting Group (project team) is conducting this **Climate Vulnerability Assessment** as part of the first phase of the Climate Element planning process. The vulnerability assessment will help the project team, the City, and planning partners prioritize climate resilience measures. This CVA complies with Washington State Department of Commerce's Climate Element Guidance, and aims to:



Figure 2. Primary objectives of the Climate Vulnerability Assessment

Why Assess Climate Change Vulnerability?

Walla Walla is already facing climate change effects, such as rising temperatures, more frequent droughts, and shifts in precipitation patterns. The IPCC's Sixth Assessment Report (2023) highlights the urgency of mitigation and adaptation, warning that without action, climate impacts will worsen, and adaptation will be necessary across multiple sectors to avoid the worst outcomes (IPCC, 2023). Without investments into climate action and adaptations to current and future climate risks, the city is expected to face increasingly severe climate impacts, including rising annual average temperatures, reducing snowpack and variable precipitation leading to longer and more frequent droughts, worsened wildfire smoke and poor air quality days, and more intense extreme weather events.



Wildfire Smoke Walla Walla Valley (Union Bulletin, 2023)

Recent examples of climate impacts include the record-breaking heat dome experienced in the summer of 2021, which caused significant heat-related illness and infrastructure strain. Coordinating climate planning efforts helps the City address "compounding impacts," where multiple hazards—such as wildfires and power outages—occur simultaneously, resulting in greater damage and more complex recovery efforts. For instance, wildfires can increase air pollution (PM2.5), and when combined with a heat wave and power outages, it can create hazardous health conditions.

Approach and Methodology

This CVA leverages research available across City, county, state, federal, and peer-reviewed sources to assess how various systems across the city are vulnerable to climate change. As a first step, the project team reviewed the landscape of current climate change risks and plans across multiple City, county, and regional reports. This CVA builds on a solid foundation of climate research, data, and planning to provide an analysis specific to Walla Walla and areas within the city.

Sectors

The project team used a qualitative approach to analyze existing literature with the goal of creating three sector-focused vulnerability assessments. There are three primary sectors within this CVA. These sectors are defined below (Table 4).

Table 4. CVA Sectors and Sub-sectors

Sector	Sub-sector
Community Health and Well-being	• Public health (physical and mental health) • Emergency management • Community services
Built Infrastructure	• Housing • Transportation • Water infrastructure
Natural and Water Resources	• Ecosystems, parks, and open space • Water supply and quality • Resource lands

Climate Vulnerability Framework

Climate vulnerability is defined by the Intergovernmental Panel on Climate Change (IPCC) as a combination of **climate risks** (a combination of exposure to climate impacts and sensitivity to those impacts) and the **capacity to adapt** (Figure 3). We use this framework to understand Walla Walla's vulnerability to climate change. To characterize **Climate Risk,** we looked at:

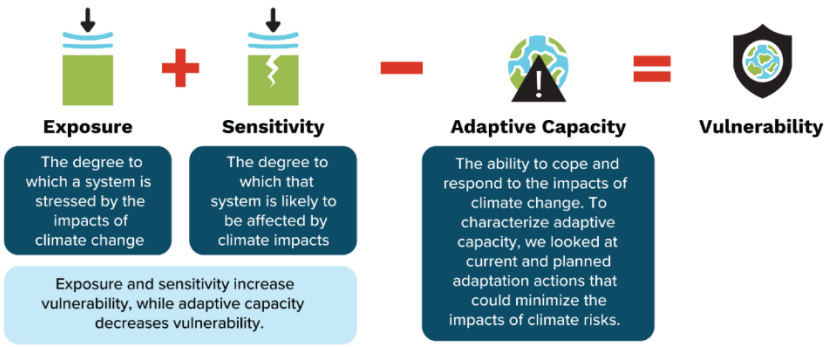


Figure 3. Climate Vulnerability Framework

Climate risks (Exposure plus Sensitivity) increase vulnerability, while adaptive capacity helps reduce vulnerability. A CVA can help identify ways to boost adaptive capacity or manage risks, thereby enhancing the city's resilience to climate change.

The overall vulnerability score for each sector combines the climate risk and adaptive capacity scores to provide a broad understanding of vulnerability to climate change impacts, ranging

from low to high. A "high vulnerability" rating signifies both a high level of climate risk and a low level of adaptive capacity. Whereas a "low vulnerability" rating indicates a low level of climate risk and a high level of adaptive capacity. For the full Climate Risk and Adaptive Capacity Scoring Matrix, refer to Appendix 1. Climate Risk and Adaptive Capacity Scoring Matrix.

It is important to note that this city-wide assessment is not intended to evaluate specific infrastructure or assets. Individual facilities and communities may have vulnerabilities that differ from the sector-level findings. Though this methodology is based on established methods, these rankings are meant to be informative and may not encapsulate some of the nuances of climate vulnerability across Walla Walla.

Documents and Resources

This CVA leveraged a wide body of research available from City, county, state, federal, and academic and peer-reviewed sources. The project team review of academic, professional and government sources was also supplemented with local, community-based sources including local newspapers and various community engagement activities. Resources reviewed include:

Category	Resources
Walla Walla Policy and Planning Context	• City of Walla Walla Comprehensive Plan (2018) • Walla Walla County Hazard Mitigation Plan (2025) • Walla Walla Water 2050 Strategic Plan (2021) • Walla Walla Regional Housing Action Plan (2021) • City of Walla Walla Urban Forestry Management Plan (2021) • City of Walla Walla Stormwater Management Plan (2015) • CTUIR Climate Adaptation Plan (2022) • City of Walla Walla Strategic Plan (2024) • Tiger Mill Plan (2025) • Walla Walla Continuing Operations Plan (2023) • Go Walla Walla Project Story Map
Regional Climate Data and Assessments	• Climate Mapping for a Resilient Washington (2023) • Fifth National Climate Assessment (2023) • Washington State Climate Summary (2022) • PNW Temperature, Precipitation, and SWE Trend Analysis Tool (2023)
Social Vulnerability Assessment Tools	• Census Data • CDC Social Vulnerability Index • WA Environmental Health Disparities Tool • Climate and Economic Justice Screening Tool

Please refer to Appendix 3. Social and Economic Vulnerability for a detailed analysis on how Walla Walla's social and economic vulnerability was considered throughout this assessment.

Spatial Analysis

In addition to existing City maps, the project team created new maps to better assess the extreme heat and wildfire vulnerabilities to key assets in Walla Walla, as well as social vulnerability data. Data was compiled from multiple data sources including the City of Walla Walla, Trust for Public Land, and the US Census Bureau. The City of Walla Walla GIS team provided point and polygon data for key features including trees, housing, and community buildings. Critical facilities and housing points were supplemented and verified with internet searches. All maps were developed in ArcGIS Pro.

Map	Data Source
Heat Severity	Trust for Public Land
Critical Facilities	City of Walla Walla – GIS Supervisor
Housing	City of Walla Walla – GIS Supervisor
Tree Canopy and Parks	City of Walla Walla – GIS Supervisor
Age and Income Demographics	US Census Bureau - American Community Survey

Engagement

The City and relevant partners were engaged through review periods, presentations, and workshops. During the CVA drafting process, the project team presented preliminary findings to the CPAT and conducted a staff workshop to solicit input and gather additional information . The vulnerability assessment was also shared with the City staff team and CPAT members for one round of review. The project team relied on input and data gathered from Climate Resilience Element public engagement activities, such as the Climate Survey, to ensure the CVA reflects local understanding and priorities.

CLIMATE CHANGE TRENDS AND PROJECTIONS

This summary analyzes historical trends and future projections to illustrate the current and anticipated impacts of climate change and related hazards in Walla Walla. The city is expected to face the following climate impacts now and into the future:

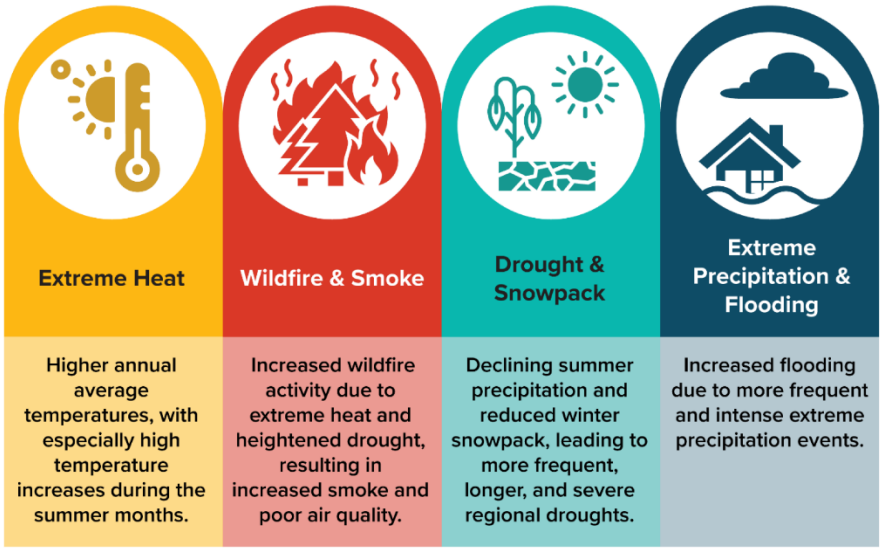


Figure 4. Key Climate Impacts in the City of Walla Walla

Climate Impacts Assessment

Methodology

The first step in the Vulnerability Assessment process was to perform a climate impacts assessment. To complete this, the project team used a variety of established and peer-reviewed resources—including the University of Washington's Climate Impacts Group's Climate Mapping for a Resilient Washington, NOAA National Centers for Environmental Information WA State Climate Summary, the 5th National Climate Assessment's Northwest Chapter, and other relevant studies and datasets—to identify observed and projected climate trends relevant for the city. When city-scale data was not available, the team relied on Walla Walla county-scale climate impact data, as noted throughout the document. Additionally, while earthquakes present a natural hazard to the city, earthquakes were not included as a climate hazard because there is limited verified correlations between climate change and earthquakes (Walla Walla County -

Emergency Management, 2024). For the full Climate Impacts Summary, see Appendix 2. Summary of Climate Impacts.

Climate Drivers and Variability

Climate change refers to the long-term shifting of environmental conditions and weather patterns. Climate change is primarily caused by human activity, particularly the emission of greenhouse gases (GHGs) from burning fossil fuels. Higher levels of atmospheric GHGs, notably carbon emissions, have driven the increase in land and ocean temperatures since the Industrial Revolution, leading to various biophysical impacts such as more frequent and intense heatwaves, wildfires, storms, droughts, melting glaciers, sea-level rise, and ocean acidification (Marvel, et al., 2023).

Natural feedback processes like the El Niño-Southern Oscillation and the Pacific Decadal Oscillation contribute to variations in air temperature, extreme weather events, precipitation, and ocean conditions over interannual and interdecadal periods. However, the rate of climate change caused by human activities far exceeds any natural variability from these processes (Perlwitz, Knutson, Kossin, & LeGrande, 2017).

Climate Scenarios and Projection Models

The rise in GHG emissions in the atmosphere has already caused the climate to change significantly, as described above. Models projecting future climate conditions and impacts, including how climate hazards will increase and intensify over the next century, use a variety of climate scenarios. These scenarios are based on factors such as future land use, population growth, technological innovation, and global GHG emission levels.

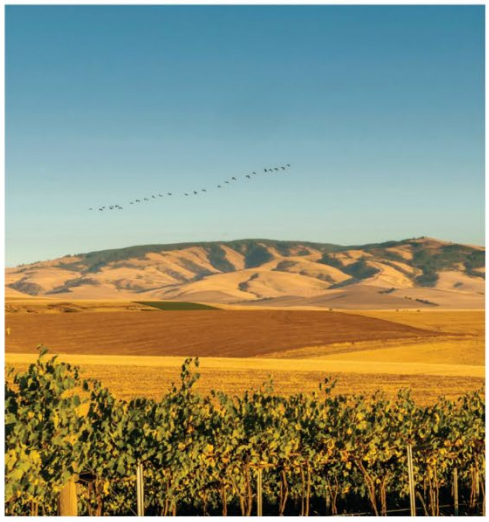
The Representative Concentration Pathways (RCPs) are scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) to model potential climate futures based on different levels of greenhouse gas concentrations. Each RCP represents a different "pathway" or level of carbon dioxide and other emissions in the atmosphere, depending on a range of possible human behaviors and climate processes. These pathways allow researchers, policymakers, and communities to explore potential risks and plan for changes (IPCC, 2022).

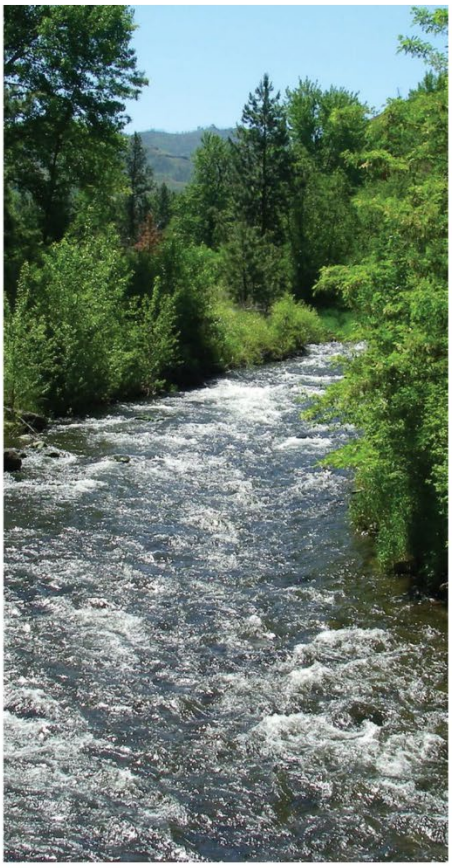
This vulnerability assessment will primarily use RCP 8.5, which represents a ”business-as-usual” scenario in which emissions continue at their current trajectory. It is a high emissions scenario and projects a global temperature warming of about 4.3˚C (approximately 7.7 ˚F) by 2100 relative to pre-industrial temperatures (IPCC, 2022). This CVA primarily uses RCP 8.5 because it represents the most realistic emissions trajectory that we are currently on.

CLIMATE VULNERABILITY ASSESSMENT

Relying on the methodology outlined above and building on the information gathered through the Climate Impacts Summary (Appendix 2. Summary of Climate Impacts) and the Social and Economic Vulnerability Assessment (Appendix 3. Social and Economic Vulnerability), the project team assessed the city's vulnerability across three key sectors. The following sections provide an assessment of overall climate vulnerability score, key takeaways and an overview of key climate risks and adaptive capacity within Walla Walla.









Community Health and Well-being

How to Read this Section

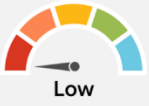
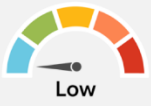
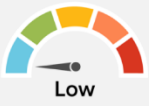
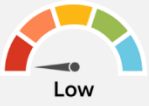
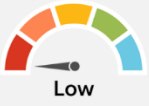
This section presents the climate vulnerability assessment of Walla Walla's physical health, mental health, emergency management, and community services sub-sectors. Each sub-sector includes an analysis of climate risks across relevant climate impacts, as well as a discussion on adaptive capacity. Note that the Community Health and Well-being sector overlaps with the other two sectors in topics such as resource lands and water infrastructure, so it is important to consider the full CVA for the most comprehensive analysis. Consequently, drought was not assessed for Physical and Mental Health or Emergency Management sub-sectors because the Natural Environment and Water Resources sector describes this climate impact and effect on communities in detail.

Introduction and Key Takeaways

Community health and well-being faces moderate risk from climate risks including extreme heat, extreme precipitation and flooding, and wildfire and wildfire smoke. Extreme heat events will impact vulnerable populations such as the unhoused, elderly, and ill, while wildfire smoke can worsen existing conditions and make it unsafe for people to work or recreate outside. Extreme precipitation and flooding can damage homes, cause trees to fall on people or buildings, and inundate important infrastructure and transportation networks in Walla Walla. Climate impacts, especially flooding and wildfire events, may strain emergency response resources. There is a need for additional comprehensive planning to address gaps to exposure and sensitivity to these climate impacts in this sector, especially for overburdened communities.

Table 5. Key vulnerability rankings for the community health and wellbeing sector

Physical and Mental Health			
Climate Stressor	**Climate Risk**	**Adaptive Capacity (Ability to Adapt)**	**Vulnerability**
Extreme Heat	 High	 Moderate	 Moderate/High
Extreme Precipitation	 Moderate	 Moderate	 Moderate
Drought	See Water Supply & Quality		
Wildfire/Wildfire Smoke	 High	 Moderate/Low	 High

Emergency Management			
Climate Stressor	**Climate Risk**	**Adaptive Capacity (Ability to Adapt)**	**Vulnerability**
Extreme Heat			
Extreme Precipitation			
Drought	See Water Supply & Quality		
Wildfire/Wildfire Smoke			
Community Services			
Climate Stressor	**Climate Risk**	**Adaptive Capacity (Ability to Adapt)**	**Vulnerability**
Extreme Heat			
Extreme Precipitation			
Drought			
Wildfire/Wildfire Smoke			

Physical and Mental Health

Climate Risk

Climate change has mental and community health impacts related to flooding and wildfire events that can displace and injure residents. In addition, Walla Walla experiences extreme temperature and storm events that can threaten the wellbeing of residents, especially vulnerable populations. Extreme heat, extreme precipitation, and poor air quality will lead to negative public health outcomes in the city, exacerbating chronic health problems and stressing the city's healthcare system (Vogel, J., et al., 2023). While all residents will experience physical and mental health impacts to some extent, some community members will be more sensitive to these impacts.

According to the WA Department of Health, Walla Walla has relatively high disparity ratings for Environmental Health Disparities, Socioeconomic Factors, and Sensitive Populations, with the north-west central area of the city ranking highest. For socioeconomic factors, which demonstrate the concentration of vulnerable populations in the area, such as those living below the poverty line, those without high school diplomas, and historically disadvantaged communities, Walla Walla's score is high, especially in the north-west area of the city. There are two census tracts with high instances of low-income residents (37-41%) with average incomes under 185% of the poverty level (Figure 5).

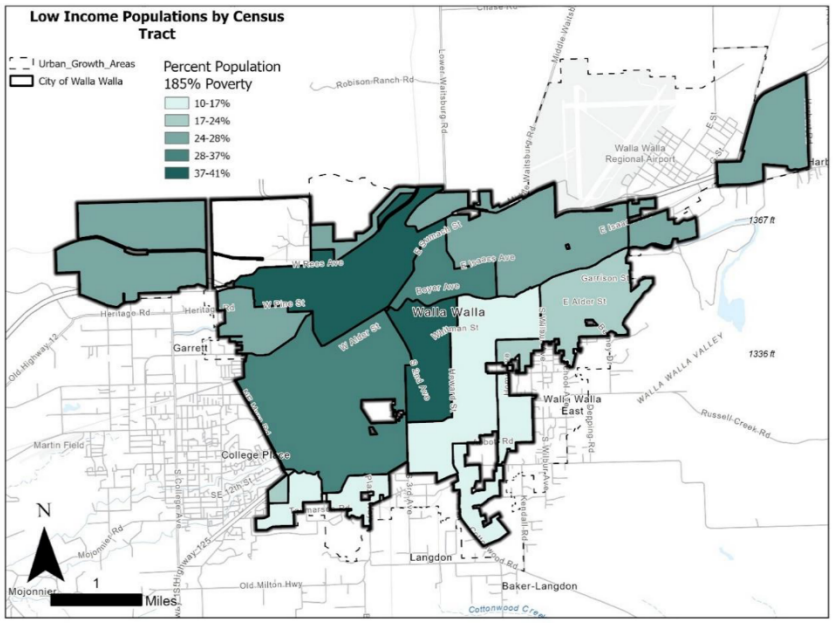


Figure 5. Percent of low-income population, defined as household income less than 185% poverty level by Census Block Group. Map by Cascadia (U.S. Census Bureau, 2023).

For sensitive populations, which demonstrates populations at risk to cardiovascular disease and populations with low birthrates, the city's score is high in the central area of the city and

medium-low in areas outside the city center. There are 9,500 residents over 65 years old in Walla Walla (U.S. Census Bureau, 2023). In 15 block groups, there is a larger percentage of the population over 65 years than the city average (Figure 6).

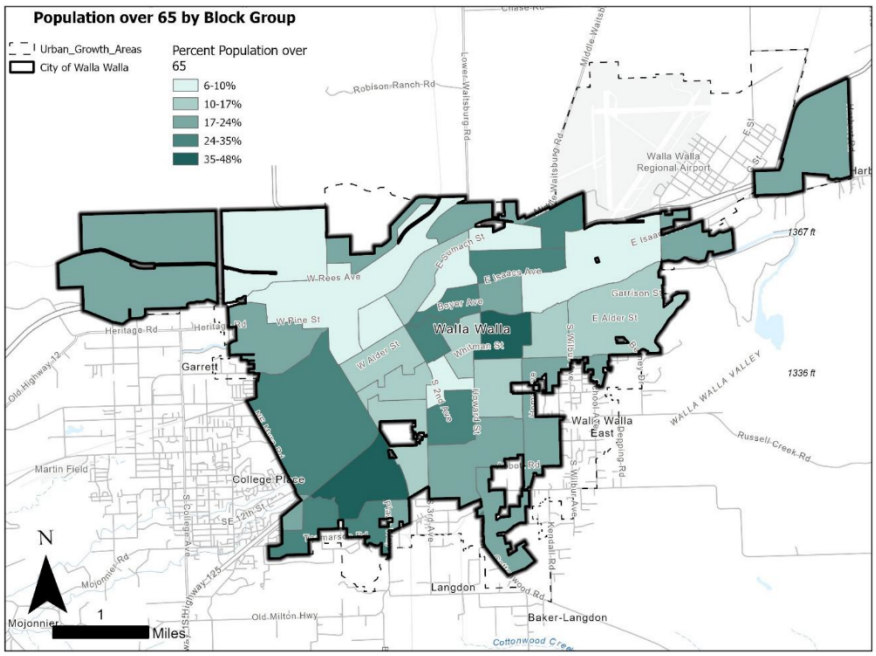


Figure 6. Percent of population over 65 years by Census Block Group. Map by Cascadia (U.S. Census Bureau, 2023).

Increased Temperatures and Heatwaves

Extreme temperatures put vulnerable populations in Walla Walla at risk. Houseless individuals and people experiencing poverty may lack adequate shelter to protect them from extreme temperatures. In the City of Walla Walla, 14.4% of the population is experiencing poverty, compared to the state rate of 10.3% (US Census ACS 2021). Extreme heat also exacerbates pre-existing health conditions such as respiratory and cardiovascular diseases (Vogel, J., et al., 2023). Figure 7 highlights the areas in the city most exposed to severe heat in the summer and highlights the distribution of tree cover and availability of green spaces for cooling and recreational purposes.

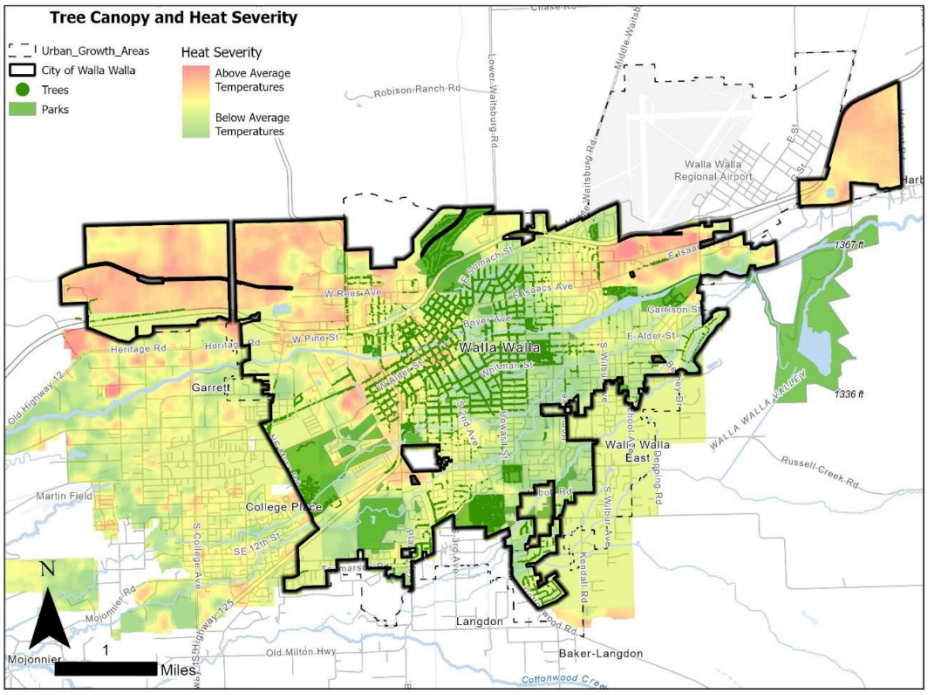


Figure 7. Heat severity, tree canopy, and green spaces in Walla Walla. Map by Cascadia (Trust for Public Land, 2025; City of Walla Walla, 2025)

Extreme heat events like the 2021 heat dome will become more likely in the future, and can cause cascading impacts on residents, businesses, and systems. Additionally, extreme heat can act as a force multiplier with compounding effects on other areas of physical and mental health, including unhealthy water conditions for species and illnesses in humans caused by excessive temperatures, longer growing seasons leading to greater pollen production and worse allergy seasons, an increase in biological contamination in surface waters, residential wells, and groundwater (Confederated Tribes of the Umatilla Indian Reservation, 2022).

Extreme heat has particularly dangerous implications for Walla Walla residents who must work outside (Center for American Progress, 2024). Prolonged heat exposure can cause heat exhaustion or stroke, potentially leading to hospitalization or death if untreated. High temperatures slow work pace and require more frequent breaks, and in extreme heat, work may be impossible. While resident well-being is crucial, reduced work opportunities also have economic impacts on families, businesses, and the city.



Walla Walla Outdoor Work (Walla Walla Public Works)

Issues related to extreme heat impact everyone, but they have particular implications for the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) and Tribal members. Extreme heat can impact Tribal members' ability to harvest traditional foods. For example, Tribal Harvesters and Entrepreneurs, who spend significant time outdoors, face disproportionate mental and physical health impacts of climate hazards such has extreme heat (Confederated Tribes of the Umatilla Indian Reservation, 2022). More specifically, individuals who spend extended periods of time tending to land and harvesting First Foods in extreme heat may experience higher healthcare costs and increased emergency room visits. The Tribal Employment Rights Office (TERO) employs a significant population of construction workers from the Tribe, who face disproportionate exposure to extreme heat and other outdoor-work related challenges exacerbated by climate change (CTUIR, 2025). Extreme heat can especially impact Tribal youth, Tribal elders, and those with pre-existing health conditions. Chronic health issues such as physical inactivity, diabetes, and heart disease are worsened by reduced access to traditional food.

Walla Walla is the site of the Washington State Penitentiary, Washington's largest prison and with a capacity of approximately 2,200 people. Prison facilities and their populations are vulnerable to extreme temperatures due to lack of adequate natural and artificial cooling and ventilation (Ovienmhada, 2024). The Washington State Penitentiary is in a high seat severity area of Walla Walla (Figure 8). Additionally, many incarcerated individuals work in local industries, such as agriculture, and are exposed to extreme heat and poor air quality (CPAT, 2025). Some vineyard operators in and around Walla Walla have their workers leave the field around 93°F. However, penitentiary community members who work in outdoor industries may

have to work up to 105°F, putting them at significantly more risk (CPAT, 2025). This population is left out of most demographic surveys and index maps, so the true impact is underrepresented, furthering their vulnerability.

In June 2021, the Pacific Northwest experienced a historic heat dome that set all-time-high temperature records across the region. In Walla Walla, temperatures reach 116°F, breaking the high temperature record (NOAA, 2021). High temperature resulted in nearly 130 deaths in Washington (Vogel, et al., 2023), including 1 in Walla Walla County (Washington State Department of Health, 2022).

Finally, extreme heat can increase physical and emotional stress and can make everyday tasks more difficult. Living in prolonged stressful conditions can negatively impact communities and their ability to communicate productively. This can lead to diminished conflict resolution ability and inhibit social cohesion, impeding communities' ability to support each other through extreme heat events (Center for American Progress, 2015).

Wildfire And Wildfire Smoke

Wildfire and wildfire smoke, which is increasing in the Northwest, present direct and indirect health threats to people and animals. The frequency of illnesses and death during extreme heat events and wildfire smoke days is increasing, stressing chronic health conditions such as asthma and health systems more broadly (IPCC, 2022). Similar to extreme heat events, prolonged exposure to smoke and poor air quality can lead to hospitalization and long-term health problems, especially for outdoor workers.

Adaptive Capacity

The City of Walla Walla has an extensive street tree program that was reestablished by the Urban Forestry Plan in 2015. The program was started and is supported as a stormwater mitigation program, but street trees have a known heat island reducing effect (City of Walla Walla, 2015). For example, street trees and urban forests provide public health benefits by cooling the air and reducing pollution. Trees improve air quality by removing several pollutants from the atmosphere, including ozone, nitrogen dioxide, and particulate matter. Additionally, trees can also reduce flooding by increasing permeable surfaces to store stormwater and manage water pollution (City of Walla Walla, 2015).

Through the Walla Walla Urban Forestry Plan, the City seeks solutions and programs to proactively manage its tree canopy to prevent emergency situations. The City has a goal to attain over 40% tree canopy coverage, with the goal of planting larger trees in less forested areas to increase tree canopy, which can reduce urban heat islands. The Walla Walla Comprehensive Plan also has policies to maintain the city's tree canopy to lower energy costs, keep people cool, and reduce heat exposure.

The Walla Walla County Department of Community Health (DCH) seeks to provide Walla Walla residents with tools and strategies to prepare for hazardous air quality events. The county shares resources including the EPA AirNow tool to allow residents to track real time air quality data. DCH shares symptoms that residents should be aware of and ways to protect themselves from wildfire smoke, including indoor air filters and reduced outdoor exposure.

The Walla Walla Comprehensive Plan also includes policies aimed at protecting water quality and human health, such as encouraging shoreline restoration and promoting physical activity

through thoughtful land use and community design. These policies contribute to the city's adaptive capacity by enhancing environmental resilience and supporting community well-being in the face of changing conditions.

Walla Walla typically operates at least one official cooling center during excessive heat warnings. Excessive heat warnings occur when two or more consecutive days temperatures exceed 105°F or nights do not fall below 75°F. The City publishes on the City website and via news outlets the location of the cooling center and other places residents can go to cool off such as libraries, parks, pools, and movie theaters. Figure 8 shows the location of the county-activated cooling center in Walla Walla. Not all residents may be aware of the location of the cooling center or have the ability to get there. For example, disabled or elderly residents may be able to access cooling centers but are among the most at risk of heat illness.

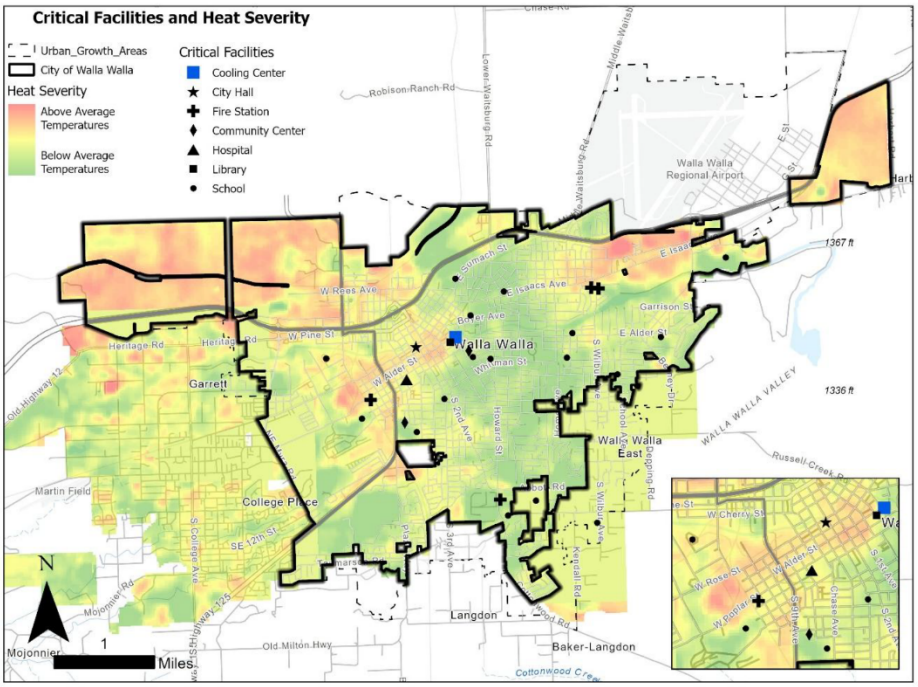


Figure 8. Heat severity and potential cooling opportunities for residents. Map by Cascadia (City of Walla Walla, 2025; Trust for Public Land, 2025).

The CTUIR Adaptation Plan includes policies and programs to increase public health beyond traditional metrics, including foods, mental health, and cultural practices. The connection and value of water, air, and land to "culturally sustainable practices" helps the Umatilla, Walla Walla, and Cayuse people survive as nations (Confederated Tribes of the Umatilla Indian Reservation, 2022). The CTUIR Adaptation Plan utilizes holistic, physical, and spiritual approaches to health, as indigenous communities define health in a multifaceted way.

Emergency Management

Climate Risk

Emergency management services including critical facilities, emergency services, and communication systems are vulnerable to climate impacts including extreme heat, flooding, and wildfire. Critical facilities and emergency services support community well-being by responding to emergencies and providing resources in critical situations. These resources include Providence Hospital, City fire stations, Walla Walla County Courthouse, police department and emergency dispatch, City Hall, and other government facilities, for example. If these facilities and resources are impacted by climate hazards such as flooding or wildfire, their ability to respond may be impacted.

Increased Temperatures and Heatwaves

More frequent and higher temperatures can increase demand for emergency services to respond and transport patients to hospitals for treatment. Higher temperatures exacerbate pre-existing conditions, especially for vulnerable populations such as those without health insurance or with disabilities.

Flooding

Flood events in Walla Walla often happen quickly. A sudden warming following a cold snap melts snow and ice, creating high meltwater in the valley (CPAT, 2025; Walla Walla County, 2025). Major impacts from flooding occur in areas without flood control measures, and severe storms can prevent or delay emergency responses. Providence Hospital has experienced employee and patient transportation issues during flooding events (Walla Walla County, 2025). Additionally, the hospital has had to shelter individuals following floods (Walla Walla County, 2025). Aging roads and bridges are also vulnerable to natural disasters, further impeding emergency responses (IPCC, 2023).

Walla Walla has experienced significant floods in 1931, 1964, 1996, and 2020. The 1931 flood led the US Army Corps of Engineers to complete flood control projects at Mill Creek. These included a diversion from Mill Creek to Yellowhawk and Garrison creeks and channelizing Mill Creek within the city.



Storm Damage (County of Walla Walla HMP)

Stormwater runoff and floodwater pose significant risks to water quality, potentially causing illness among residents. Walla Walla experiences around 2 extreme precipitation events of 1-inch or more annually, which exacerbate health risks related to flooding (Abatzoglou & Brown, 2012). In addition to concerns over waterborne diseases, these storms increase the likelihood of trees and limbs falling, further endangering residents and damaging buildings (Frankson, et al. , 2022). This situation presents an urgent emergency management challenge, requiring proactive measures to protect public health and infrastructure.

Wildfire

Drought increases the risk of wildfires in and around the City of Walla Walla, which increases the need for emergency management plans and programs. During a wildfire event, first responders need to quickly respond to the fire and support residents needing to evacuate. This depends on adequate and accessible communication channels and sufficient evacuation routes. The County has identified communication limitations due to the extensive and mountainous geography that interferes with radio communication (Walla Walla County Emergency Management, 2023). These communication challenges put first responders at risk and increase the likelihood of fires spreading and could lead to significant harm if a wildfire threatens Walla Walla (Walla Walla County Emergency Management, 2023).



Blue Creek Fire, Image from (NBC Right Now, 2015)

The 2015 wildfire season was the most destructive fire season to date in the region. It burned one million acres, around six times the average annual wildfire season (Frankson, et al. , 2022).

Adaptive Capacity

The City's Comprehensive Plan includes policies for wildfire mitigation, erosion control, emergency preparedness, and infrastructure readiness, enhancing the community's ability to manage climate-related hazards. These measures, including improved risk assessments, emergency water and power systems, and shelter availability, strengthen Walla Walla's adaptive capacity to effectively respond to emergencies and climate challenges.

The City of Walla Walla Continuity of Operations Plan (COOP) outlines the processes and people responsible for responding to different emergency situations, including climate related hazards such as flooding and storms.

The Walla Walla County Community Wildfire Protection Plan also seeks to identify and address wildfire risks and improve wildfire response capabilities. Walla Walla has a watershed attendant and pays for fire watch with US Forest Service, as well as a 100-year partnership with the WA Department of Natural Resources.

The 2025 County Hazard Mitigation Plan (HMP) has some flooding priority projects to mitigate flooding risks around Mill Creek. The plan includes general community protection measures such

as debris and sediment management, as well as vegetation and development controls, all focused on safeguarding against various hazards, including flooding. Additional policies include the construction of emergency generators to ensure a reliable water supply and building a local emergency communication system. The Hazard Mitigation Plan also recommends implementing the Mill Creek and Walla Walla County Community Wildfire Protection Plan to increase the City of Walla Walla's adaptive capacity.

Walla Walla seeks to continually improve flood awareness and preparation. The Mill Creek Flood project helped mitigate the flooding impacts in 1996 and 2020. In addition, the City has 13 National Flood Insurance Program policies in place with $5,150,000 in coverage. A FEMA grant to develop a watershed resiliency plan can ensure continuation of drinking water supply by increasing forest resilience to wildfire (City of Walla Walla, 2024). To increase preparedness for other disasters, the Walla Walla Strategic Plan identifies a proposal to strengthen the Community Paramedic Program. Additionally, the 2025 Myra Road South extension project seeks to reduce emergency response times by extending the road to connect to US 12. This extension will be completed by April 2026.

Community Services

Climate Risk

Community services include social services, cultural resources, food access, and schools supporting the Walla Walla community. This includes access to cultural resources and practices such as Indigenous stewardship and First Foods, which play a fundamental role in the health, well-being, and cultural identity of the Confederated Tribes of the Umatilla Indian Reservation. Community services can provide an opportunity for Walla Walla residents to access resources necessary for resilience in the face of current and projected climate impacts. However, the physical and social infrastructure associated with community services are vulnerable to extreme heat, flooding, drought, and wildfire in the city.

Increased Temperatures and Heatwaves

Populations most vulnerable to the effects of high heat, such as houseless community members, can also be the hardest to support. Unhoused and low-income residents may have shelter that does not adequately protect against extreme temperatures, leaving them vulnerable to heat related illnesses. Building trust, relationships, and ongoing community resources is an important step service providers may take to ensure the health of all residents. Addressing the needs of vulnerable populations also requires supporting access to vital resources, such as First Foods, which are deeply connected to both cultural and community well-being.

First Foods, their nutritional value, and the ecosystems they depend on are highly vulnerable to the impacts of climate change. While First Foods are extremely adaptive to climate change, the City must also manage land and resources for their success to promote resiliency (CTUIR, 2025). Rising temperatures, including the warming of surface waters, are disrupting the lifecycles and relationships of key species and threatening access to vital cultural resources. These disruptions not only affect the availability of First Foods but also undermine cultural and ceremonial practices, which are critical to the mental, cultural, and physical well-being of Tribes. Such changes have the potential to hinder the transmission of traditional knowledge, which plays a vital role in promoting Indigenous health and healing intergenerational trauma (IPCC, 2022).

Extreme weather events further exacerbate these challenges by affecting plant habitats, pollinator populations, and the overall health of ecosystems. Climate-induced stresses like increased invasive species, mismatches between vegetation growth and the nutritional needs of game animals, and rising risks of plant and animal diseases are all contributing to the destabilization of these essential food systems. As a result, the ecosystems that support the abundant and nutritious growth of First Foods are increasingly at risk, directly impacting the social services they provide, especially in times of climate changes (CTUIR, 2025).

Flooding

Several institutions that provide critical resources for city residents are vulnerable to flooding. The city is home to both hospitals in Walla Walla County, including the VA Medical Center, which is outpatient only, and Providence Hospital. During flood events, hospital employees experience transportation issues and may require time off. While the hospital is elevated, its generators are on the ground floor, making it vulnerable to power disruptions if there is a flood.

Walla Walla is also home to two colleges: Whitman College and Walla Walla Community College. Due to their proximity to Mill Creek, these large campuses and their populations may be vulnerable to flooding if Bennington Lake or the Mill Creek Channel overflow. Essential services and resources such as grocery stores, public works, large employers, and other community resources are at risk of severe weather impacts, such as flooding. These locations may be damaged by floods or made inaccessible by flooded roadways.

There are other critical facilities in the City of Walla Walla that may be at risk of a Mill Creek flood, including City Hall and WESCOM (City of Walla Walla, 2023).

Drought and Snowpack

Drought and low streamflow may impact some of Walla Walla's most important cultural resources, including First Foods growing and access to fishing rights. First Food availability and the health of their ecosystems is dependent on a healthy watershed and are vulnerable to variable precipitation including drought.

Wildfire

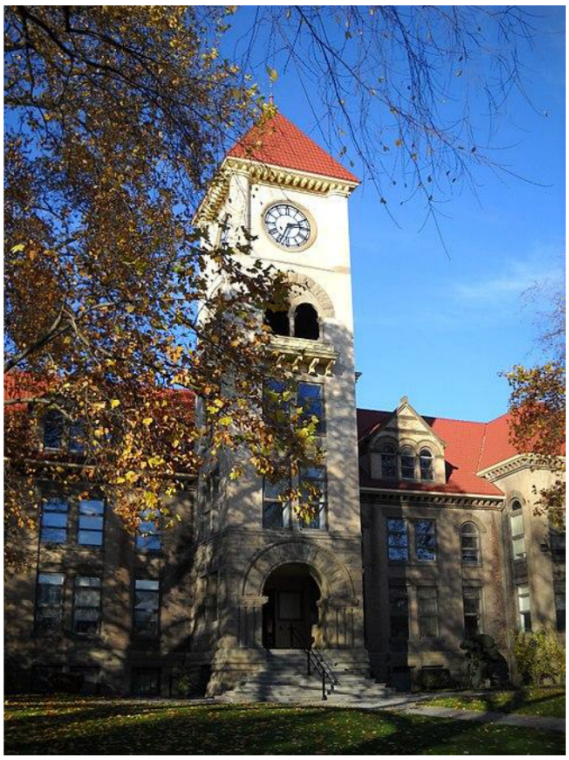
Wildfire can burn harvestable crops, cropland, and First Foods. As discussed above, wildfires can increase erosion, harming the quality and quantity of available topsoil to grow First Foods and other crops such as wine grapes. Additionally, wildfire smoke and related poor air quality can be harmful to anyone trying to harvest First Foods as short- and long-term exposure can have serious health effects. Integrating Indigenous cultural burning practices, such as intentionally lighting small, controlled fires, can help reduce wildfire risk by thinning forests, reducing fuel loads, and promoting healthy ecosystems (Lake, 2020). The Tiger Mill Project also aims to manage the spread of natural and prescribed fire safely and effectively, and reducing the risk associated with wildland fire's potential to degrade the municipal water supply (USDA Forest Service).

Childcare facilities in the city are particularly vulnerable to wildfire smoke, which are in high demand and must respond to high heat and smoke warnings (Climate Policy Advisory Team, 2025). As wildfire smoke events increase, childcare centers require additional tools and resources to keep their participants safe.

Adaptive Capacity

Walla Walla has a robust public-school and higher education network, which are important community features that can support the distribution of information and resources to community members. Schools and universities can take on a more intentional role to serve as community resource hubs providing shelter, support, and information about climate resilience and during natural hazard events.

Childcare providers are mandated to respond to smoke warnings to ensure the health and safety of the children. Some childcare centers have begun drafting plans to respond to smoke and heat warnings (CPAT, 2025). For example, childcare centers can provide air conditioning or adopt indoor air policies when poor air quality or high temperatures reach a certain threshold.



Whitman College Administrative Building.

Natural Environment and Water Resources

How to Read this Section

This section presents the overall climate vulnerability of Walla Walla's ecosystems, parks, and open space; water supply and quality; and resource lands. Each sub-sector includes an analysis of climate risks across relevant climate impacts, as well as a discussion on adaptive capacity. Note that the Natural Environment and Water Resources sector overlaps with the other two sectors in topics such as community services and water infrastructure, so it is important to consider the full CVA for the most comprehensive analysis. As noted in the summary table below, extreme precipitation was not assessed for the Water Supply and Quality sub-sector due to limited data availability, and drought was not assessed in the Ecosystems section because of overlapping content in the Water Supply and Quality sub-sector.

Introduction and Key Takeaways

Walla Walla's natural environment and water resources face moderate to high risks from climate change, particularly from extreme heat, drought, and wildfires, which impact ecosystems, natural resources, and agricultural lands. Rising temperatures are expected to affect water quality, availability, and ecosystems in the Walla Walla Watershed and surrounding area, while drought poses a significant threat to water supply and crop yields, particularly due to reduced snowpack and high water demand. The Mill Creek Watershed is highly vulnerable to wildfires, which could degrade water quality and habitats. Although some measures like water conservation, regional coordination of natural resources, and a Community Wildfire Protection Plan are in place, there is limited policy support for agricultural and ecosystem resilience directly related to climate, leaving crops, critical habitats, and cultural foods at risk. Overall, while there are some adaptive measures, more comprehensive planning related to climate resilience is needed to address the growing challenges of climate change on this sector.

Table 6. Key vulnerability rankings for the natural environment and water resources sector

Ecosystems, Parks, and Open Space			
Climate Stressor	**Climate Risk**	**Adaptive Capacity (Ability to Adapt)**	**Vulnerability**
Extreme Heat	 Moderate/High	 Moderate/High	 Moderate/High
Extreme Precipitation	 Moderate	 Moderate/High	 Moderate
Drought	See Water Supply & Quality		
Wildfire/Wildfire Smoke	 High	 Moderate	 High

Water Supply and Quality			
Climate Stressor	**Climate Risk**	**Adaptive Capacity (Ability to Adapt)**	**Vulnerability**
Extreme Heat			
Extreme Precipitation	Not assessed for this sector.		
Drought			
Wildfire/Wildfire Smoke			
Resource Lands			
Climate Stressor	**Climate Risk**	**Adaptive Capacity (Ability to Adapt)**	**Vulnerability**
Extreme Heat			
Extreme Precipitation			
Drought			
Wildfire/Wildfire Smoke			

Ecosystem, Parks, and Open Space

Climate Risk

Walla Walla's parks, ecosystems, and open spaces are increasingly vulnerable to various climate impacts, including declining snowpack, drought, prolonged heatwaves, and destructive flooding.

The City of Walla Walla park system exceeds 600 acres (18 parks), offering a variety of green spaces, programs, and community events (Figure 9). However, while the current park areas are sufficient for the population, projected growth in the southern part of the city will require additional park space to meet the needs of a younger and older population with higher demands for recreational activities (City of Walla Walla, 2018).

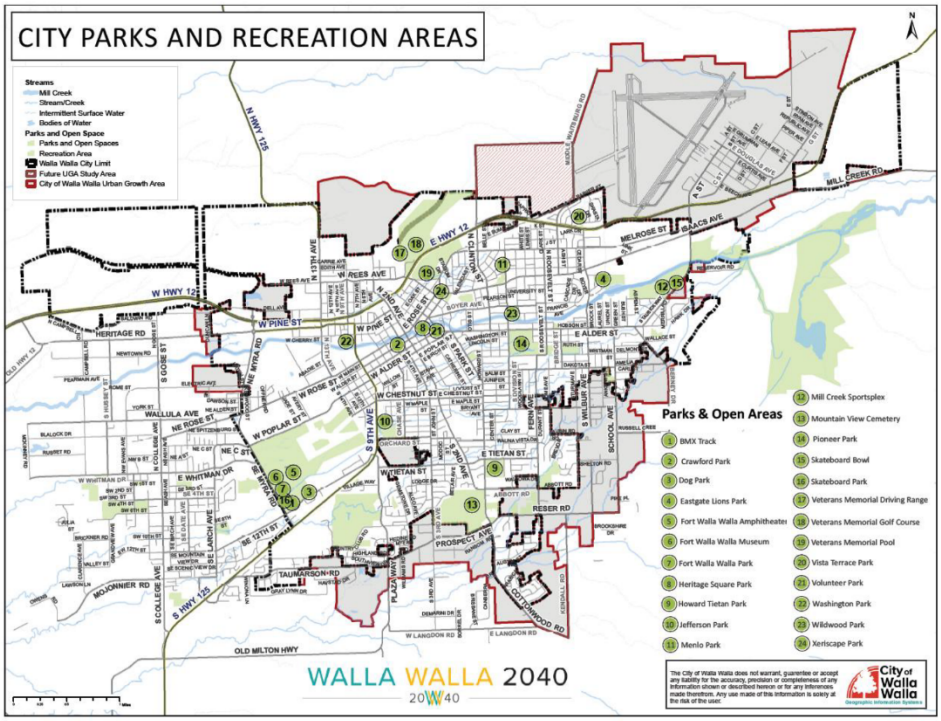


Figure 9. City Parks and Recreation Areas

Increased Temperature and Heatwaves

Within the City's UGA, there are several fish and wildlife habitat conservation areas and priority habitats that will likely be affected by climate impacts (Figure 10). For example, climate change can impact where native and non-native species live and how their populations change. Some non-native species can outcompete others, becoming invasive in both natural areas and human-managed lands like forests used for timber or recreation (Chang, et al., 2023). Rising temperatures, the spread of disease, and increased competition are putting native fish like the bull trout and cutthroat trout at risk.

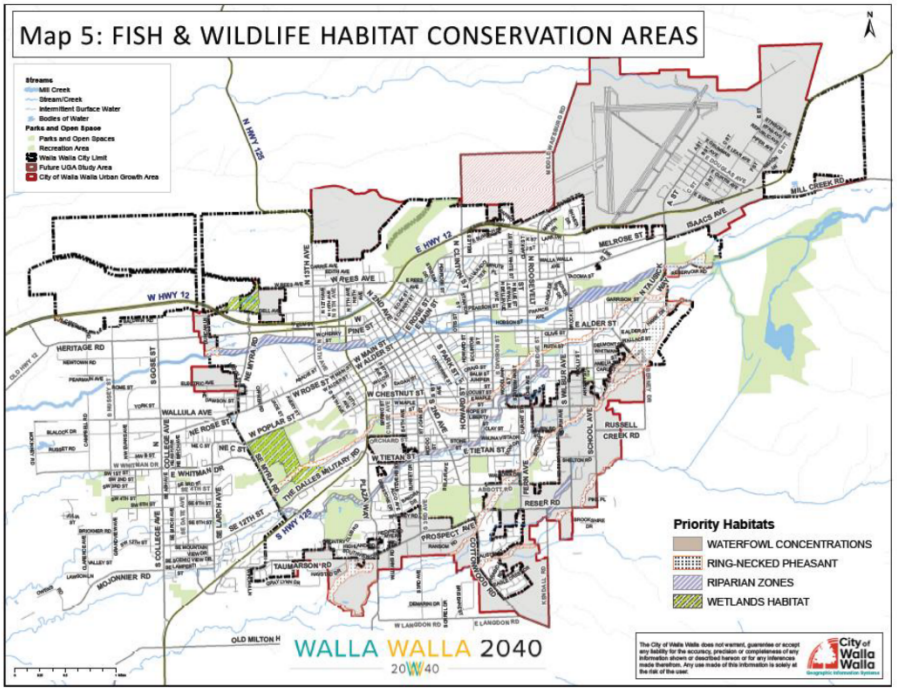


Figure 10. Fish and Wildlife Conservation Areas - City of Walla Walla

The CTUIR First Foods ecosystems also depend on native insects for health and abundance. Climate change will likely reduce suitable habitats for key pollinators, including a 30% loss for Black-Notched Bumblebees and 6% for Fuzzy Horned Bumblebees by mid-century (Confederated Tribes of the Umatilla Indian Reservation, 2022). Additionally, invasive species, such as mussels, predatory fish, and drought-tolerant grasses, will benefit from changing conditions, outcompeting native species and increasing ecosystem stress. Warmer temperatures are likely to alter pathogen distribution, increasing disease and pest impacts on plants and animals, including conifers and big game, culturally important species to the CTUIR (Confederated Tribes of the Umatilla Indian Reservation, 2022).

Extreme Precipitation and Flooding

The City of Walla Walla maintains thousands of trees across public spaces and has been a Tree City USA for over 30 years, helping to improve flooding impacts and stormwater management. Trees help reduce stormwater management costs by intercepting rainfall, saving the City approximately $13,812 annually (ArborPro and City of Walla Walla, 2021). The city has several frequently flooded areas, including along Mill Creek, where parks also exist (Figure 11).

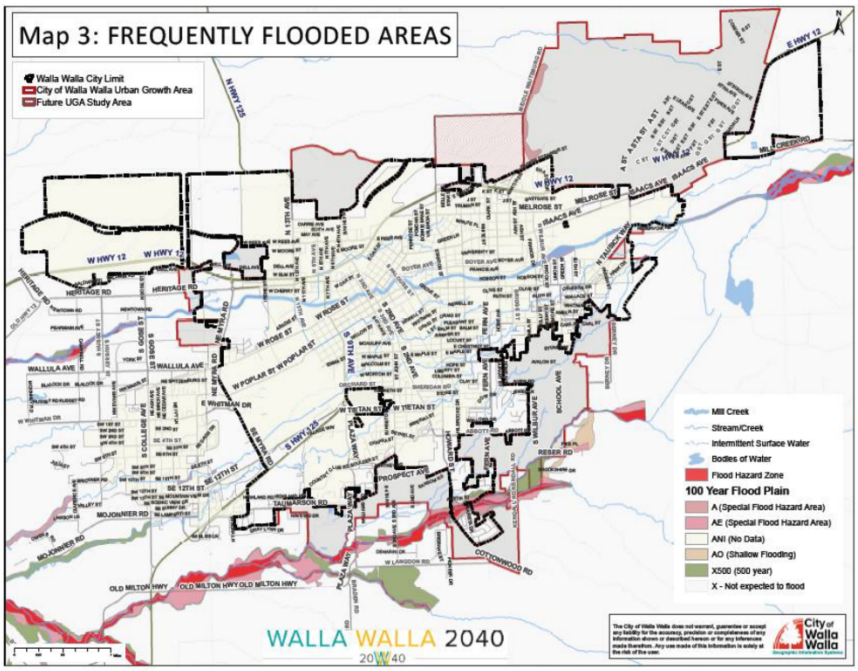


Figure 11. Frequently Flooded Areas - City of Walla Walla

In 2018, the City of Walla Walla launched a green infrastructure maintenance program, funded by the Stormwater Utility and managed by the Parks and Recreation Department. Most of the trees in Walla Walla (69%) are in "good" or "better" condition as of 2021, with approximately 6.1% of the city's trees in poor condition; and less than another 1% in critical or dead condition (ArborPro and City of Walla Walla, 2021). Additionally, about 22% of Walla Walla's potential urban forest remains unplanted.



Pioneer Park (Rose Garden at Pioneer Park, 2016)

Walla Walla has experienced, on average, two significant storms every year for the past 50 years. Changing precipitation patterns is also likely to disrupt vegetation growth, affecting big game nutritional needs and reproductive success for key species to the CTUIR (Confederated Tribes of the Umatilla Indian Reservation, 2022).

The County of Walla Walla suffered considerable damage from a windstorm on January 4, 2008, with gusts reaching 78 mph and sustained winds of 55 mph. The storm caused an estimated $4.9 million in damage across Walla Walla County, with nearly 40% of homes in the valley affected, largely due to falling trees. While this storm was Countywide, many of the trees affected were in urban areas, such as within the City's UGA.

Wildfire

Fire was once a natural part of Washington's ecosystems, occurring regularly with seasonal lightning storms and through cultural burning (Lake, 2020). The frequency and intensity of fires varied based on plant types and conditions. However, over the last century of wildfire suppression, fuel buildup has led to more intense and uncontrollable fires (Walla Walla County Emergency Management, 2023).

Regional weather shifts are also increasing fire risk, with wet seasons leading to excessive vegetation growth followed by dry conditions. Wildfire risk is expected to rise significantly, with the Columbia River region seeing two to three times greater risk and the Blue Mountains facing a six times increase with a 1.8°F rise in temperature (Confederated Tribes of the Umatilla Indian Reservation, 2022).

Between 1970 and 2015, the Walla Walla watershed experienced 37 fire ignitions. Current fire fuel models show over 23,000 acres of timber and nearly 10,000 acres of shrub/grasslands at

high risk for extreme fire behavior, especially during typical fire season conditions (Walla Walla County Emergency Management, 2023).

For ecosystems, increases in wildfire size and intensity are expected to lead to local extinctions of resident fishes, warmer stream temperatures, and increased sediment transport, turbidity, and fine sediments in streambeds. Connecting habitats can help prevent local extinctions after wildfires and debris flows, but if habitat areas are small and separated by factors like temperature or road barriers, extinctions may be permanent (Chang, et al., 2023).

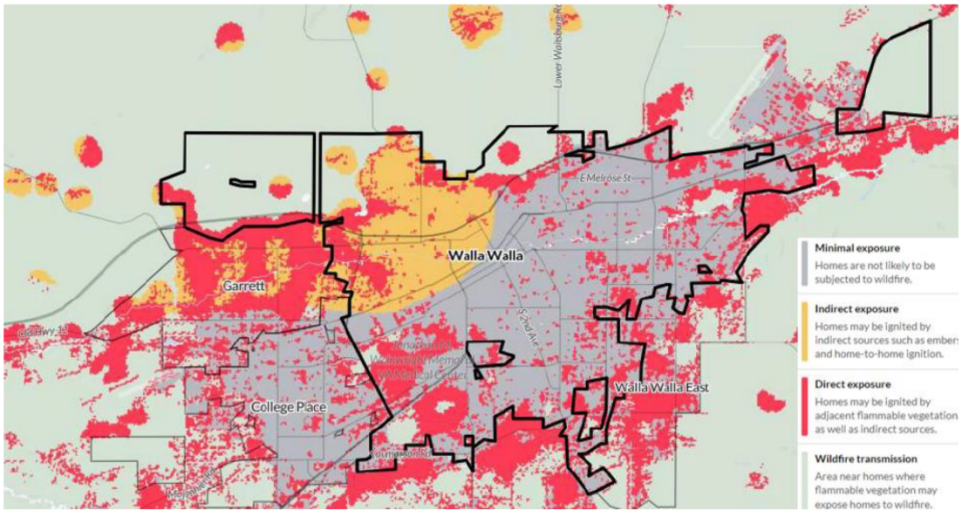


Figure 12. Wildfire Risk Reduction Zones (Walla Walla County - Emergency Management, 2024)

Wildfire risk analysis identifies the southwestern and northern parts of Walla Walla County, along with areas between Eureka Flats and the City of Walla Walla, as the most fire prone. This is due to fire frequency, proximity to emergency services, fuel availability, fire history, and development in these regions (Walla Walla County Emergency Management, 2023).

In 2015, the Blue Creek Fire threatened the Mill Creek Watershed, igniting on July 20th near the watershed's western boundary, approximately 10 miles east of Walla Walla, Washington. Caused by harvest equipment during a wheat harvest and exacerbated by dry conditions, the fire burned 5,992 acres, costing over $10 million in suppression efforts. The Columbia Complex Fire, which occurred in 2006, was sparked by lightning and consumed 132,048 acres of forested land northeast of Walla Walla, resulting in a suppression cost of over $35 million and the destruction of six structures (Walla Walla County Emergency Management, 2023).

Adaptive Capacity

Walla Walla has been improving its urban forestry despite historical funding challenges, planting 1,500 trees in the last three years (Climate Policy Advisory Team, 2025). The City is experimenting with native and drought-tolerant vegetation to withstand heat and cold, while collaborating with development, engineering, and utilities to integrate more trees into neighborhood areas and right-of-way spaces. Efforts are ongoing to find sustainable ways to

coexist with housing and development while expanding tree planting capacity (Climate Policy Advisory Team, 2025).



In the winter of 2021, the City of Walla Walla contracted with ArborPro to conduct a comprehensive street tree inventory update and develop an updated Urban Forest Management Plan. The inventory found Walla Walla's coverage at 20.3%, and suggests aiming for a 40% canopy cover goal, using vacant sites to guide future planting efforts. (ArborPro and City of Walla Walla, 2021). The City has completed several open space and park infrastructure projects over the last few years, such as the Walawála Plaza, 2024 Heritage Square project, 2023 Mill Creek Sportsplex, and 2024 Pioneer Park Pedestrian Improvements (City of Walla Walla, 2024).

Pioneer Park Recreation Area (Pioneer Park, 2018)

The City also completed additional open space and park infrastructure projects, including improving the picnic shelter at Washington Park, featuring triangular sail shades to provide sun and rain protection. The City's investment in projects such as this, focused on reducing the impacts from heat waves and other extreme weather events and improving public outdoor spaces, will support the community's adaptive capacity going forward. Additional measures can be taken to improve equitable access to parks, especially for more vulnerable populations such as those with limited mobility or low income.

To respond to fire risk in the watershed and surrounding areas, Walla Walla completed fire fuels reduction projects in 2008, 2015, and 2018 on areas within the watershed it has ownership. The City also ensures that trees and vegetation are pruned and trimmed as necessary to protect roads, bridges, and other infrastructure from damage (Walla Walla County, 2025).

Water Supply and Quality

Mill Creek, the City's primary water source, flows through Walla Walla and College Place before joining the Walla Walla River. "Walla Walla (pášxa)" means "many small waters" in the local Sahaptin language (čiškíin ~ ičiškíin) (Confederated Tribes of the Umatilla Indian Reservation, 2025). The city is surrounded by many tributaries, including Mud Creek, Yellowhawk Creek, Birch Creek, Cottonwood Creek, Caldwell Creek, and Russell Creek, along with other smaller streams (City of Walla Walla, 2018).

In the Walla Walla Urban Growth Area (UGA), water availability depends on rainfall, runoff, and aquifer recharge. The area relies on a combination of shallow gravel aquifers, deep basalt aquifers, and surface water sources. The City of Walla Walla's municipal water supply primarily

comes from Mill Creek, with some service areas extending into the UGA. While wells are occasionally used to supplement Mill Creek surface water, they are not the primary source. Outside the city limits, private wells are commonly used for drinking water and irrigation.

Climate Risk

Over the past century, water use has increased, causing lower aquifer levels, reduced creek and river flows, and higher temperatures in the Walla Walla River and its tributaries, including Mill and Yellowhawk Creeks (City of Walla Walla, 2018).

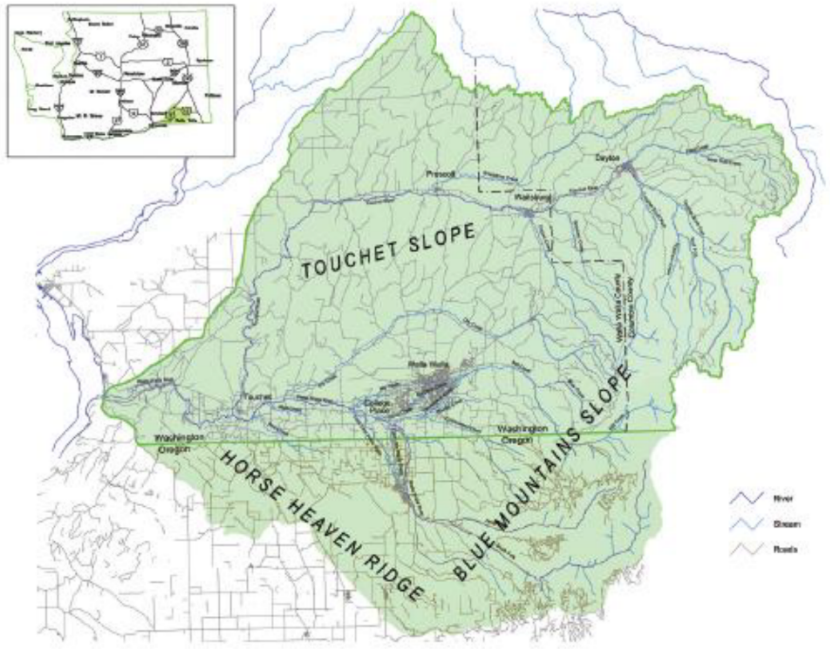


Figure 13. Walla Walla River Basin

Drought

The City's current water demand forecast does not take climate change into account. Lower aquifer levels have led to water quality degradation and reduced stream flow, which harms aquatic life, habitats, and species. If Mill Creek were temporarily unavailable, the City could rely on its wells running almost continuously. However, in the case of a long-term loss of Mill Creek, the City would need to upgrade its infrastructure and find additional water sources (City of Walla Walla, 2018). Additionally, low streamflow has been worsened by irrigation diversions, alterations like concrete channels and levees, pollution from both point and non-point sources, declining water levels in aquifers, increased stream temperatures, and degraded habitats for fish and other species (Walla Walla Watershed Management Partnership, 2021).

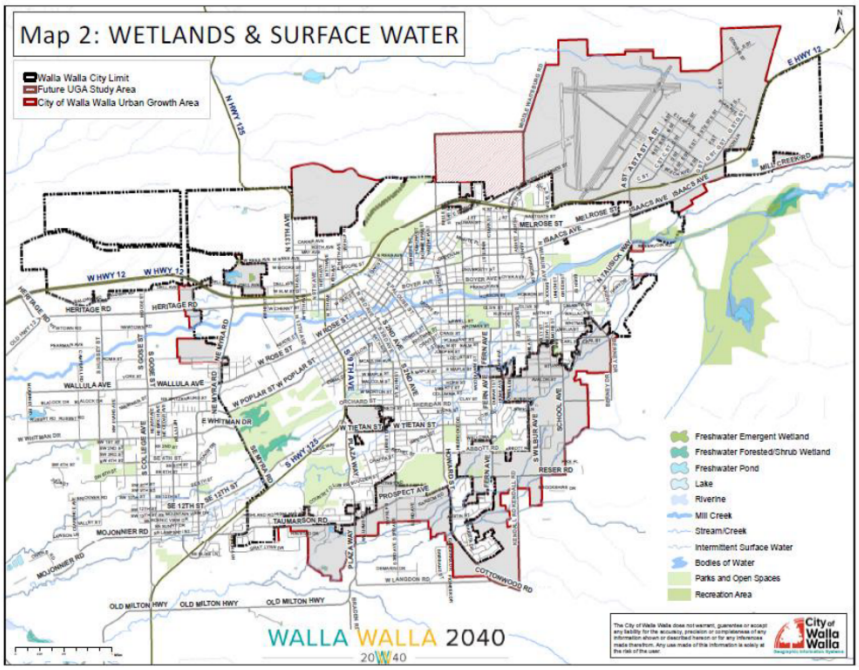


Figure 14. Walla Walla Wetlands & Surface Water

The Walla Walla River Basin in Milton-Freewater experiences a 20% groundwater well contamination rate, with a projected increase of 214-377% by 2050 (Confederated Tribes of the Umatilla Indian Reservation, 2022). Pumping groundwater may be required during times of drought when surface water is insufficient. The City uses an Aquifer Recharge System for excess surface water during certain times of the year and injects it into the deep basalt aquifer to ensure sufficient groundwater. However, groundwater is sensitive to changes in annual precipitation and population growth and development will increase the sensitivity of water resources to changes in annual precipitation (Raymond & Rogers, 2022).

Additionally, warming winters reduce snowfall reliability, shifting precipitation to rain, and increasing the likelihood of rain-on-snow events. The CTUIR Adaptation Plan suggests a significant reduction (75-100%) in snow water equivalent by the 2080s (Confederated Tribes of the Umatilla Indian Reservation, 2022). 60% of Blue Mountains surface water and 100% of CTUIR residential water comes from groundwater, highlighting the need for careful management of recharge and extraction that emphasizes natural and passive water management and floodplain restoration solutions.

Wildfire

While direct wildfire risk within the City of Walla Walla is considered low, impacts to the city's water supply from a wildfire within the Mill Creek Watershed could be severe and is considered highly vulnerable (Walla Walla County, 2025). The Mill Creek Municipal Watershed and its surroundings are particularly vulnerable to wildfires, posing risks to both residential areas and water quality, which affects the City of Walla Walla's water supply for over 34,000 residents.

The watershed is characterized by forest conditions with heavy fuel loads and is vulnerable to wildfires, which could result in destruction of timber, structures, personal property, wildlife habitat, recreation areas and watershed areas (Walla Walla County, 2025).

Over the past century, fire suppression has disrupted natural ecosystems, leading to an accumulation of fuels, while access challenges hinder effective mitigation and suppression. A high severity fire could increase sedimentation into Mill Creek, reduce the quality and quantity of water supply, and increase treatment costs for the City of Walla Walla (City of Walla Walla, 2024). The 2006 Community Wildfire Protection Plan notes that wildfires can harm water quality for 5 to 10 years, with the worst effects during the first runoff season, especially after rain or snowmelt.

The Blue Creek Fire began on July 20, 2015 in agriculture lands at the base of the Blue Mountains. The fire grew rapidly due to Red Flag Warning conditions and spread to adjacent forest lands. The fire was controlled at the edge of the Mill Creek Watershed which provides the drinking water for the City of Walla Walla (Walla Walla County, 2025).



Mill Creek Dam (Mill Creek, 2021)

Increased Temperatures and Heatwaves

Climate change is driving drastic shifts in temperature and habitats, with the Walla Walla Water Basin seeing a historic loss of fisheries, especially salmonids (Walla Walla Watershed Management Partnership, 2021). Historically, the Walla Walla Basin was home to a wide variety of fish, including several species of salmon and trout. Today, only a few native fish species remain, such as summer steelhead and bull trout, both listed as threatened under the Federal Endangered Species Act. With growing population, industry, and tourism on top of climate impacts such as increasing temperatures, the basin faces even more pressure to meet competing water needs, while still maintaining the instream flows necessary to support a healthy ecosystem (Walla Walla Watershed Management Partnership, 2021).

Adaptive Capacity

The City's Comprehensive Plan has existing policies that support emergency systems to supply water in the face of disasters, such as emergency power generators. The City also has a goal to reduce water loss by 1% per year and include water conservation measures such as school outreach, customer education, and landscaping initiatives (xeriscaping demonstration, irrigation timers, etc.). Planning efforts are being coordinated at the watershed level to improve management of surface water, groundwater, and aquatic habitat (City of Walla Walla, 2018).

To promote ecosystem flood resiliency, the City is working on sedimentation and flood control projects with sluice gates and injection wells, and working with residents who have creeks in their backyard to improve natural climate solutions and water flow (CPAT, 2025). The Tiger-Mill Project is also being proposed to protect the Mill Creek Municipal Watershed and restore ecosystem processes and functions that foster landscape diversity and achieve desired vegetation conditions (Umatilla National Forest Supervisor's Office, 2025).



Mill Creek Dam (US Army Corps of Engineers)

The Walla Walla Basin is an important center for agricultural production in the region. Over the last three decades there have been significant efforts to address water management in the basin with several collaborative planning processes and completion of many on the ground projects (Walla Walla Watershed Management Partnership, 2021). The Watershed Partnership began a 10-year pilot program in 2009 that allowed local decision-making and flexibility in water management. The Legislature passed Senate Bill 5352 in 2019 which tasked the Watershed Partnership and Ecology to collaboratively develop a 30-year strategic plan for water management in the Walla Walla Basin (Walla Walla Watershed Management Partnership, 2021). The Walla Walla Water 2050 Strategic Plan reflects a two-year planning effort by Ecology, the Watershed Partnership, CTUIR, and Washington and Oregon stakeholders to guide water resource decisions for the next 30 years in the Walla Walla Basin.



Walla Walla River (Walla Walla River)

The CTUIR also promotes actions to address opportunities for water recapture and understanding of unique hydrology, including understanding how groundwater sources are affected by flood and drought (such as infiltration of high flows into hallow aquifers) (Confederated Tribes of the Umatilla Indian Reservation, 2022).

However, the City's policies lack a comprehensive drought management strategy that includes preparedness, resilience, and response, especially with the anticipated increase in dry spells. There is also a lack of specific information on water loss due to drought in Mill Creek, and the policies are limited in addressing the impacts of drought on agriculture and food systems. Furthermore, there are no robust public awareness or education campaigns on water conservation (City of Walla Walla, 2018).

Resource Lands

Agriculture, particularly grape growing and winemaking, became a prominent industry in Walla Walla and the surrounding farmland in the mid-1980s. The wine industry has had a significant impact on reinvestment in Walla Walla's downtown and supports the region's job and tourist economy. In the Walla Walla UGA, about 34% of the land is in agriculture use, with half of the city's planning area zoned for residential purposes and the rest divided between agriculture, commercial, and industrial uses (City of Walla Walla, 2018). Agricultural lands within the city are expected to transition to urban uses as the city grows, which could help prevent the conversion of surrounding rural agricultural lands. The region has a long growing season from May to September, and crops like winter wheat and peas can withstand colder temperatures, growing from late winter to early summer (City of Walla Walla, 2018).

Climate Risk

Walla Walla's economy is closely tied to surrounding agricultural activities and wine tourism, making changes to agricultural land use and productivity directly relevant to the city's long-term economic resilience. Although many of the resource lands climate-related impacts occur outside the city's urban growth area, they have significant implications for the local economy and community well-being. In Walla Walla County, the predominant land use is agriculture—including dryland and irrigated fruits, berries, grain crops, livestock grazing, and land enrolled in the federal Conservation Reserve Program. As of 2012, the county had 943 farms covering 645,121 acres, accounting for 82% of the total land area. Because these impacts extend across jurisdictional boundaries, effective response will depend more on regional coordination and advocacy than on city-specific policies alone.

Heat and Drought

Dryland farming is common in the Walla Walla basin, but much of the basin's lowlands and floodplains rely on irrigation to grow crops like sweet onions, alfalfa seed, fruit, and row crops. Irrigation from surface water and groundwater makes up the largest portion of water use in the region. Agriculture remains one of the area's top industries, growing at almost 1% annually and providing jobs for around 13% of Walla Walla County's population (Walla Walla Watershed Management Partnership, 2021).

Additionally, over the past two decades, the region has seen an increase in winery development, with over 180 wineries now operating and contributing significantly to the local economy. Both agriculture and wineries are heavily reliant on water, and both industries face challenges in securing enough water to meet current and future demands, which is expected to worsen with climate change (Walla Walla Watershed Management Partnership, 2021).

Climate change impacts crop production, with varying effects on yield depending on the crop and region, causing both increases and decreases in projections. For example, the 2021 drought in the region led to limited irrigation access and crop yield losses.



Blue Mountain Vineyard - Walla Walla County (Winter Vineyard)

More specifically, changes in temperature and precipitation are affecting the region's wine industry, which supports part of the region's agricultural economy (Two Degrees, 2020). Daytime and nighttime temperatures have increased in the region, and the daily shift between high and low temperature that is critical to growing grapes has been reduced (Two Degrees,

2020). Agricultural land use changes may also result in shifts in the local workforce, as certain crops may no longer be viable to grow in the region. This could force farmers to either adapt by switching to different crops or face financial strain. The transition could lead to higher costs for production and labor, further impacting the local economy. One CPAT member noted that agricultural workers are generally required to leave outdoor work environments when temperatures reach 95°F . In the region, this threshold is expected to increase from an average of 17 days to 35-42 days a year by mid-century. This shift raises concerns about the ability to manage resources effectively, as it reduces available work hours and challenges the provision of adequate resources for worker safety.

For the Confederated Tribes of the Umatilla Indian Reservation, as seasonal precipitation and temperatures change, suitable habitat for First Food species will shift – with an expected 10-40% reduction in habitat suitability for huckleberries across much of CTUIR. The timing of harvests may shift 1-2 months earlier, and as resource availability changes, conflicts over who can access existing resources is likely to increase; particularly for water management practices that prioritize Indigenous stewardship and reciprocal relationships. For Tribal people, health is intertwined with cultural and spiritual connections to land, and First Foods affect physical and emotional wellbeing and health.

Wildfires

Populations in Walla Walla County depend on forests and other resource lands for resources and cultural practices, but warmer temperatures and less summer rainfall have worsened wildfires, and this trend is expected to continue. Human activities like recreation, development, and energy infrastructure also affect wildfire frequency, with longer wildfire seasons and more human-caused ignitions expected as droughts become more frequent and severe (Chang, et al., 2023).



Walla Walla Fire 2023 (Union Bulletin, 2023)

In Walla Walla County, agricultural fields can act as fuel for fires, burning similarly to grassy areas. While fires in these fields may not be as challenging to control as large timber fires, they can still cause considerable damage if precautions aren't taken. Wind-driven fires in these areas spread quickly and can be hard to contain, especially during extreme droughts or high winds,

making suppression efforts more difficult (Walla Walla County Emergency Management, 2023). Additionally, wildfire smoke can negatively impact wine growing and tourism by compromising the quality of grapes, while also deterring visitors who may be concerned about air quality and health risks during wildfire seasons (Paterson, 2022).

Tribal landscape management, including practices like prescribed burns, bolsters cultural and environmental connections and resilience, but management legacies, forced relocation of Tribal peoples, and legal restrictions have limited Tribes' ability to use these techniques, impacting sovereignty and cultural preservation (Chang, et al., 2023). For fire-dependent communities and ecosystems, fire can serve as a biodiversity component and burning can help with resource management, actually helping to reduce a hazardous build-up of fuels that lead to larger and more catastrophic fires (Lake, 2020).

Flooding and Extreme Weather

Agriculture land in the UGA is threated by flash floods and rapid warm winds, called Chinook wind events, which will be exacerbated by climate change. In spring 2017, one of these events resulted in damage to existing infrastructure and loss of economic land with an estimated cost of $1.3 million to repair the damage, and acres of land lost to rapid erosion (Walla Walla County, 2025).

Adaptive Capacity

Because agriculture lands primarily exist outside of the City's UGA, existing City policies are limited in addressing drought impacts on agriculture and food systems in Walla Walla. However, the City's Comprehensive Plan does have policies on protected and sustainable natural resource areas. These policies aim to create and sustain protected natural resources, waterways, and forests. Additionally, the CTUIR Adaptation Plan includes goals to promote First Foods knowledge, access, processing, and safe harvest, as well as land management practices that prioritize Indigenous stewardship and reciprocal relationships (Confederated Tribes of the Umatilla Indian Reservation, 2022).



Built Infrastructure

How to Read this Section

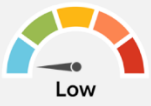
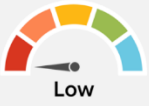
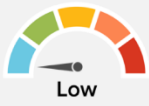
This section presents the overall climate vulnerability of Walla Walla's transportation, housing, and water infrastructure sub-sectors. Each sub-sector includes an analysis of climate risks across relevant climate impacts, as well as a discussion on adaptive capacity. Note that the Built Infrastructure sector overlaps with the other two sectors in topics such as emergency management, community services, and water infrastructure, so it is important to consider the full CVA for the most comprehensive analysis. As noted in the summary table below, drought was not assessed for the Transportation or Housing sub-sectors due to its minimal direct risk, and heat and wildfire were not assessed for the Water Infrastructure sector as they are covered in the Water Supply and Quality sub-sector.

Introduction and Key Takeaways

The transportation sector is moderately vulnerable to extreme heat and precipitation, with low to moderate vulnerability to wildfire and smoke, as extreme temperatures can damage roads and rail lines. The housing sector faces moderate risks from heat, precipitation, and wildfire, particularly in the South Ward, which is near wildfire-prone areas and flood-prone streams. Water infrastructure is moderately vulnerable to heavy rain but has minimal risk from drought, while Walla Walla's stormwater systems may face increased pressure during floods. The Mill Creek flood control project protects the city from significant flood risks as approximately 60% of the City of Walla Walla would otherwise be in the Mill Creek floodplain. Walla Walla's extensive street trees program and other green infrastructure projects increase the city's heat resilience and stormwater capacity by reducing the urban heat island effect and increasing surface permeability. The City also has wildfire resilience and home repair programs that support weatherization and retrofits, especially benefiting low-income and elderly residents (City of Walla Walla CDBG, 2019).

Table 7. Key vulnerability rankings for the built infrastructure sector

Transportation			
Climate Stressor	**Climate Risk**	**Adaptive Capacity (Ability to Adapt)**	**Vulnerability**
Extreme Heat	 Moderate	 Low	 Moderate
Extreme Precipitation	 High	 Moderate	 Moderate/High
Drought	Not assessed for this sector.		
Wildfire/Wildfire Smoke	 Moderate/Low	 Low	 Moderate/Low

Housing			
Climate Stressor	**Climate Risk**	**Adaptive Capacity (Ability to Adapt)**	**Vulnerability**
Extreme Heat			
Extreme Precipitation			
Drought	Not assessed for this sector.		
Wildfire/Wildfire Smoke			
Water Infrastructure			
Climate Stressor	**Climate Risk**	**Adaptive Capacity (Ability to Adapt)**	**Vulnerability**
Extreme Heat	Not assessed for this sector.		
Extreme Precipitation			
Drought			
Wildfire/Wildfire Smoke	See Water Supply and Quality		

Transportation

Climate Risk

Increased Temperatures and Heatwaves

The age and materials used to construct infrastructure such as roads and bridges will determine their sensitivity to extreme heat. Extreme heat can cause asphalt and concrete to expand and buckle damaging road surfaces (McQuate, 2024). The impacts to transportation corridors may in some cases displace households and reduce regional labor supply (IPCC, 2022). The

replacement of aging infrastructure, such as those listed in Table 8, provides opportunities to incorporate resilient design strategies and materials in new infrastructure projects.

The Columbia Walla Walla Railroad moves through the city, primarily transporting agriculture products including wheat and vegetables. Steel rail lines can also buckle and kink in extreme heat, forcing trains to slow down to avoid derailment (Yale Climate Connections, 2024).

The asphalt and concrete used for the runways at the Walla Walla Regional Airport may be vulnerable to high heat, as well as Valley Transit Station which is in a moderate heat severity area. Existing policies do not prioritize the resilience of transportation infrastructure, and the City has struggled to fund maintenance and replacement of aging infrastructure. Without necessary retrofits, infrastructure is ill-prepared to withstand climate stressors like extreme heat or flooding.

Table 8. Walla Walla bridges undergoing repair and maintenance in 2025. (City of Walla Walla, 2024)

City Bridges Undergoing Repair in 2025
Myra Road
2nd Avenue
Main Street
Colville Street
Otis Street
Merriam Street
Clinton Street
Wilbur Avenue

Flooding and Extreme Weather

Flash floods at Mill Creek impact bridges, roads, and culverts in the 100- and 500- year floodplains, or other low-lying areas with flood potential. The Walla Walla County Hazard Mitigation Plan identifies that there are 38 land parcels in the city that are in flood zones. The parcels have a value of $44.8 million. Four of those parcels have minimal exposure to flooding but are valued at $34.7 million (Walla Walla County - Emergency Management, 2024). Major arterials in the South Ward, such as 2nd Avenue, are at risk of flooding from the creeks in the south part of the city, such as Stone Creek, Garrison Creek, and Yellowhawk Creek (CPAT, 2025). Damage to transportation infrastructure from flash floods demonstrates a need to implement transportation infrastructure upgrades tolerant to repeat floods and flash floods (Walla Walla County, 2025).



Mill Creek near Whitman College during February 2, 2020 Flood Event (Reese, 2020)

Based on Walla Walla's FEMA floodplain map, 169 structures in the urban growth area are in the 100-year flood zone along Middle Waitsburg Road and Russell and Reser Creeks (Walla Walla County, 2025). The Mill Creek Flooding Project controls and diverts excess rainfall and water from Mill Creek to reduce impacts to the city. The conveyance channel directing Mill Creek through and beneath the city is aging and requires significant repairs or reconstruction (Climate Policy Advisory Team, 2025). Additionally, some downtown buildings are built directly above or against the Mill Creek Channel (Climate Policy Advisory Team, 2025).

The National Weather Service reports three flash floods annually since 2000. It is important to note that the City's floodplain and floodway boundaries have not been updated since the initial mapping in 1983, which could put additional people and buildings at risk, and some flooding policies and efforts remain unfunded or partially funded (Walla Walla County, 2025). Extreme precipitation increases the risk of erosion and landslides in Walla Walla, yet the Comprehensive Plan currently overlooks flooding impacts on roadways, including the need for elevated, flood-resistant sidewalks and roads.

Policies also fail to address the long-term social, economic, and environmental impacts of flooding on housing, livelihoods, and ecosystems. Repeated flood events further damage infrastructure repair efforts, with the age and quality of roads, bridges, and buses affecting their ability to endure extreme weather events.

Wildfire

Wildfires directly and indirectly impact Walla Walla's transportation network, especially near major roads and highways in wildfire exposure areas. Infrastructure in areas like Mill Creek Road and the Kooskooskie region, with high wildfire hazard ratings, faces risks of disruption and heavy traffic during evacuations (Walla Walla County, 2025).

Adaptive Capacity

Several City plans and policies outline steps to improve the resilience of Walla Walla transportation infrastructure. The CTUIR has implemented Land Development Codes and a comprehensive plan to mitigate the effects of extreme weather events and long-term stress on infrastructure. It includes policies to implement "multi-use development zoning for carbon-free commutable neighborhoods" (Confederated Tribes of the Umatilla Indian Reservation, 2022). Additionally, Kayak Public Transit supports the community and economy by managing a regional transportation system that spans southeastern Washington and northeastern Oregon, with four fixed routes and four commuter bus services. The program is funded through Federal and State grants, as well as CTUIR general funds, and all bus services are currently free to the public (CTUIR, 2025).

Flooding is a natural process vital to river function, and future infrastructure can be designed to avoid flood risks by being located outside the 100-year floodplain. Development also offers opportunities to restore floodplains, mitigate impacts on infrastructure, and enhance habitats, with ongoing projects like the Walla Walla Watershed's erosion control and the Mill Creek Flood Project already helping to reduce flood damage.



Mill Creek in Walla Walla, June 13, 2022. (Walla Walla Union-Bulletin, 2022)

The Walla Walla Comprehensive Plan includes policies emphasizing a circulation system to ensure safe and efficient movement of people and goods, incorporating pedestrian and bicycle transportation while minimizing disruptions. The plan also includes policies fostering active transportation and transit use by providing attractive end-of-trip facilities, reducing off-street vehicle parking requirements for developments near transit, and enhancing infrastructure for walking and biking.

The City of Walla Walla has many infrastructure projects in progress, including numerous road construction projects that promote upgrades to water infrastructure and increased capacity of the water treatment plant. Additional projects to repair and upgrade City bridges provide the opportunity to utilize building practices that increase climate resilience.

The Mill Creek and Walla Walla County Community Wildfire Protection Plan was developed in response to the threat of wildfire to Walla Walla County residents. A wildfire threat analysis provides firefighters and managers with a wildfire tool that describes various physical and environmental conditions for fire risk across a landscape. The risk analysis considered locations where fire threats coincide with infrastructure, cultural and environmental resources, and residences.

Housing

Climate Risk

Housing infrastructure in the city can be stressed by extreme events including precipitation, droughts, and heatwaves that are expected to intensify in the coming years. These impacts will be exacerbated by challenges such as a high number of cost burdened households, a lack of well-paying jobs, and a housing supply deficit (Walla Walla Watershed Management Partnership, 2021). There are over 11,000 houses in Walla Walla that may face different climate hazards (Table 9).

Table 9. Types and quantities of houses in Walla Walla. Table by Cascadia. (City of Walla Walla, 2025)

Housing Type	Number of Units in Walla Walla
Single-Family	10,662
Multi-Family	162
Apartment	186
Manufactured Home	603
Senior Housing	13
Affordable Housing	8
Total	**11,634**

Increased Temperatures and Heatwaves

Extreme heat poses a significant danger to residents in non-climate-controlled housing, as high temperatures can lead to heat-related illnesses and even death. Renters in Walla Walla are particularly vulnerable to climate risks like extreme heat due to the aging rental housing stock (CPAT, 2025). There are nearly 4,200 housing units in the city in severe heat areas, or areas where the summer temperatures can be much hotter than the city average (Figure 15). Figure 15 shows that some of the city's manufactured homes and affordable housing are in heat severity areas in the northeast and southwest areas of the city. In addition, many apartments, condominiums, and senior housing are in heat severity areas (Figure 15). These hot areas make residents more vulnerable if they do not have weatherized homes, air conditioning, or access to a cooling center. Similarly, energy utilities may face financial challenges if decreases in heating demand during warmer seasons affect their revenue, particularly those more reliant on winter sales.

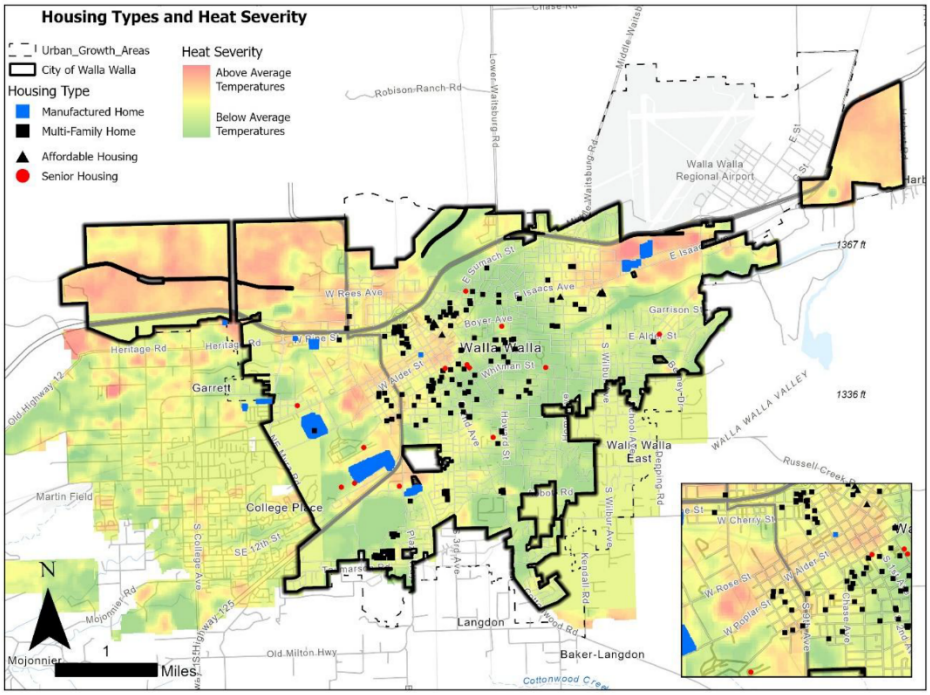


Figure 15. Locations of selected home types and extreme heat areas. Map by Cascadia (City of Walla Walla, 2025; Trust for Public Land, 2025).

Table 10. Houses in areas with above average temperatures, indicating risk of heat severity. Table by Cascadia. (City of Walla Walla, 2025)

Housing Type	Total Number of Houses	Number in Minimal Severe Heat Area	Number in Moderate Severe Heat Area	Number in High Severe Heat Area
Apartment	186	66	45	-
Manufactured Home	603	241	330	11
Multi-Family	162	51	27	-
Condominium	29	19	13	-
Single-Family	10,662	2498	863	12
Affordable Housing	8	2	4	-
Senior Housing	13	2	2	-
Total	11,634	2,879	1,284	23

Flooding and Extreme Weather

Flooding in Walla Walla is most severe in areas without flood control measures, like channelized streams, and can undermine the long-term social and economic resilience of residents. Rising insurance costs, driven by local climate hazards like flooding and wildfires, are making it harder for some residents to secure coverage, particularly in vulnerable areas like the South Ward, where development faces high risk in flood-prone zones south of Prospect Ave.

A February 2020 flood in the Upper Mill Creek impacted houses in Walla Walla County, forcing some residents to evacuate by helicopter and four-wheelers, as roads and bridges were also damaged (Walla Walla County, 2025).



Mill Creek Flood (Walla Walla County, 2025)

Wildfire

Residents in proximity to grassland and farms deal with wildfire evacuations from quick burning wildfires. Additional areas with wildfire risk include those where developments are built in close proximity to forested and prairie areas. The USDA's Wildfire Risk Reduction Zones model for Walla Walla shows that 82% of buildings are in the minimal exposure zone, with 11% (over 1,400 buildings) in the indirect exposure zone, primarily in the city's northwest. About 7% of buildings (978 buildings) fall in the direct exposure zone, located mostly along less urban areas and the city's edges (Walla Walla County, 2025).

Wildfire smoke can threaten the safety and health of residents in non-climate enforced housing (Chang, et al., 2023). Building design and codes can affect sensitivity to wildfire, including age, construction materials and degree of fire resistance. Older and less well-maintained buildings may be more affected by poor air quality from wildfire smoke due to poor insulation or older HVAC systems (EPA, n.d.).

The July 2022 Van Ausdle Fire burned 1,000 acres, causing minimal damage but forcing evacuations for some residents (Walla Walla County, 2025). More significantly was the potential for wildfire smoke to impact residents of Walla Walla.



Van Ausdle Fire 2022 (Lehman, 2022)

Adaptive Capacity

Several Comprehensive Plan policies seek to address housing sustainability and adaptability including those that encourage quality of life for residents and community vitality through aligning UGA development with sustainability standards, promoting public parks and green spaces, and supporting affordable housing. The Comprehensive Plan also establishes a housing

assistance program for low-income homeowners to support small-scale green remodeling projects (City of Walla Walla, 2024).

Renters are often left out of weatherization programs and do not get the associated economic and health benefits. Walla Walla may consider developing programs to update aging housing stock, especially rental houses, to increase their climate weatherization and reduce utility costs for renters. These programs may support landlords to make these improvements and ensure availability of affordable, safe, energy efficient housing.

The Regional Housing Action Plan (HAP) includes strategies and policies focused on affordable housing, housing retrofits for seniors, and reducing displacement for financial reasons (Cities of College Place, Dayton, Waitsburg, and Walla Walla, 2021). The HAP also encourages residential development that conserves water, reduces energy use, and uses sustainable materials.

Walla Walla also utilizes Community Development Block Grant (CDBG) funds to provide microgrants for property owners to complete home repair projects (Cities of College Place, Dayton, Waitsburg, and Walla Walla, 2021). Since 2013, the City has received CBDGs to fund affordable housing, essential services, and job creation for low- and middle-income populations. The Blue Mountain Action Council provides a low income home weatherization program, the Sustainable Living Center offers weatherization services, and the Youth Housing Hub, built in 2018, provides healthcare, food, shelter, childcare, and more to support vulnerable community members. However, income and capacity restrictions limit participation and the full community impact of these programs.

The Home Repair Program in Walla Walla, funded by a Community Development Block Grant, provides low- to moderate-income homeowners with deferred zero-interest loans for essential repairs, including heating, plumbing, electrical systems, roofs, and insulation. The program also offers additional weatherization improvements at no cost, benefiting approximately five homes annually, particularly aiding disabled, elderly, and female head-of-household families.

Finally, the County's HMP policies do not address infrastructure resilience to extreme heat and do not require mitigation or resilience measures in the construction of over 440 new homes (Walla Walla County, 2025).

Water Infrastructure

Climate Risk

Mill Creek, running through the heart of Walla Walla, is highly susceptible to flooding events. To mitigate flooding risks and damage to the region, numerous infrastructure projects have been completed over the past few decades. In 1940, the US Army Corps of Engineers built a major flood control project and created Bennington Lake as a flood control reservoir. In addition, there is a 0.3 miles cut-and-cover tunnel through downtown directing Mill Creek's water flow.

Flooding and Extreme Weather

Extreme precipitation can saturate soil, reducing the amount of stormwater the ground can absorb and putting more pressure on stormwater systems to manage excess water. If stormwater systems fail, they can cause pollutants to enter waterways (IPCC, 2022). In

extreme precipitation and flooding events, Walla Walla has a levee system that protects 21,700 people and 9,600 structures (Walla Walla County, 2025).

The Mill Creek Dam, classified as Low Risk by the National Inventory of Dams, poses a hazard primarily due to the potential for failure or mis-operation, not its condition, while climate change may exacerbate these risks through extreme weather events. Similarly, the Cottonwood Sewage Lift Station, located within the 100-year floodplain, is a critical facility vulnerable to flooding, which could be intensified by increasing precipitation and changing flood patterns due to climate impacts (Walla Walla County, 2025).

The location of both the wastewater treatment plant and the water treatment plant may put them at risk of flooding related climate impacts (Walla Walla County, 2025). The wastewater treatment plant is next to Mill Creek on the city's western border and the water treatment plant is near the airport and just north of Titus and Mill Creeks (City of Walla Walla, 2025). The vulnerability of these facilities cannot be fully assessed until updated FEMA Floodplain maps are created.

Wildfire

As discussed in the Water Supply and Quality Section, wildfires can damage water infrastructure, especially aging facilities, and increase the risk of pollution and erosion affecting water sources. A severe wildfire could also raise water treatment costs (Walla Walla Watershed Management Partnership, 2021).



Erosion In a Wildfire Damaged Area (USDA Forest Service).

Mill Creek, the city's main unfiltered water supply, is vulnerable to disturbances like landslides and wildfire contamination (Walla Walla County Emergency Management, 2023). Wildfires can degrade water quality for up to 10 years due to increased erosion, debris, and ash blocking streams and intakes, while flooding from rain and snowmelt further concentrates contaminants. Erosion rates are highest in the first-year post-fire, with elevated runoff and peak flows continuing for up to 10 years, increasing sediment, turbidity, and harmful substances like cyanide, nitrates, and metals. As a result, major wildfires could strain Mill Creek's ability to provide water to the city and critical infrastructure, such as hospitals.

Adaptive Capacity

Walla Walla is already implementing several programs and projects to improve the city's stormwater capacity through hard infrastructure upgrades and green infrastructure, including street trees. To date, City infrastructure improvement projects have likely saved the City an estimated $75 million in potential flood damage with the Mill Creek Channel and Bennington Lake Dam and $13,812 annually in stormwater management costs (Walla Walla Watershed Management Partnership, 2021).

In 2018, Walla Walla began using funds from the stormwater utility for the Parks and Recreation department to perform stormwater-specific facility and right-of-way maintenance. According to 2019 data, green infrastructure in Walla Walla includes 71 green infrastructure facilities and 7,052 street trees (City of Walla Walla, 2015). The City recognizes that trees can be an important tool for stormwater management and works to continue to grow the program, however, funding and liability make street tree maintenance difficult.

In addition to street trees, updates to the Stormwater Management Program include public education and outreach, illicit discharge detection and elimination, and construction site stormwater runoff control. The City runs a program providing water and sewer utility rate discounts to low-income citizens, supporting the resilience and adaptive capacity of at-risk Walla Walla residents (Cities of College Place, Dayton, Waitsburg, and Walla Walla, 2021). The City also requires mapping and reporting of potential pollution sources to the stormwater system to better assess impacts on the system (City of Walla Walla, 2015).



Downtown Walla Walla Street Trees (City of Walla Walla, n.d.)

The City completed an update to the 2009 Flood Response Plan and conducted a flood vulnerability assessment of Cottonwood Sewage Lift Station, which was identified as a critical facility located in the 100-year floodplain (Walla Walla County, 2025). As part of the City's road improvement projects, stormwater system upgrades are being incorporated. Notable examples include the 2024 Pioneer Park Pedestrian Improvements, which will add new water, sewer, and

stormwater infrastructure, and the Clinton Street Utilities Replacement project. Other projects, such as W. Pine Street reconstruction, Hobson-Division-Madison Water Project, and Poplar 5th to 14th reconfiguration, also focus on improving water, sewer, and stormwater facilities to enhance treatment and infiltration capacity.

Additionally, the Walla Walla Watershed Strategic Plan includes goals to expand stormwater monitoring and management, increase green infrastructure to better absorb stormwater, and develop a detailed forest management plan for the upper Mill Creek Watershed. The FEMA funded Walla Walla Watershed Resiliency Plan will also support providing high quality water and protecting valuable ecological and community resources in the Mill Creek Watershed.

The CTUIR places high importance on water, recognizing its vulnerability to climate change, with impacts on both surface and groundwater that affect all aspects of life. To enhance adaptive capacity, they have developed policies for water conservation, storage, habitat restoration, and water recapture, outlined in key documents such as the CTUIR Comprehensive Plan, Water Code, and Hazard Mitigation Plan (Confederated Tribes of the Umatilla Indian Reservation, 2022).



Mill Creek Watershed.

CONCLUSION AND NEXT STEPS

Conclusion

The Walla Walla Climate Vulnerability Assessment highlights the city's exposure to increasing climate risks, particularly extreme heat, wildfire, drought, and flooding. Through analysis of historical trends, climate projections, City staff discussions, and community engagement, this assessment identifies vulnerabilities across key sectors and socially vulnerable populations. The findings underscore the need for proactive resilience strategies to protect residents, essential services, and critical infrastructure from future climate impacts.

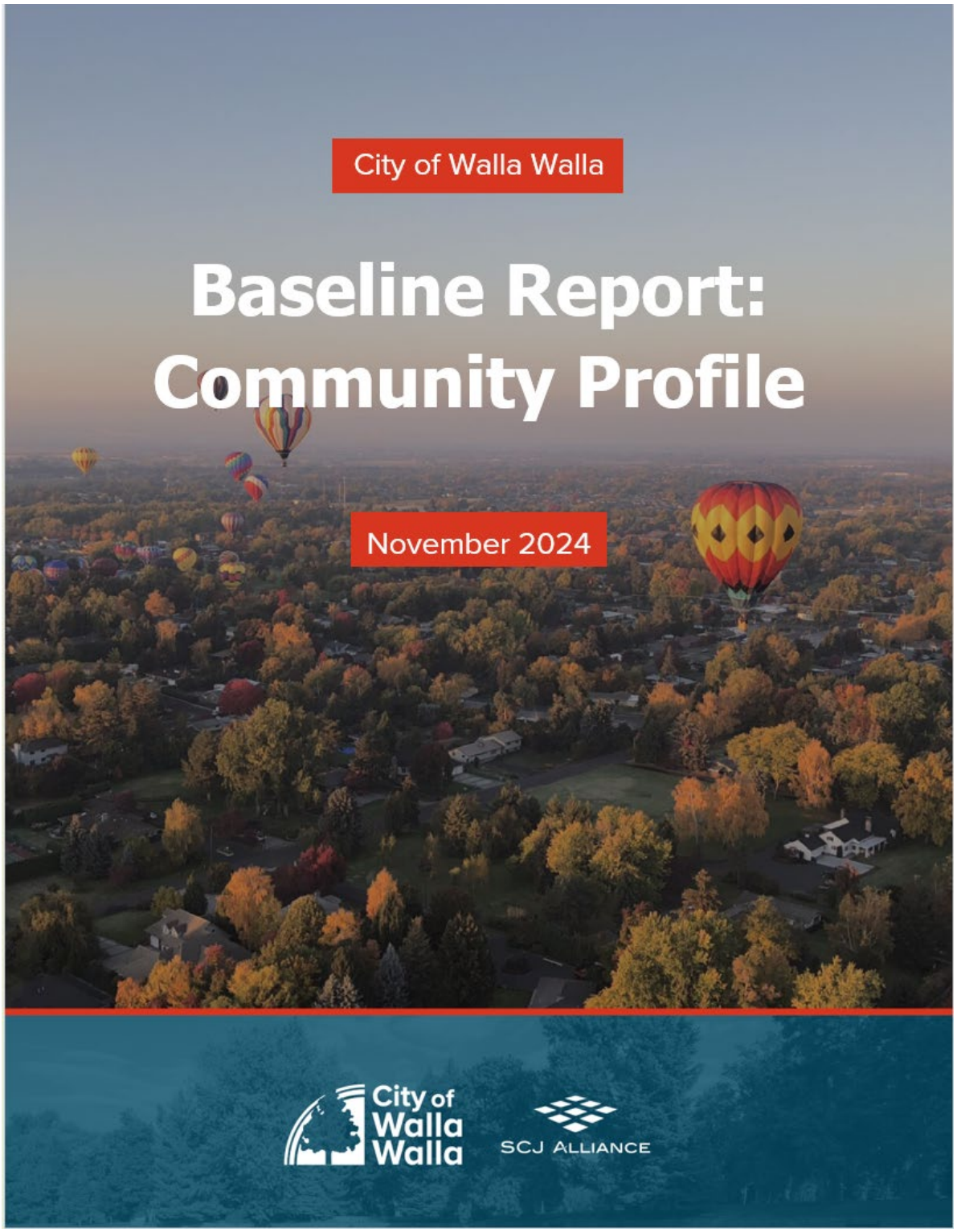
Walla Walla faces moderate to high climate vulnerabilities across multiple sectors, impacting community health, the natural environment, infrastructure, and housing. Extreme heat, flooding, and wildfire risks pose significant threats to vulnerable populations, such as the elderly, unhoused, and those with pre-existing health conditions. Wildfire smoke and flooding can disrupt daily life and strain emergency resources, while gaps in planning for human-focused water quality and drought impacts highlight the need for stronger, more comprehensive strategies. The natural environment and water resources are also at risk, with drought and rising temperatures threatening water availability, agricultural yields, and ecosystems, especially in the Mill Creek Watershed. While some measures like water conservation and wildfire protection are in place, more climate-resilient policies are needed for agriculture and habitat protection. Infrastructure, particularly transportation and housing in the South Ward, faces risks from extreme heat, flooding, and wildfire, requiring enhanced resilience strategies like improved stormwater systems and wildfire protection. Overall, while some adaptive measures are in place, more comprehensive planning and policy support are essential to address the growing climate challenges and protect the community's well-being, environment, and infrastructure.

This CVA builds on existing City and regional plans by addressing gaps in understanding. While these existing efforts support Walla Walla's ability to adapt to climate impacts, continued investment in climate resilience is essential. By incorporating this CVA into the City's Climate Resilience Element, Walla Walla can establish clear policies and actions to further enhance its climate resilience.

Next Steps

Next, the City will integrate findings from this CVA into the City's Comprehensive Plan Update, to both reflect the City's goals and priorities and comply with Commerce's Climate Element guidance. The City will develop policies to address areas of vulnerability outlined in this CVA, including protecting assets across the city, mitigating the social vulnerability of communities in Walla Walla, and integrating climate resilience considerations into planning. Additionally, this CVA may be used to inform future decision-making around climate change and land use, zoning, infrastructure, housing, and policy decisions. The report will serve as a resource to help decision-makers and the public identify priority communities, understand proposed changes, and guide future projects to improve climate resilience.

Appendix X. Community Profile





1.0 Introduction

This community profile is prepared to support the City of Walla Walla in its 2026 Comprehensive Plan update. This report articulates past and current characteristics of the community, as well as forecasts future conditions. It provides an update to the demographics and community data presented in the city's previous Comprehensive Plan document (2018) and includes key characteristics like population, economic indicators, and housing trends. Data and findings from this report will ultimately be incorporated into the updated Comprehensive Plan document.

Reviewing this data helps establish an understanding of where the city has been, where it is now, and where it hopes to go, and sets the foundation for Walla Walla's long-range planning efforts. Wherever possible, the data for Walla Walla is compared with data from Walla Walla County or Washington State, illuminating how the city compares with the larger surrounding regions.

1.1 Setting & History

The City of Walla Walla, located in southeastern Washington State, is nestled in the fertile Walla Walla Valley. Surrounded by the Blue Mountains to the southeast and the Columbia River to the west, the city is part of the Columbia Basin, known for its agricultural richness. Its semi-arid climate, characterized by warm, dry summers and cool, wet winters, makes the area ideal for growing crops like wheat and wine grapes, which play a significant role in its economy. Walla Walla is renowned for its thriving wine industry, with over 100 wineries contributing to the region's economic and cultural vitality.

Historically, the area was home to the Walla Walla people, part of the Plateau tribes that lived in the region long before European settlers arrived. The name "Walla Walla," meaning "many waters" in the Sahaptin language, reflects the abundant natural resources that supported the indigenous population. Tribes such as the Walla Walla, Cayuse, and Umatilla engaged in seasonal hunting, fishing, and trade. European contact began in earnest with the arrival of the Lewis and Clark Expedition in 1805, marking the beginning of increased European-American influence. In 1836, Marcus and Narcissa Whitman established the Whitman Mission near present-day Walla Walla, aiming to convert Native tribes to Christianity and encourage European-style farming. However, tension between settlers and indigenous peoples, exacerbated by diseases brought by settlers, culminated in the killing of the Whitmans and others in 1847, which led to the Cayuse War and a heightened military presence in the area.

Walla Walla officially became a city in 1859 when it was established as a military post, Fort Walla Walla, to protect settlers and trade routes. It quickly grew into a major center of commerce during the gold rushes in nearby Idaho and Oregon, becoming the largest city in the Washington Territory by the late 1860s. When the gold rushes subsided, the city's focus shifted to agriculture, particularly wheat farming. The introduction of irrigation systems in the 20th century further solidified its status as an agricultural hub, with farming and food processing dominating the local economy.

In the modern era, Walla Walla has gained international recognition for its burgeoning wine industry, with the Walla Walla Valley AVA (American Viticultural Area) established in 1984. This has transformed the city into a destination for wine enthusiasts, boosting tourism and economic growth. Additionally, Whitman College, founded in 1882, plays a significant role in the city's educational and cultural life, while the Walla Walla State Penitentiary, established in 1886, remains a major employer in the area.

Today, Walla Walla is a city that balances its rich historical roots with its modern agricultural and wine-growing economy. Its downtown area has been revitalized, blending historic charm with contemporary attractions like boutique shops, restaurants, and wineries. Sites like the Fort Walla Walla Museum and the Whitman Mission National Historic Site continue to honor the city's past, showcasing its unique blend of Native American heritage, frontier history, and modern cultural development.





2.0 Community Characteristics

The following sections summarize the existing conditions within the City of Walla Walla, including demographics and population trends, economic indicators, and housing trends. Data sources include U.S. Census Decennial Data, U.S. Census American Community Survey (ACS) 2022 5-Year Estimates, and Washington State Office of Financial Management (OFM) housing data and population estimates.

2.1 Population

OFM issues annual population estimates for all cities and counties in Washington, which are the state's official population counts for long-range planning purposes. These annual estimates are based on the most recent Decennial Census counts. The official Office of Financial Management (OFM) 2024 population estimate for Walla Walla is 34,580

[1]. The 2024 population estimate for Walla Walla County is 63,375. The city of Walla Walla accounts for 54.56% of the county's population.

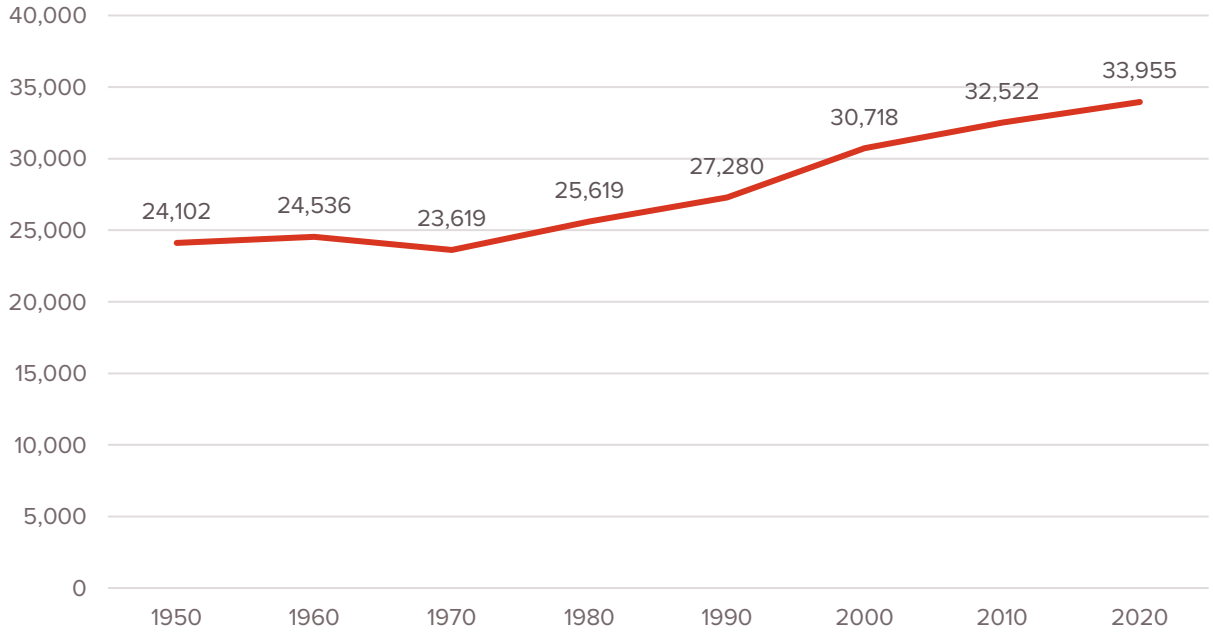
2.1.2 Historic Population Trends

Figure 1 illustrates the City of Walla Walla's historic population changes from 1950 through 2020, while Table 1 illustrates the city's population as a percentage of Walla Walla County's population over the same period. Decade over decade, Walla Walla's population has increased on average 5% every ten years, with some decades being higher or lower than others. Only once during this time has the population decreased, which occurred between 1960 and 1970. The most significant increase was between 1990 and 2000, when the city's population grew by nearly 13%.

Figure 2 also shows the city's population in recent years between 2014 and 2024. Looking at year-over-year estimates from 2014 through 2024, the city's population has averaged an annual growth rate of 0.8%. In total, the past decade has seen an increase of 8.4%, growing from 31,895 in 2014 to 34,580 in 2024.

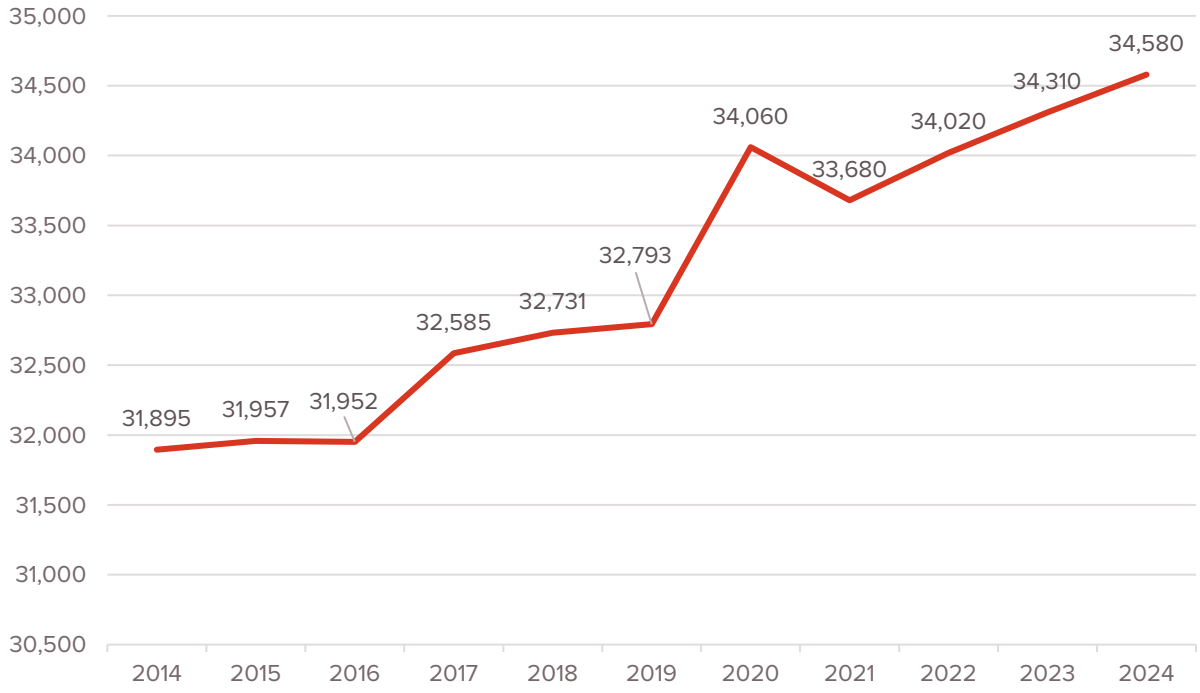
[1] https://ofm.wa.gov/sites/default/files/public/dataresearch/pop/april1/ofm_april1_population_final.pdf

Appendix X Figure 1. Historic Walla Walla Population (1950-2020)



Source: U.S. Census Bureau, Decennial Census Data.

Appendix X Figure 2. City of Walla Walla Population between 2014-2024



Source: U.S. Census Bureau, American Community Survey 2014- 2024 5-Year Estimates.

Appendix X Table 1. Percent of Walla Walla County Population

Year	City of Walla Walla Population	Walla Walla County Population	% of County Population
1950	24,102	40,135	60.05%
1960	24,536	42,195	58.15%
1970	23,619	42,176	56.00%
1980	25,619	47,435	54.01%
1990	27,280	48,439	56.32%
2000	30,718	55,180	55.67%
2010	32,522	58,781	55.33%
2020	33,955	62,584	54.26%

Source: U.S. Census Bureau, Decennial Census Data 1950-2020.

2.1.2 Race and Ethnicity

This section delves into the race and ethnicity dynamics in Walla Walla, Walla Walla County, and the State of Washington as a whole. Table 2 presents the percentages of Walla Walla's racial diversity, compared to those of Walla Walla County and the state of Washington.

It's important to distinguish that race generally refers to physical characteristics and genetic heritage, such as White, Black, Asian, and Native American classifications, whereas ethnicity refers to cultural factors, including language, national origin, and shared traditions. As such, individuals identifying as Hispanic or Latino may belong to any racial group while sharing a common cultural or linguistic heritage.

According to the social definition of racial categories used by the U.S. Census Bureau's ACS 5-Year Estimates, 60.8% of Walla Walla residents self-identified as white, compared to 63.4% in Walla Walla County overall, and 69.9% in the state of Washington. According to Table 3, about 23.6% of Walla Walla's residents self-identified as Hispanic or Latino, slightly higher percentage than that of both Walla Walla County (22.3%) and Washington state (14%).



Appendix X Table 2. Race Distribution

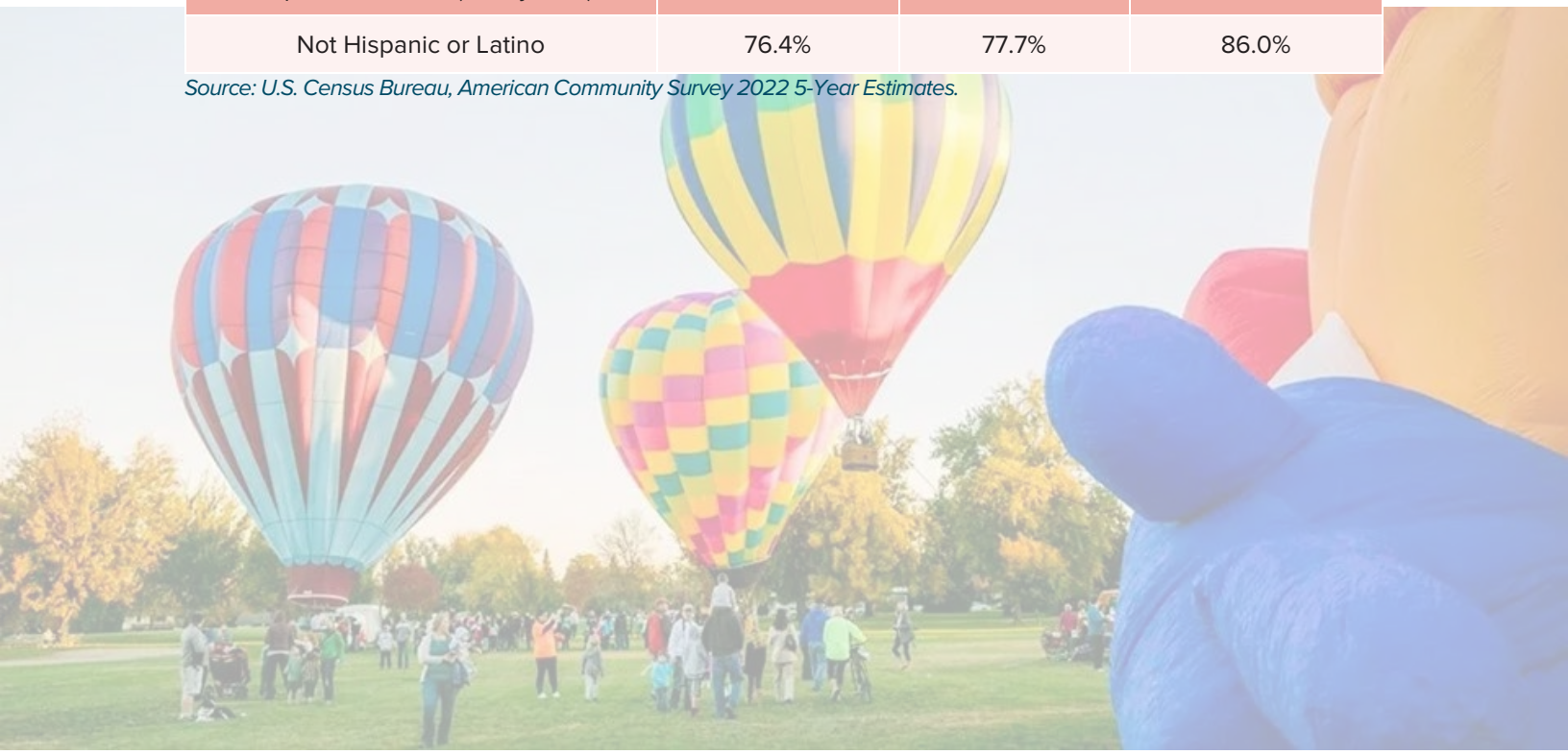
Race	% of City of Walla Walla Population	% of Walla Walla County Population	% of Washington Population
White alone *	60.8%	63.4%	69.9%
Black or African American alone *	2.4%	1.6%	3.9%
American Indian and Alaska Native alone *	1.7%	1.2%	1.2%
Asian alone *	2.0%	1.5%	9.2%
Native Hawaiian and Other Pacific Islander alone *	0.3%	0.2%	0.7%
Some other race alone *	6.8%	7.0%	5.2%
Two or more races	7.0%	7.0%	9.9%

Source: U.S. Census Bureau, American Community Survey 2022 5-Year Estimates.
(*) Includes persons reporting only one race.

Appendix X Table 3. Ethnicity Distribution

Ethnicity	% of City of Walla Walla Population	% Walla Walla County Population	% of Washington Population
Hispanic or Latino (of any race)	23.6%	22.3%	14.0%
Not Hispanic or Latino	76.4%	77.7%	86.0%

Source: U.S. Census Bureau, American Community Survey 2022 5-Year Estimates.



2.1.3 Age and Gender

The median age in Walla Walla is 37.2 years, which is slightly younger than Walla Walla County (38.0 years), and the state of Washington (38.0 years). About 15% of Walla Walla's population is under the age of 15, and 18.3% is over the age of 65. Table 4 provides Walla Walla's age distribution as compared to Walla Walla County and Washington State.

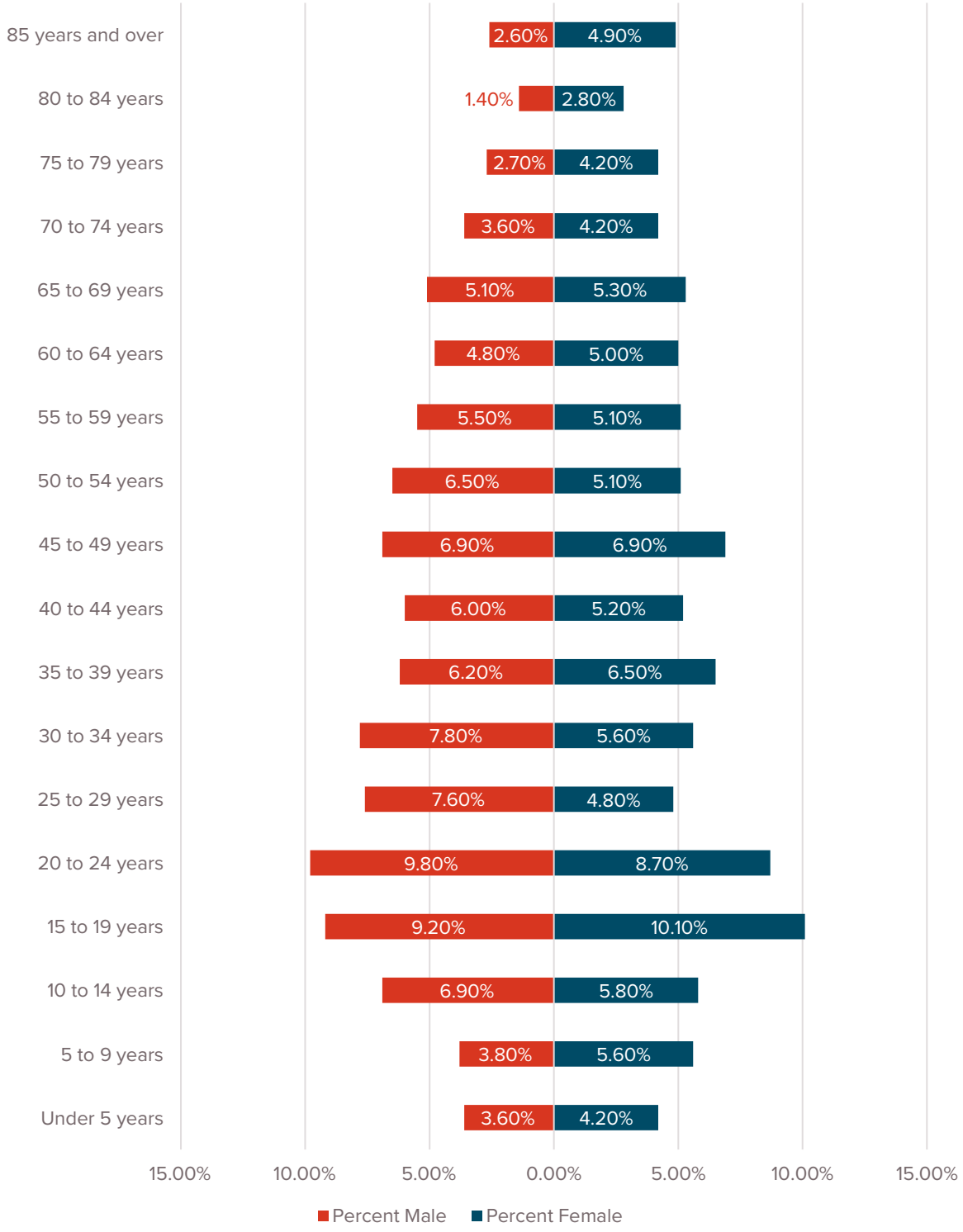
Appendix X Table 4. Age Distribution

Age Range	% of City of Walla Walla Population	% Walla Walla County Population	% of Washington Population
Under 5 years	3.9%	5.0%	5.7%
5 to 14 years	11.1%	11.7%	12.3%
15 to 24 years	18.9%	17.5%	12.4%
25 to 34 years	12.9%	12.1%	15.1%
35 to 44 years	11.9%	11.4%	13.9%
45 to 54 years	12.7%	11.1%	12.2%
55 to 64 years	10.2%	11.9%	12.4%
65 years and over	18.3%	19.2%	16.0%
Median age (years)	**37.2**	**38.0**	**38.0**

Source: U.S. Census Bureau, American Community Survey 2022 5-Year Estimates.

Figure 3 on the following page is a population pyramid for the City of Walla Walla, which provides the breakdown of the city's population by age group for binary gender self-identifications (male and female). The city's population differential is fairly even by age group. The population pyramid indicates that for the age cohorts under 9 years, between 15-19 years, between 35-39 years, and for ages 60 and over, the female population is slightly higher than the male population; however, for the age cohorts between 10-14 years, 20-34 years, 40-44 years, and 50-59 years the male population is generally higher. The male and female populations are the same for ages between 45-49 years.

Appendix X Figure 3. City of Walla Walla Population Pyramid



Source: U.S. Census Bureau, American Community Survey 2022 5-Year Estimates.

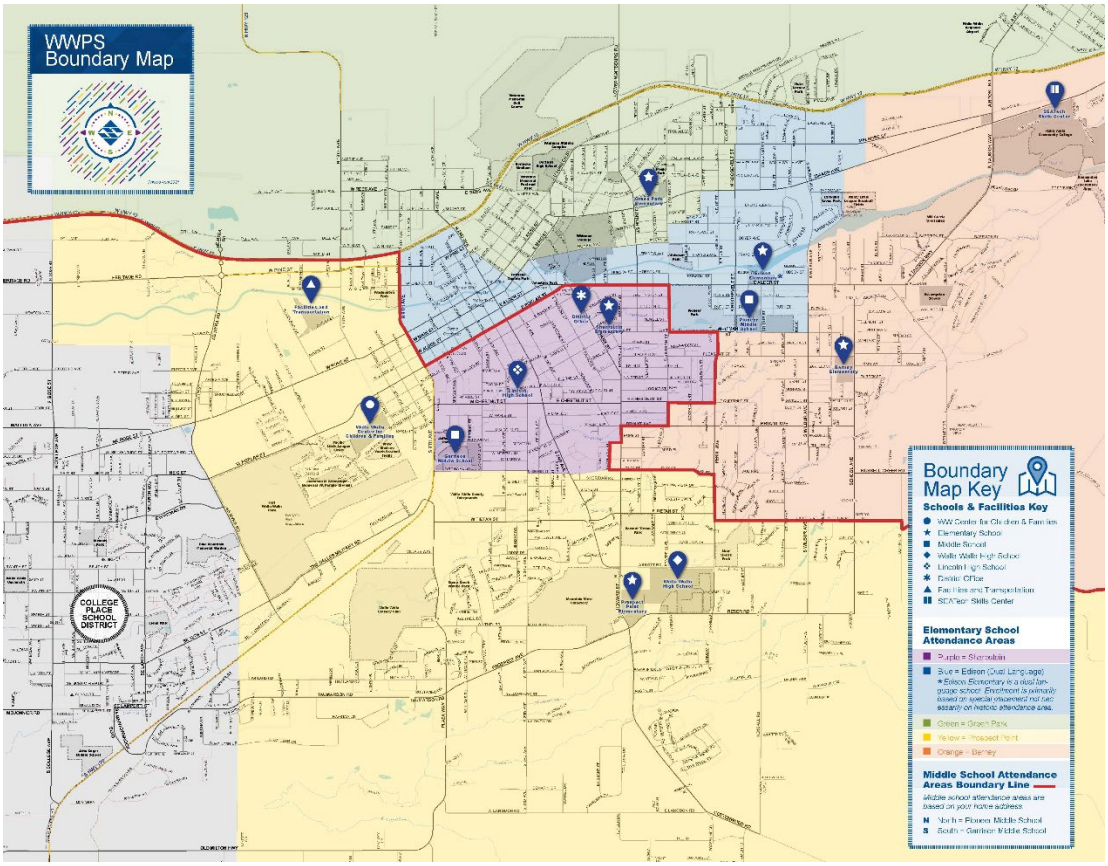
2.1.4 Education

Walla Walla Public Schools operates two high schools, two middle schools, and five elementary schools that serve Walla Walla students. For the 2024-2025 school year, the district's enrollment was 5,490 students, with 44.9% identifying as Hispanic/Latino and 6.6% identifying as racial minorities. There were 345 classroom teachers employed, for a student-to-teacher ratio of 15.9:1[2]. Walla Walla Public Schools' geographical coverage is shown in Figure 4.

Educational attainment for Walla Walla's population is presented in Table 5 and indicates the highest level of education an individual has attained. 22.2% of Walla Walla's residents have attained high school graduate or equivalent; 7.3% of Walla Walla's residents have attained 9th to 12th grade, no diploma; and 5.0% represent those who have achieved less than 9th grade.

Approximately 40.7% of Walla Walla residents have attained a college, graduate, or professional degree, compared with 41.6% of Walla Walla County residents and 48.1% of Washington residents.

Appendix X Figure 4. Walla Walla Public Schools Map



Source: Walla Walla Publiic Schools

[2] **Washington Office of Superintendent of Public Instruction (OSPI) School District Report Card https://reportcard.ospi.k12.wa.us/ReportCard/ViewSchoolOrDistrict/100283.**

Appendix X Table 5. Educational Attainment

Educational Attainment	% of City of Walla Walla Population	% Walla Walla County Population	% of Washington Population
Less than 9th grade	5.0%	4.6%	3.4%
9th to 12th grade, no diploma	7.3%	6.5%	4.5%
High school graduate (includes equivalency)	22.2%	21.9%	21.8%
Some college, no degree	24.9%	25.4%	22.2%
Associate's degree	11.4%	11.8%	10.1%
Bachelor's degree	16.2%	16.9%	23.3%
Graduate or professional degree	13.1%	12.9%	14.7%

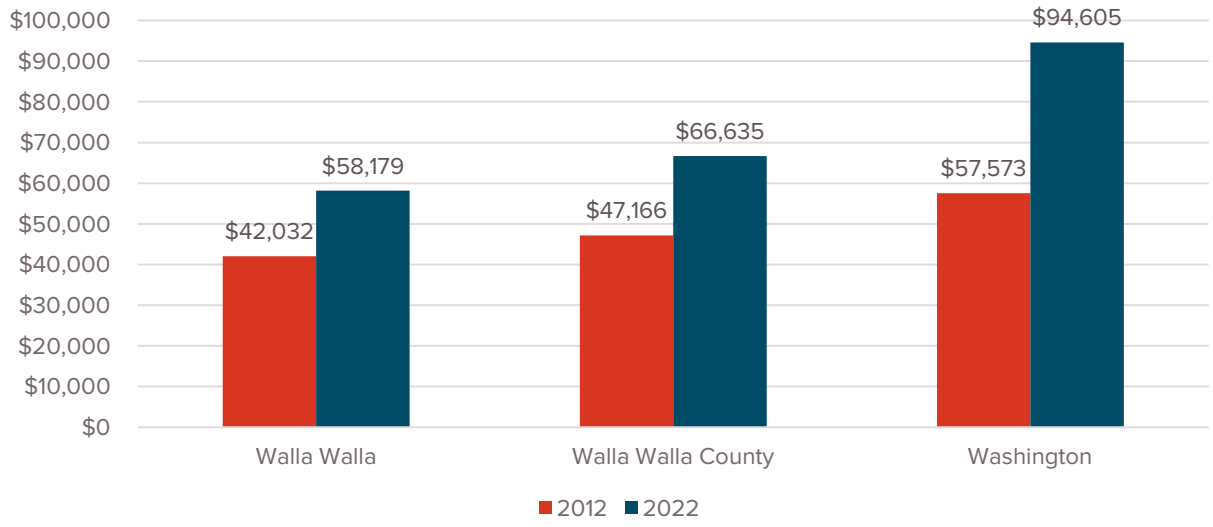
Source: U.S. Census Bureau, American Community Survey 2022 5-Year Estimates.

2.2 Economic Indicators

2.2.1 Income and Wages

Using the 2022 American Community Survey (ACS) 5-Year Estimates, Figure 5 shows that households in the city of Walla Walla have a median household income of $58,179, which is lower than both Walla Walla County and the state of Washington as a whole. Washington's median income levels increased by approximately 64.3% between 2012 and 2022, while Walla Walla's median income levels increased by 38.4% during the same period.

Appendix X Figure 5. Median Household Income



Source: U.S. Census Bureau, American Community Survey 2022 5-Year Estimates.

2.2.2 Poverty and Unemployment

The federal poverty guidelines are an economic measure to determine the income level for households to qualify for certain federal benefits and programs, such as Medicaid, food stamps, family and planning services, Children's Health Insurance Program (CHIP), and National School Lunch Program. The poverty threshold defines what poverty is and provides statistics on the number of Americans who live in poverty. There are 7 Federal Poverty Levels (FPL) which are explained below:

- **100% FPL** – This is the official poverty line. People at or below this level are considered to be living in poverty.
- **138% FPL** – Used in determining Medicaid eligibility in states that have expanded Medicaid under the Affordable Care Act (ACA).
- **150% FPL** – Used for some public programs, such as certain utility assistance programs or reduced-fee healthcare services.
- **200% FPL** – Used to define a broader group of economically vulnerable people who might qualify for programs like the Children's Health Insurance Program (CHIP) or subsidized childcare.
- **250% FPL** – Used in certain programs like cost-sharing reductions for healthcare coverage under the ACA.
- **300% FPL** – Some state-based programs use this threshold for eligibility in programs such as housing assistance or state-funded health programs.
- **400% FPL** – The upper threshold for subsidies under the ACA for health insurance coverage. Households earning up to this amount may qualify for tax credits to help reduce healthcare costs.

Cities often use 200% and 400% of the FPL instead when reporting poverty because these higher thresholds capture a broader range of economic vulnerability. The 100% FPL is considered a very low benchmark, and many households just above this level still struggle with basic expenses, especially in urban areas with higher living costs. The 200% and 400% FPL levels better reflect the challenges faced by people who are not officially in poverty but face financial

insecurity. Additionally, these levels are also relevant because they correspond to eligibility thresholds for many public assistance programs. For example, healthcare subsidies under the Affordable Care Act (ACA) extend to households earning up to 400% FPL, and programs like Medicaid and the Children's Health Insurance Program (CHIP) often cover families earning up to 200% FPL. By reporting poverty at these higher thresholds, cities can better understand and address the needs of a larger portion of their population, including those who may not be officially classified as living in poverty but are still financially insecure. Table 6 on the following page shows the federal poverty level figures that were set by the US Department of Health and Human Services for 2022.



Appendix X Table 6. Federal Poverty Level Figures

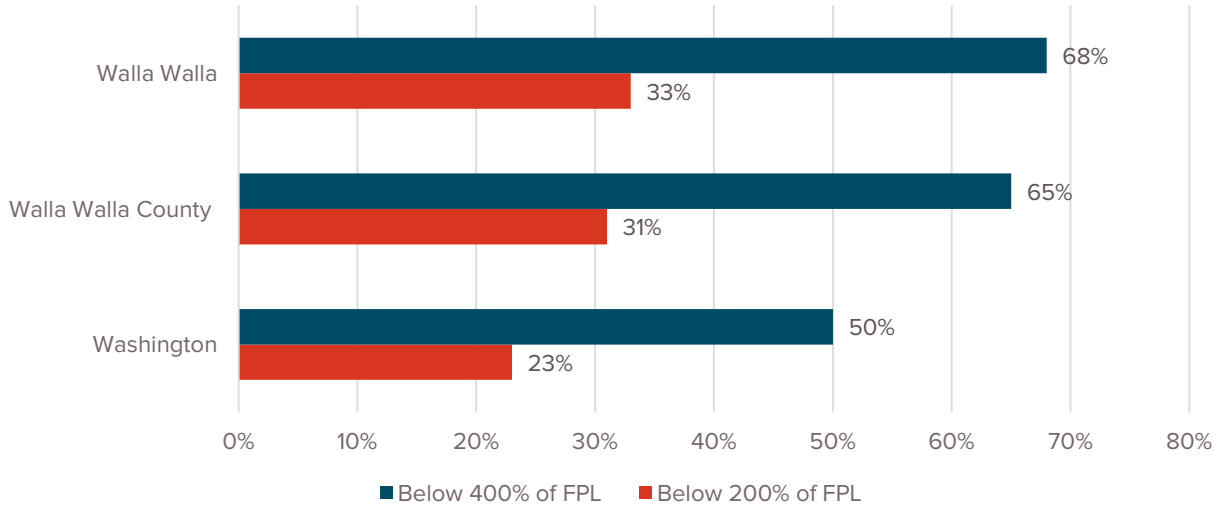
Household Size	100% FPL	200% FPL	400% FPL
1	$13,590	$27,180	$54,360
2	$18,310	$36,620	$73,240
3	$23,030	$46,060	$92,120
4	$27,750	$55,500	$111,000
5	$32,470	$64,940	$129,880
6	$37,190	$74,380	$148,760
7	$41,910	$83,820	$167,640
8	$46,630	$93,260	$186,520

Source: US Department of Health and Human Services.

Per the 2022 ACS 5-Year Estimates, approximately 33% of Walla Walla residents lived below 200% of the federal poverty level in 2022 which is only slightly higher compared to 31% in Walla Walla County, and 23% statewide. In other words, 33% of Walla Walla residents earned less than 200% of the federal poverty guideline, and 68% of residents earned less than 400%. As an example of what this means: a household of four in 2022 earning less than $55,500 annually would be considered living below the 200% federal poverty guideline and a household of four earning less than $111,000 annually would be considered living below the 400% federal poverty guideline.[3]

[3] *Federal poverty guidelines are updated annually and are published in the Federal Register.*

Appendix X Figure 6. Share of Population Below 200% and 400% Federal Poverty Level



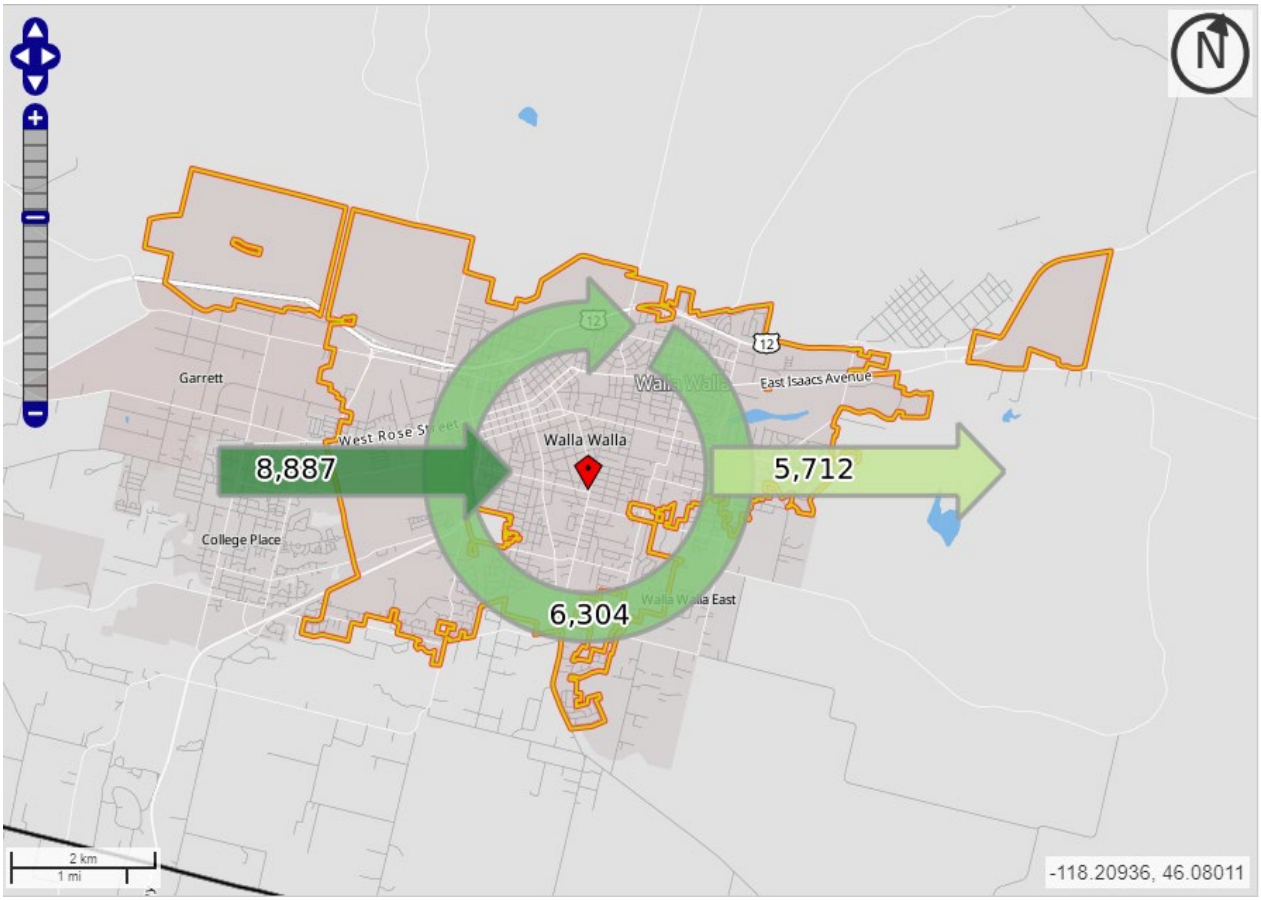
Source: U.S. Census Bureau, American Community Survey 2022 5-Year Estimates, Table S1701.

According to the 2022 ACS 5-Year Estimates, the unemployment rate in the City of Walla Walla is 6.2%, while Walla Walla County's is 5.8%. These are both higher than that of Washington state (4.9%).

2.2.3 Workforce Profile

Based on the U.S. Census Bureau's tool, OnTheMap, Walla Walla had approximately 15,191 total jobs (2021). Additionally, approximately 47.5% of Walla Walla residents were employed outside the city limits. Among jobs within the city, 41.5% were held by Walla Walla residents, with the remainder held by residents from cities and jurisdictions elsewhere in the region. Figure 7 shows how many people remain in Walla Walla, travel out, or travel in for work.

Appendix X Figure 7. Commuting Patterns in Walla Walla



Source: U.S. Census OnTheMap, https://onthemap.ces.census.gov/.

The largest industries in terms of the number of jobs held by workers in Walla Walla businesses are:

- **Healthcare and Social Assistance** – 3,996 jobs (26.3%)
- **Public Administration** – 2,101 jobs (13.8%)
- **Educational Services** – 1,750 jobs (11.5%)
- **Accommodation and Food Services** – 1,488 jobs (9.8%)
- **Retail Trade** – 1,417 jobs (9.3%)

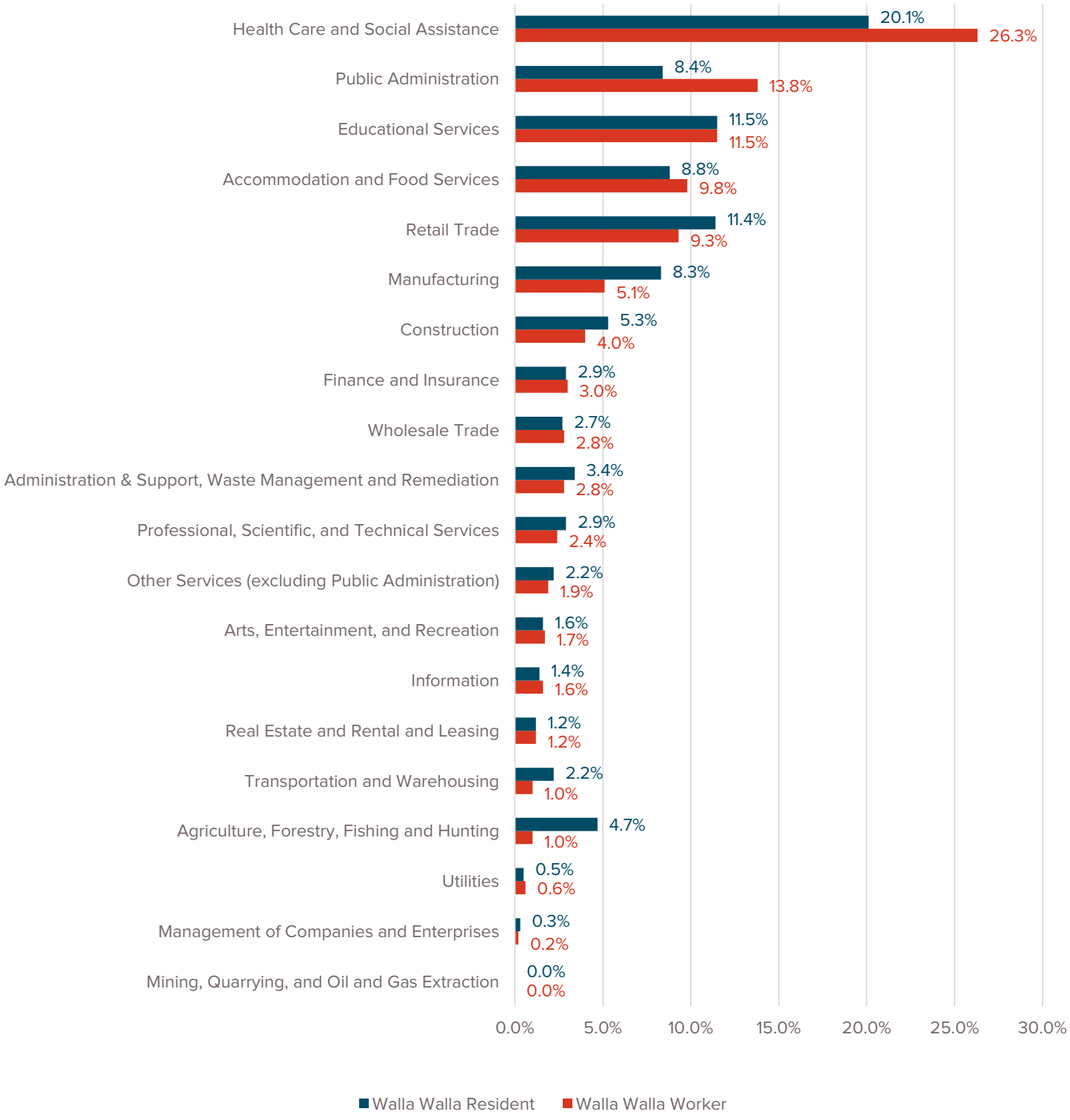
Walla Walla residents work primarily in the following industries, which are both inside and outside of the city limits:

- **Healthcare and Social Assistance** –2,413 jobs (20.1%)
- **Educational Services** – 1,383 jobs (11.5%)
- **Retail Trade** – 1,372 jobs (11.4%)
- **Accommodation and Food Services** – 1,062 jobs (8.8%)
- **Public Administration** – 1,008 jobs (8.4%)
- **Manufacturing** – 998 jobs (8.3%)

Figure 8 on the following page shows the distribution of jobs by industry for workers working inside of Walla Walla, as well as for Walla Walla residents working inside and outside of the city. Healthcare and social assistance is the biggest industry for those working in Walla Walla, as well as the largest industry employing Walla Walla residents.



Appendix X Figure 8. Employment by Industry



Source: U.S. Census Bureau OnTheMap, 2021.

2.3 Housing

2.3.1 Household Size

According to OFM's intercensal population estimates, Walla Walla's average household size was 2.38 persons in 2020, a decrease from an average of 2.43 persons per household in 2010. Walla Walla County's average household size in 2020 was 2.47, a slight decrease from its 2010 average of 2.49. Table 7 Presents Walla Walla's average household size as compared to that of Walla Walla County and Washington State for both 2010 and 2020.

Appendix X Table 7. Household Size

Year	City of Walla Walla	Walla Walla County	Washington
2010	2.43	2.49	2.51
2020	2.38	2.47	2.54

Source: OFM Intercensal Estimates, 2010-2020.

2.3.2 Housing Occupancy

Table 8 shows the percentage of occupied and vacant households; Table 9 shows the percentage of owner-occupied versus renter-occupied units in Walla Walla City as compared to Walla Walla County and Washington. OFM estimated the total number of housing units in the City of Walla Walla to be 12,514 in 2010 and 13,571 in 2020, an increase of 1,057 units (8.4%) over that decade. The percentage of occupied housing units decreased from 92.4% in 2010 to 90.1% in 2020. Of the city's occupied units, 60.4% were owner-occupied in 2022, while 39.6% were renter-occupied (a decrease from 40.2% in 2012).

Appendix X Table 8. 2010 Housing Occupancy

	# of Units in the City of Walla Walla	% Age of Total Housing Units in the City of Walla Walla	% Age of Total Housing Units in the County of Walla Walla	% Age of Total Housing Units in the State of WA
Occupied	11,723	92.4%	92.3%	90.8%
Vacant	968	7.6%	7.7%	9.2%
Total Units	12,691	100.0%	100.0%	100.0%

Source: U.S. Census Bureau, American Community Survey 2012-2022 5-Year Estimates, Table S2501.

Appendix X Table 9. 2020 Housing Occupancy

	# of Units in the City of Walla Walla	% Age of Total Housing Units in the City of Walla Walla	% Age of Total Housing Units in the County of Walla Walla	% Age of Total Housing Units in the State of WA
Occupied	12,414	90.1%	91.6%	90.8%
Vacant	1,359	9.9%	8.4%	9.2%
Total Units	13,773	100.0%	100.0%	100.0%

Source: U.S. Census Bureau, American Community Survey 2012-2022 5-Year Estimates, Table S2501.

Appendix X Table 10. 2012 Percent of Owner vs. Renter-Occupied Units

	City of Walla Walla	Walla Walla County	WA State
Owner-Occupied	59.8%	62.5%	62.3%
Renter-Occupied	40.2%	37.4%	37.7%

Source: U.S. Census Bureau, American Community Survey 2012-2022 5-Year Estimates, Table S2501.

Appendix X Table 11. 2022 Percent of Owner vs. Renter-Occupied Units

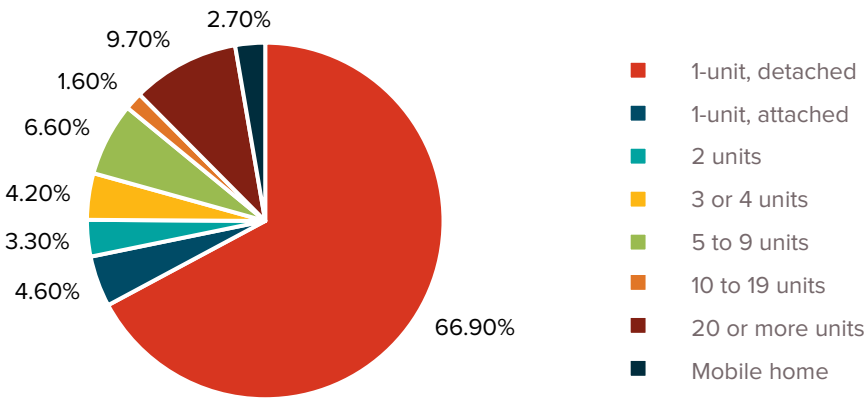
	City of Walla Walla	Walla Walla County	WA State
Owner-Occupied	60.4%	66.2%	63.8%
Renter-Occupied	39.6%	33.8%	36.2%

Source: U.S. Census Bureau, American Community Survey 2012-2022 5-Year Estimates, Table S2501.

2.3.3 Housing Types

A breakdown of Walla Walla's housing units by type is shown in Figure 9. Detached single-family units are by far the most prevalent housing type in Walla Walla, accounting for 67% of the city's existing housing stock. Single-family housing accounts for a smaller share of the housing units in Walla Walla when compared with Walla Walla County (73.5%). However, the city has a greater proportion of single-family housing units than that of Washington State (62.7%). Multifamily housing consisting of 3 or more units comprises nearly 23% of Walla Walla's housing stock, attached single-family homes account for about 4.6%, and two-unit/duplex homes account for 3.3%.

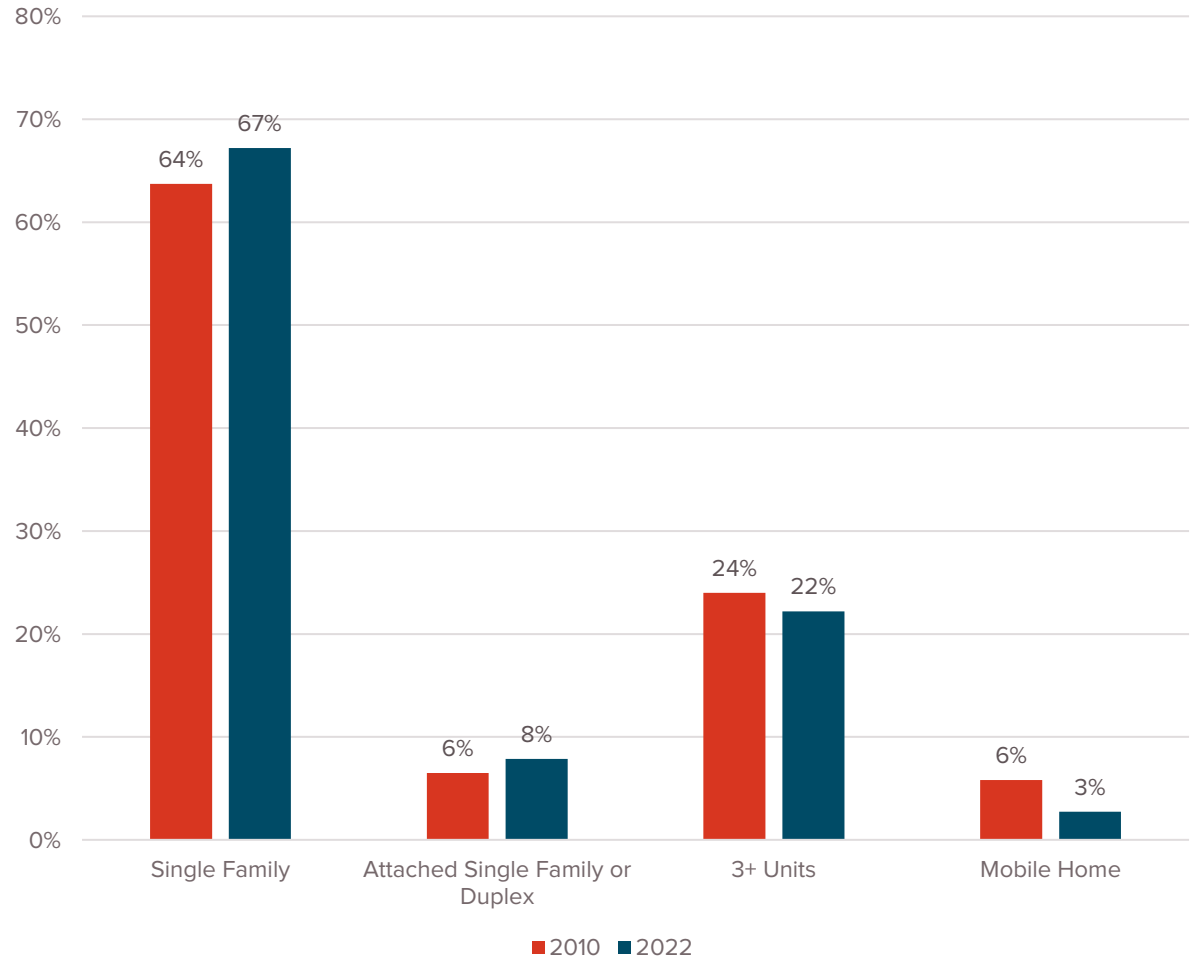
Appendix X Figure 9. Existing Housing Units by Type in Walla Walla



Source: U.S. Census Bureau, American Community Survey 2022 5-Year Estimates, Table DP04.

Figure 10 on the following page shows the change in the number of housing units between 2010 and 2022. While the total number of units increased, the variety of housing types stayed about the same. Single-family detached homes made up 64% of housing types in 2010 and 67% in 2022, whereas attached single-family or duplex housing units increased from 6% to 8% over the same time, while housing units with 3+ units actually decreased from 24% to 22% of all housing units. Mobile homes decreased from 6% to 3% of all housing units.

Appendix X Figure 10. Housing Units in the City of Walla Walla (2010-2022)



Source: U.S. Census Bureau, 2010-2022 American Community Survey 5-Year Estimates, Table DP04.

2.3.4 Age of Housing Stock

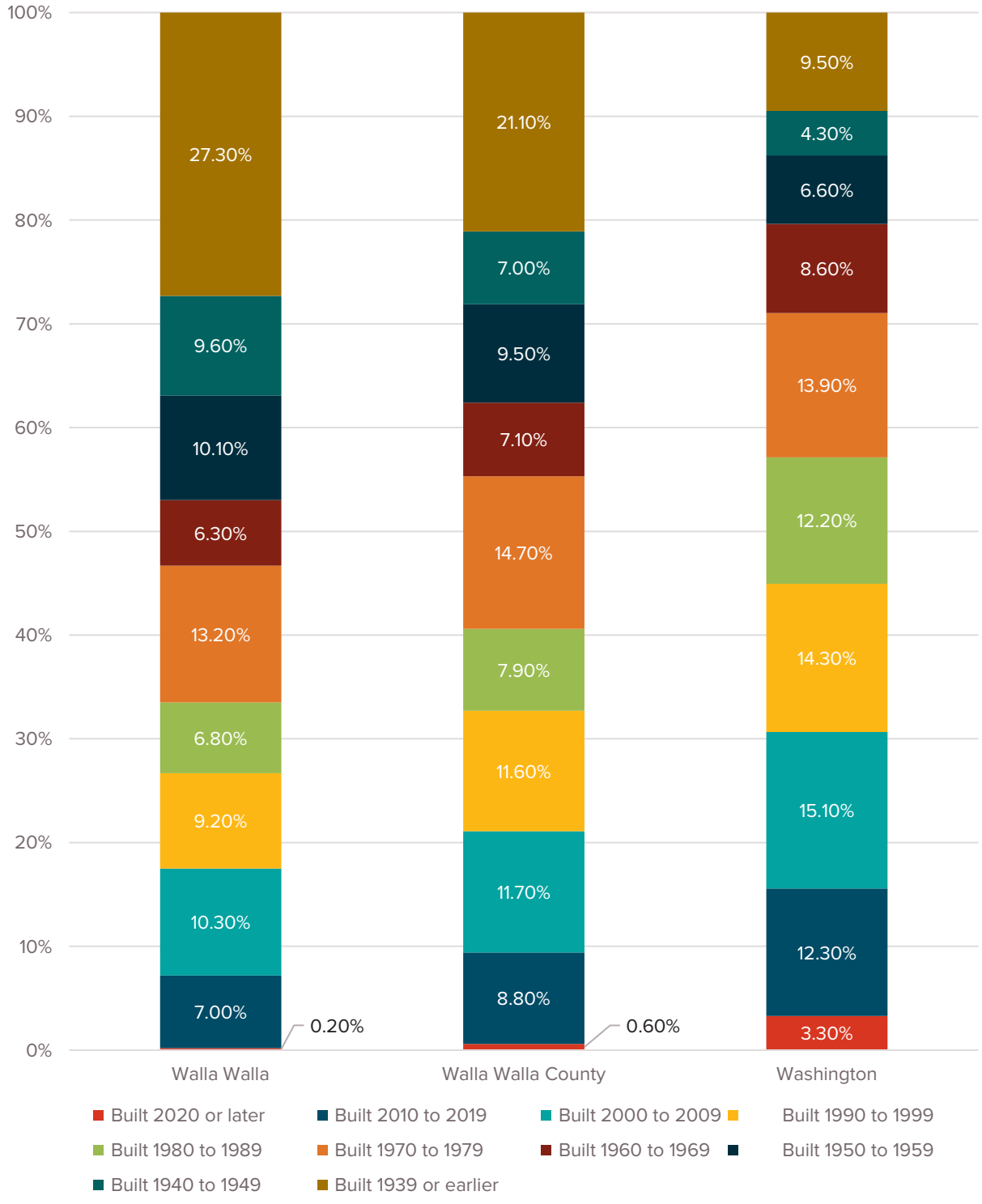
As shown in Figure 11, 7.2% of Walla Walla's existing housing stock has been constructed in the years since 2010. By comparison, 9.4% of the housing stock in Walla Walla County and 11.5% of that in Washington state as a whole was constructed in 2010 or later.

The highest percentage of houses in Walla Walla were built before 1940 (27.3%) with the second highest being houses built between 1970 and 1979 (13.2%). In Figure 11, the decades represented

account for the most significant increases in the city's population based on the available data from 1950 onward.

Walla Walla's housing stock tends to be older on average than that of Walla Walla County and that of Washington State as a whole.

Appendix X Figure 11. Existing Housing Stock in Walla Wall by Year of Construction



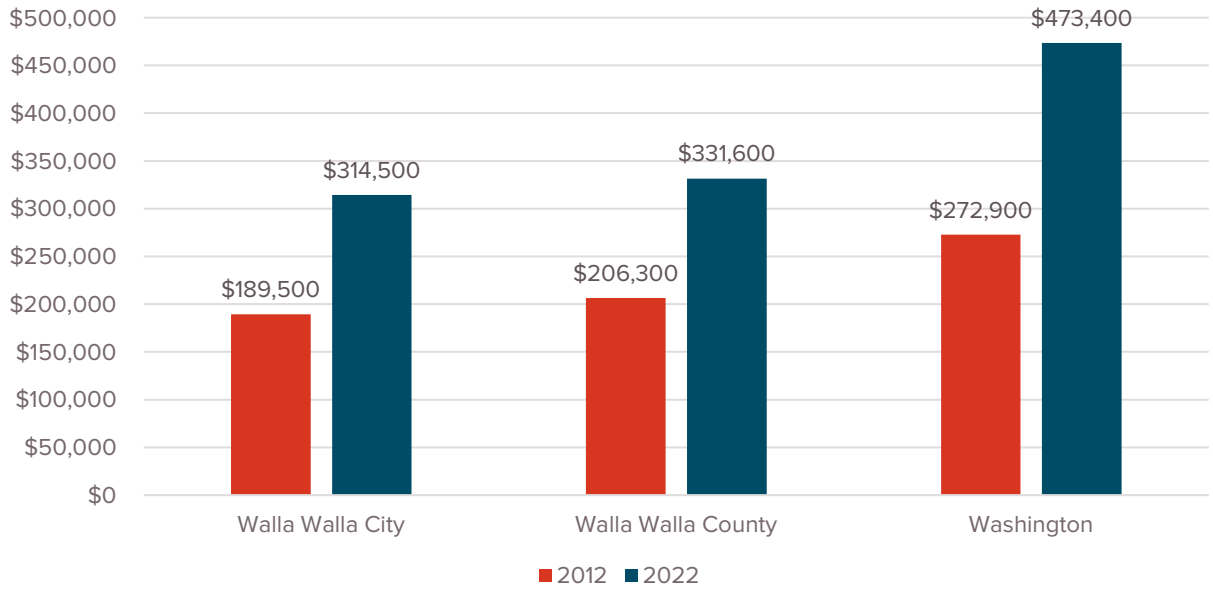
Source: U.S. Census Bureau, American Community Survey 2021 5-Year Estimates, Table DP04.

2.3.5 Housing and Rental Costs

As shown in Table 9 in the "Housing Occupancy" section above, approximately 39.6% of Walla Walla's occupied housing units are rentals and 60.4% are occupied by the owner. Walla Walla County has a much lower percentage of rental units, making up 33.8% of all occupied county housing units.

Rent prices are significantly more difficult to track than housing prices, particularly for smaller geographies. Census data on rent prices is both delayed and self-reported, and large real estate websites do not track rent prices at a granular level for smaller communities. However, the Census data shown in Figure 12 represents the median home value in Walla Walla in both 2012 and 2022. The median home value in Walla Walla in 2022 was $314,500, which is a 65.9% increase from the 2012 median home value of $189,500. During this same period, Walla Walla County saw its median home value increase by 60.3%, slightly less than Walla Walla. Both Walla Walla and Walla Walla County experienced a much lower increase in median value than Washington State (73.5%). The median home value in 2012 in Washington state ($272,900) was notably higher than that of Walla Walla County ($206,300) and the City of Walla Walla ($189,500).

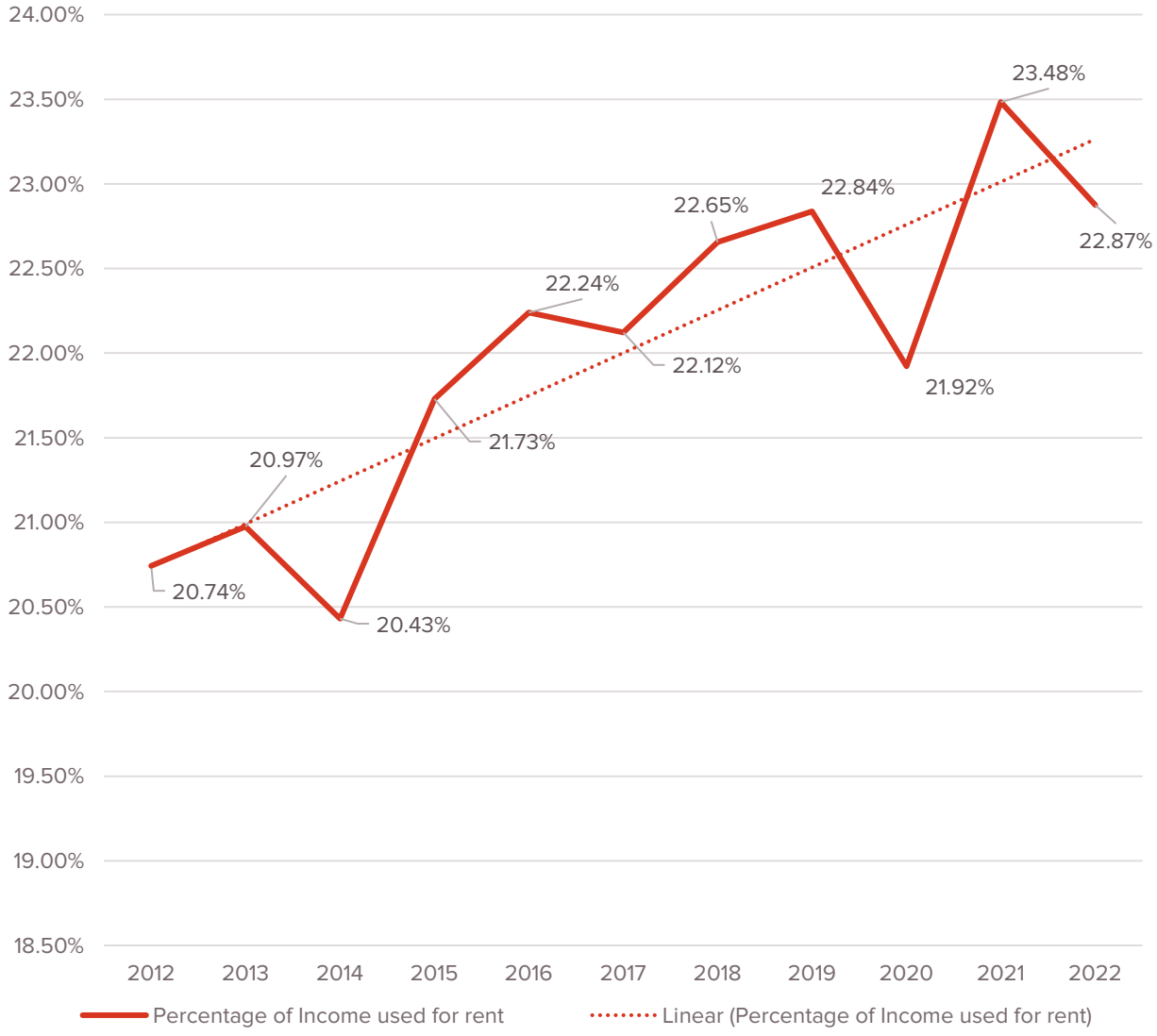
Appendix X Figure 12. Median Home Value (2012-2022)



Source: U.S. Census Bureau, 2010-2022 American Community Survey 5-Year Estimates, Table DP04.

Like the rest of the state and much of the country, the cost of housing in Walla Walla has increased in recent years, and incomes have not kept pace with housing costs, as shown in Figure 13. When compared with a 2012 baseline, the percentage of income that is used for rent has been increasing in Walla Walla.

Appendix X Figure 13. Percentage of Income Used for Rent (2012-2022) in Walla Walla



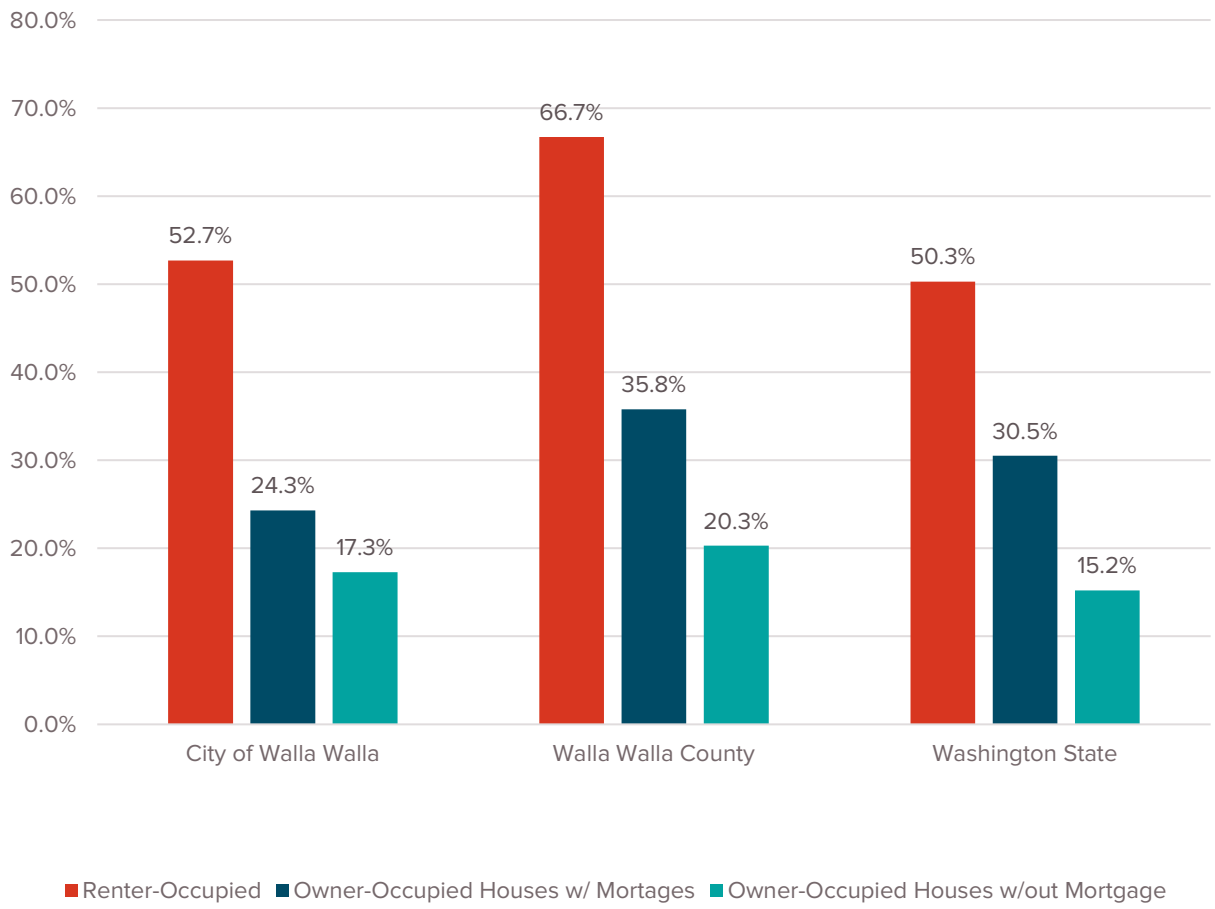
Source: U.S. Census Bureau, 2010-2022 American Community Survey 5-Year Estimates Table DP04, S1901.

2.3.6 Cost-Burdened Households

The U.S. Department of Housing and Urban Development (HUD) uses a measurement of "cost burden" to determine which subset of a community's residents are most in need of housing support or most at risk of displacement or housing hardship. A household is "cost-burdened" if they spend more than 30% of their monthly income on housing costs (including rent and utilities).[4]

[4] **U.S. Department of Housing and Urban Development (HUD), https://archives.hud.gov/local/nv/goodstories/2006-04-06glos.cfm.**

Appendix X Figure 14. Households that Spend More than 30% of their Household Income on Housing Costs or Rent



Source: 2022 ACS 5-Year Estimates, Table DP04.

Of the 12,865 households (2022 ACS 5-Year Estimates, Table S1101) for which monthly housing costs were calculated as a percentage of income, this means about 31.4% of households in Walla Walla, 40.9% of households in Walla Walla County, and 32.0% of households in Washington State are considered cost-burdened by HUD standards.

2.4 Land Use

Examining the existing zoning and land uses in Walla Walla clarifies how the city can accommodate its anticipated population growth over the next 20 years.

2.4.1 Existing Zoning

Walla Walla's zoning code contains 14 districts. General descriptions of what is allowed in each zoning district can be found in Table 10 on the following pages, and a map of Walla Walla's existing zoning districts is shown in Figure 15 on Page 23. In general, the majority of the city is zoned for large lots of single-unit residential and low-density residential dwellings.

Appendix X Table 12. Zoning Districts in Walla Walla and their Descriptions

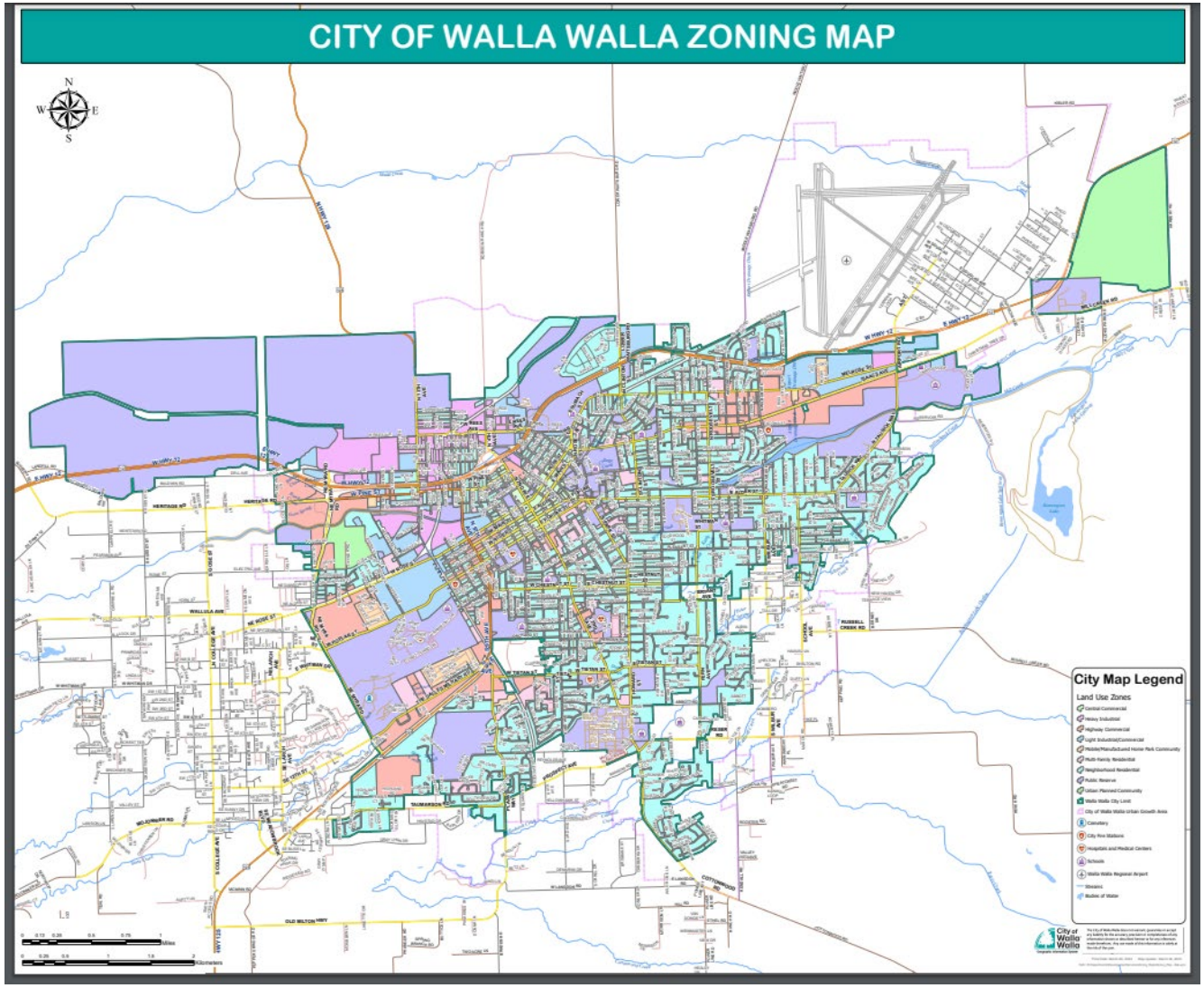
Zoning District	Description
RN- Neighborhood Residential	The Neighborhood Residential Zone is intended to provide for a variety of housing dwelling unit types including but not limited to single-family residential, duplexes, triplexes, fourplexes, townhomes, cottage housing, tiny homes, stacked flats, and accessory dwelling units.
RM- Multi-family Residential	The Multi-Family Residential Zone is intended to accommodate a compatible mixture of multifamily residential uses. Such areas generally serve as transition or buffer zones between major arterials or more intensively developed commercial areas and residential districts.
MHC- Mobile/ Manufactured Home Park Community	The Mobile/Manufactured Home Park Community Zone is intended to provide and protect affordable opportunities for the long-term occupancy of manufactured housing and mobile homes for residential purposes or rented or leased sites in mobile/manufactured home parks. Regulations are designed to establish, stabilize, and protect the residential character of the zone and to prohibit all incompatible activities. Certain essential and complementary uses are also permitted under conditions and standards which ensure the protection of the character of the zone.
CC- Central Commercial District	The Central Commercial Zone is intended to accommodate a wide variety of commercial activity (particularly those that are pedestrian oriented) together with compatible residential lifestyles and uses of upper story levels which will result in the most intensive and attractive use of the city's Central Business District.
CH- Highway Commercial	The Highway Commercial Zone is intended to accommodate a wide range of commercial activities which largely depend upon proximity to major streets and arterials for trade and transportation. The types of uses permissible in this zone are generally similar to the types permissible in the Central Commercial Zone, except that additional automobile-oriented businesses and land extensive commercial activities such as automobile sales lots, greenhouses and nurseries, lumber yards, etc., are permissible.
IL/C- Light Industrial/ Commercial	The Light Industrial/Commercial Zone is intended to: (A) provide for the development of areas near designated truck routes, highways and railroads in which certain types of industrial activities, which do not generate noise levels, light, or odor of fumes that would constitute a nuisance or hazard and which do not create exceptional demands upon public facilities and services, may be located; (B) permit in the same areas such commercial uses as may be compatible with the light industrial activities; and (C) protect such areas from other uses which may interfere with the stated purposes and efficient functioning of those purposes.
IH- Heavy Industrial	The Heavy Industrial Zone is intended primarily to provide adequate land area for the location of a broad range of industrial activities which may, by their nature, create a greater degree of hazard or annoyance than would be permitted in any other zoning district. Certain uses such as residential and retail businesses are not permitted in this zone in order to promote a viable heavy industrial area which will not be injurious to nor hindered by incompatible uses.



Zoning District	Description
PR- Public Reserve	The Public Reserve Zone is intended to: (A) protect and preserve certain areas of land devoted to existing and future use for civic, cultural, educational and similar facilities; (B) provide for the social needs of the community as those needs relate to public services, open space and institutions, whether publicly or privately sponsored; (C) enhance the identity and image of the community as a desirable place for human growth and development; (D) provide opportunities and facilities for the various activities and needs of a diverse and dynamic population; and (E) provide and protect parks, open space and other natural, physical assets of the community to improve the aesthetic and functional features of the community.
AD- Airport Development District	The Airport Development District Zone is intended for the development and use of land within the boundaries of the Walla Walla Regional Airport, primarily for aviation and industrial development. Public and quasi-public uses, agricultural development, and commercial activity which functions as a secondary support to aviation and agriculture are also permitted. Review of proposed development is to ensure compatibility with aviation facilities and adjacent properties, and to enhance the potential for future commercial, industrial, public and quasi-public development, and will include input from the management of the Walla Walla Regional Airport. The airport manager will be responsible for application of specific airport development standards and aviation related standards of the Federal Aviation Administration (FAA).
AA- Airport Approach- Overlay Zone	The Airport Approach – Overlay Zone is intended to protect certain runway approaches of the Walla Walla City-County Regional Airport from land uses and structures which would tend to impair the full utilization of the runways. It is further the purpose of this overlay zone to protect the health and lives of the public by preventing the undue concentration of population subject to airport hazards. The rules of this overlay zone are imposed in addition to those of the underlying district. Developments must comply with the requirements of both zones, and the more restrictive of the two.
UPC- Urban Planned Communities	The purpose of the Urban Planned Communities (UPC) Zone is to provide greater flexibility and encourage more creative land planning solutions on large parcels of land than would be achieved by traditional lot-by-lot development using the other zoning districts in this code, while at the same time ensuring substantial compliance with the goals and policies of the Comprehensive Plan and permitting more advantageous and efficient use of sites and infrastructure through the location and arrangement of structures, circulation, parking, and open spaces. The purposes of this district also are to provide flexibility to achieve public benefits and to respond to changing community needs. (Ord. 2018-53 § 12(part), 2018: Ord. 2016-49 § 7, 2016: Ord. 2012-09 § 36, 2012. Formerly 20.50.105).

Source: Walla Walla Municipal Code Title 20 (Chapter 20.50).

Appendix X Figure 15. City of Walla Walla Zoning Map



Source: City of Walla Walla.

2.4.2 Existing Land Uses

Walla Walla's incorporated boundaries cover about 7,294 acres. A breakdown of the land uses for the 7,294 acres is shown in Table 11 and Table 12. 2,870 acres of land in Walla Walla are designated for residential purposes. 633 acres of land are designated for commercial purposes and 462 acres represent industrial purposes. Table 11 gives a complete breakdown of all the land uses and the acres of land occupied by each land use. Table 12 also shows the vacant and redevelopable acres in Walla Walla. This analysis will be updated as part of the 2026 Comprehensive Plan process, which will include a new land capacity analysis.

Appendix X Table 13. Land Uses in Walla Walla and the Acres of Land They Occupy

Land Use Designation	Acres In City	Acres In UGA	Total Acres
Residential	2,870	1,785	4,655
Public	2,863	99	2,962
Commercial	633	4	636
Industrial	462	386	848
Airport	—	2,006	2,006
Master Planned Community	353	—	353
Downtown	113	—	113
TOTAL	**7,294**	**4,279**	**11,573**

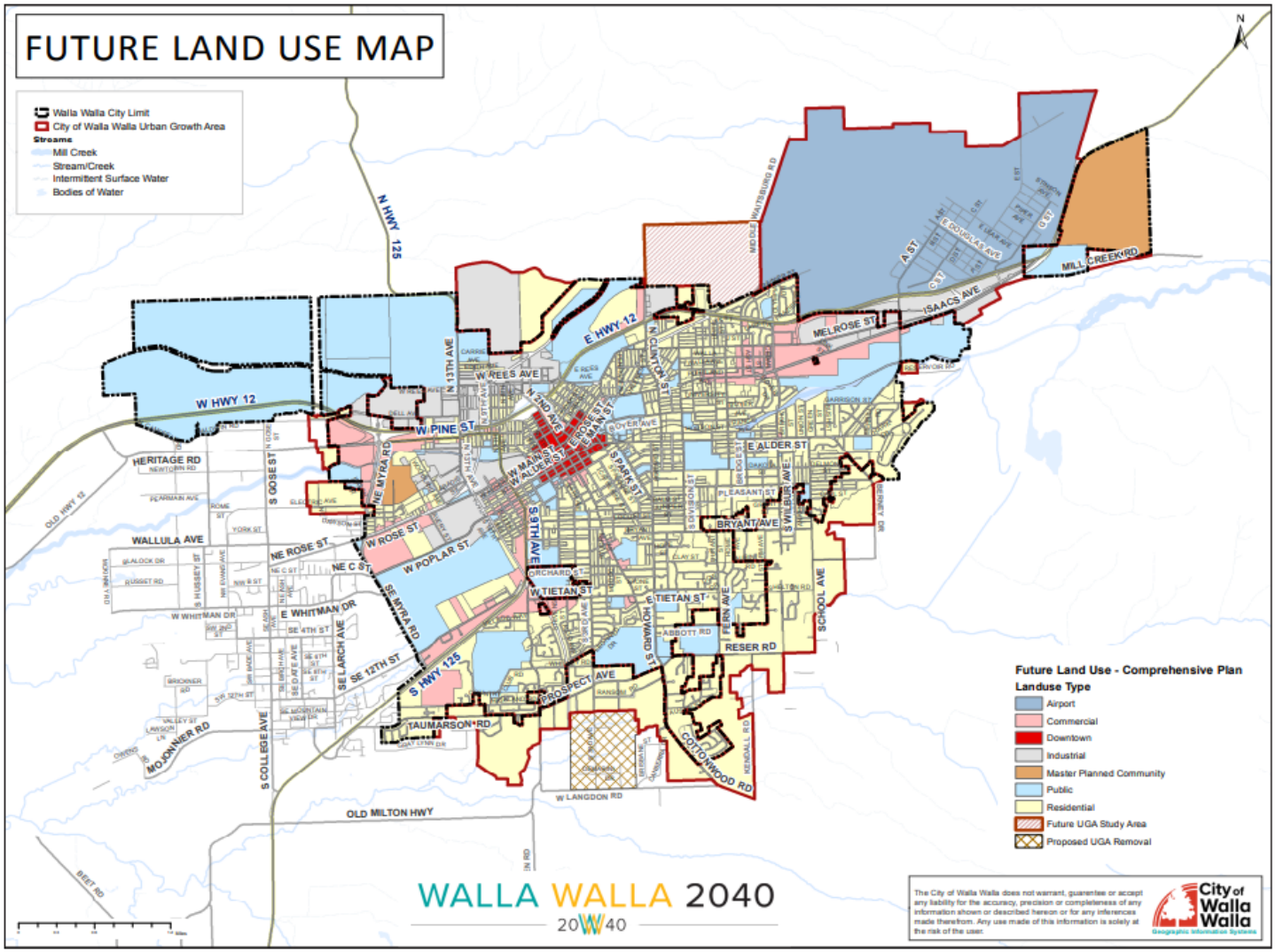
Source: Walla Walla Comprehensive Plan 2018.

Appendix X Table 14. Vacant and Redevelopable Lands in Walla Walla

Zoning Type	Vacant Acres	Redevelopable Acres
Central Commercial	1	5
Light Industrial/Commercial	79	12
Heavy Industrial	382	21
Highway Commercial	9	31

Source: Walla Walla Comprehensive Plan 2018.

Appendix X Figure 16. Future Land Use Map of City of Walla Walla



Source: Walla Walla Comprehensive Plan 2018.



3.0 Findings & Conclusion

Population Trends:

- Walla Walla's population has steadily increased, reaching 34,580 in 2024.
- The city accounts for 54.37% of Walla Walla County's total population.
- The growth rate has remained modest, with significant growth observed between 2000 and 2010 (+5.87%) and from 2010 to 2020 (+4.4%).

Demographics:

- The racial composition of the city reveals that 60.8% of residents identify as White, which is categorized as a race. In addition, 19.1% of residents identify as Hispanic or Latino, an ethnicity that may span various racial backgrounds. The remaining population includes smaller percentages of other racial groups, each contributing to the diversity of the city's demographic landscape.
- The city has a median age of 37.2 years, and 18.3% of the population is over 65.

Economic Indicators:

- Median household income in 2022 was $58,179, lower than both Walla Walla County and Washington State.
- The poverty rate is relatively high, with 33% of residents living below 200% of the federal poverty level.
- The unemployment rate in the city (6.2%) is higher than the state average (4.9%).

Employment:

- Healthcare and social assistance are the largest employment sectors within the city, followed by public administration and educational services.
- A significant portion of the workforce (47.5%) works outside of Walla Walla.

Housing Trends:

- Walla Walla has seen an 8.4% increase in housing units from 2010 to 2020.
- Homeownership is prevalent, with 60.4% of housing units being owner-occupied and 39.6% being renter-occupied.
- The cost of housing has risen, with median home values increasing by 65.9% between 2012 and 2022.
- Over half (52.7%) of rental households are cost-burdened, meaning they spend more than 30% of their income on housing.

Land Use and Zoning:

- The city is predominantly zoned for residential use, with a focus on single-family homes.
- Zoning districts include a variety of residential, commercial, and industrial zones, reflecting the city's diverse economic activities.

Forecast Conditions:

- The population is expected to continue growing, which will require careful planning for housing, employment, and infrastructure needs.



Appendix XI. Capital Facilities Plan

City of Walla Walla

FINAL

2026 – 2031

Capital Facilities Plan

December 3, 2025

Page 1

Introduction

Capital Facilities Plan

City of Walla Walla

INTRODUCTION

The City's Capital Facilities Plan (CFP) provides a list and schedule of capital expenditures for City Facilities. Anticipated funding sources include local funds, as well as State and Federal grants. Expenditures included in this plan have largely been identified through other planning efforts such as:

- The Downtown Master Plan
- Water System Plan
- General Sewer Plan
- Comprehensive Stormwater Management Plan
- Landfill Master Plan
- Six-Year Comprehensive Transportation Program
- Walla Walla Valley Metropolitan Planning Organization's 2040 Plan
- Parks & Recreation Comprehensive Plan

The reader is referred to these plans for additional details.

Why is it important for a city to develop and keep a capital facilities plan up to date? In particular, the following three compelling reasons drive the development and update of the City's capital facilities plan:

1. City health and long term stability in terms of quality of life and its economy require replacement and repair of existing infrastructure, investment in new infrastructure, and correction of deficiencies.
2. The City receives many State and Federal grants for infrastructure. For example, a significant portion of street improvement projects are funded with grants. The majority of infrastructure grants and loan programs require that projects be identified in an adopted plan.
3. The Washington State Growth Management Act of 1990 requires that capital facilities plans be adopted and consist of (1) an inventory of existing capital facilities; (2) a forecast of the future needs for such facilities; (3) the proposed locations and capacities of expanded or new facilities; (4) at least a six-year plan that will finance such facilities within projected funding capacities and clearly identifies sources of public money for such purposes; and (5) a requirement to reassess the land use element if funding falls short of meeting existing needs.

The purpose of the CFP is to ensure the City plans for adequate facilities that are (1) consistent with the goals and policies of the Walla Walla Urban Area Comprehensive Plan; (2) consistent with the projected population growth and land use plan; (3) concurrent with, or within six years of the impacts of new development in order to achieve and maintain adopted level of service standards; and (4) based on sound fiscal policies for the city.

This document is intended to be updated annually. Projects funded in the first two years of the plan are intended to be consistent with the City's biennial budget. This document in conjunction with the aforementioned individual public facility plans provide the information required by RCW 36.70A.070(3).

The city-owned public facilities encompassed by the plan include:

- streets
- sidewalks, paths and trails
- street lighting systems
- traffic signals
- domestic water system
- fire
- sanitary sewer system
- stormwater system
- parks and recreation facilities
- general administrative facilities
- cemetery
- landfill
- wastewater treatment facilities
- water treatment facilities
- police
- library
- bridges
- parking lots

This plan does not include Operations and Maintenance budgets (internal labor, supplies, materials, equipment, vehicles, etc.). The process and procedures for establishing and adopting Operations and Maintenance budgets is done through the bi-annual budget adoption.

DEFINITIONS

The following definitions will help in understanding how this Capital Facilities Plan is put together and read.

Capital Facilities: Capital facilities are structures, improvements, equipment (excluding fleet vehicles) or other major assets (including land) with a useful life of at least ten (10) years. Capital improvements are projects that create, expand, or modify a capital facility. The definition applies to projects that cost more than ten thousand ($10,000) dollars.

Level of Service: Levels of service are usually quantifiable measures of the amount of public facilities that are provided to the community. Measures of levels of service typically are expressed as ratios of facility capacity to demand by actual or potential users. Sometimes, levels of service (LOS) standards are based on the public service, such as police protection, rather than on the facility that houses the service (e.g. police station).

Concurrency: This is a term that requires public facilities and services necessary to serve development to be in place at the time of development or a financial commitment is made to provide the facility within a certain period of time. The Growth Management Act requires concurrency on transportation facilities, while all other public facilities must be "adequate."

CFP ORGANIZATION

This Capital Facilities Plan is organized around each of the public facilities provided by the city. Because the city wants to make sure that the Capital Facilities Plan is based on sound fiscal policy, all capital facilities for which city funds would be expended are included in the CFP, not just those facilities required to accommodate future growth. The CFP is based on the following categories:

- Transportation
- Transportation Benefit District (TBD)
- Infrastructure Repair & Replacement Plan (IRRP)
- Water
- Wastewater
- Stormwater
- Landfill
- Sanitation
- Public Facilities (Service Center & City Hall)
- Library
- Parks & Recreation
- Fire Department
- Police Department

LEVEL OF SERVICE STANDARDS

The Level of Service Standards for Public Facilities are as follows:

Fire Protection
Department goal is to have a response of less than 6 minutes 90% of the time.

Police Protection
All calls for assistance will be answered within a reasonable time consistent with the nature of the call.

Water Supply
Based on International Fire Code requirements for fire flow and Washington State Department of Health requirements for a safe supply of potable water.

Sanitary Sewer
Daily load demand times 2.5 for collection system
Daily load demand for treatment capacity

Transportation
LOS "D" for intersections along any collector or arterial roadway, except for intersections along the following arterial segments where LOS "E" is applied:

- Myra Road
- Poplar Street (Myra Road to Ninth Ave.)
- Rose Street (Myra Road to Ninth Ave.)
- Second Ave.
- Isaacs Ave. (Wilbur Ave. to Airport Way)
- Tietan Street

LOS "E" for all critical movements at local roadways.

FINANCIAL CONSTRAINTS

The first two years of the capital facilities plan is typically consistent with the City's adopted biennial budget. However, since capital expenditures sometimes impact multiple years after funding has been committed, it is prudent to plan ahead for the expenditure of funds for at least three years and in some cases longer. In addition, some of the City's adopted plans include longer term expenditure plans in which resources are actively being pursued when opportunities arise. Often grants become available for certain types of projects resulting from changing public policy at Federal, State, and local levels. The City of Walla Walla monitors these opportunities and puts forth funding applications for projects consistent with Federal, State, and local funding objectives.

Transportation

TRANSPORTATION

Transportation System
The City of Walla Walla's transportation system inventory covers a variety of multimodal system elements including streets, transit lines, air transport, rail transport and non-motorized traffic (pedestrian and bicycles). Traffic signals, City owned street lights, and bridge facilities are also included as street facilities. The review of all available modes of transportation in Walla Walla must provide consistency with state, regional and county plans to meet objectives of the Growth Management Act (GMA).

Planning Documents
In June 2018, the City developed a City specific Transportation System Plan as part of the 2018 Comprehensive Plan update. The following is a list of historical transportation planning documents:

- Walla Walla Valley Metropolitan Planning Organization's 2040 plan
- City of Walla Walla's Regional Bicycle and Pedestrian Plan
- Walla Walla Regional Airport: Airport Layout Plan Update
- Six-Year Comprehensive Transportation Program (CTP), also known as the Six-Year Transportation Improvement Program (TIP) for the City of Walla Walla
- 2004 Walla Walla/College Place Traffic Circulation Study
- Walla Walla/College Place UGAs Long Term Arterial Plan – 2007 - County Map TR-2
- 1994 ADA Compliance Plan

Roadway Classifications
The City of Walla Walla's street system consists of National Highway System roads, Highways of Statewide significance, Heritage Corridors, Regional Transportation System roads and city streets.

The City has three roads within the National Highway System: US 12; SR 125; and Airport Way, from US 12 to the Walla Walla Airport. Highways of Statewide Significance include US 12 from I-182 to the Columbia County Line and SR 125 from Oregon State Line to US 12.

The Metropolitan Planning Organization/Regional Transportation Planning Organization (MPO/RTPO) determines which roads are designated as part of the regional transportation system. All principal arterials, as well as some selected minor arterials in the City of Walla Walla are a part of the regional transportation system.

All streets are classified within the Federal Functional Classifications. The classifications define four different types of streets: principal arterials, minor arterials, collector streets and local streets. The classification of the street reveals the purpose or function the street serves. The functional classifications serve as a hierarchy of streets with principal arterials as the major urban or regional routes at the top of the hierarchy.

The function of a principal arterial is to carry the greatest amount of travel volume, transporting through traffic around the central city, between central business districts and outlying residential areas, between major inner city communities or between major suburban centers.

Minor arterials serve to supplement the principal arterials, interconnecting the street system by collecting and distributing traffic to collector or local streets or directly to destinations. Local bus routes tend to follow the minor arterials. Collector streets provide a link between residential neighborhoods and the arterial system. Local roads function as access to adjacent land uses and to higher road classifications.

Pavement Maintenance and Rehabilitation
A Street and Roads Task Force was formed by the City Council in 2002. The Task Force hired a consultant to complete a Pavement Maintenance and Rehabilitation Plan in 2003. The study was a comprehensive evaluation to look into solutions to improve the conditions of the entire City street network, excluding state routes and alleyways.

Roadways are evaluated on a number of criteria that result in an Overall Condition Index (OCI) which represents the average surface condition of each segment of roadway. The rating is based on a scale of 0 to 100, where 0 is failed and 100 being a newly constructed roadway.

The average overall OCI rating of City streets in 2002 was 59. The average score for principal arterials was 71, while minor arterials scored 66, collectors scored 61 and residential or local access roads were 56. These scores indicate that historically, most dollars for roadway improvements have been spent on the arterial roadways.

WSDOT considers triggering corrective action on any highway at an OCI rating of 85. The study provided funding scenarios which range from doing nothing to improving all of the streets. The study recommended that an optimized approach with an annual budget of $2.75 million be applied over a 10-year period. This would result in an average OCI of 86. The study indicated that the 10 year, "Do Nothing" option would result in an OCI rating of 26. The study concluded that just to maintain the OCI at 2003 levels; the City would need to invest over $1.5 million per year.

This Pavement Management System (PMS) budget was substantially more than the City could afford with the ($600,000 to $700,000) annual proportionate share of the gas tax revenues received from the State. Due to insufficient funding, pavement conditions in the city steadily declined. However, beginning in 2010, the City pursued avenues to renew pavement conditions beginning with the creation of the Infrastructure Repair and Replacement Program, formation of the City of Walla Walla Transportation Benefit District (TBD) and passage of the voter approved 0.2% sales tax for streets initiative in 2012 (sunsets in 2022), and most recently (2015), the Council approved 2% utility tax increase on public utilities. These local sources are helping to rebuild and fund preventative maintenance efforts.

Beginning in May of 2019, a re-evaluation of all roadways is being performed to update the OCI scores. From this data, a comprehensive pavement maintenance plan will be developed. This plan is expected to be completed in 2023.

City of Walla Walla citizen surveys have consistently shown that improving and maintain streets is a top priority. Pavement Management is a systematic approach to planning pavement maintenance and rehabilitation to maximize the pavement condition at the lowest cost. This is composed of applying the right treatment, to the right road, at the right time.

One dollar of preventative maintenance keeps a road in good condition, saving $10 of rehabilitation, or $20 for reconstruction in the future. The City has 145 centerline miles of road, or enough lane miles to complete a 2-lane road from Walla Walla to Portland, Oregon. If the City had to reconstruct their entire road network, it would cost about $250 million, so managing this asset is critical.

In 2019, the City conducted a Pavement Condition Index (PCI) assessment of every City street. The rating is based on a scale of 0 to 100 where 70-100 is very good, 50-69 is good, 25-49 is poor, and below 25 is very poor. The City's overall network PCI scored at a 62, principal arterials 78, minor arterials 70, collectors 64, and local roads, which are the majority of City streets, 58. The analysis also included parking lots, which scored a 66. Preventative maintenance is typically applied to PCI's of 60 or higher. Scores below 60 are either rehabilitation or outright reconstruction.

The City ran through 15, 6-year budget scenarios ranging from doing nothing to meeting all network needs at a cost of $13.4 million per year. Staff presented options to Council on June 8, 2020. Maintaining the current PCI score was presented as a cost of $5.7 million per year. As this funding ask was viewed as too high, staff presented Council with options for annual budgets of $1, 2, and $3.7 million per year.

At the August 24, 2022, Council Work Session, the formation of a Pavement Management Program task force was discussed with the idea of this group reviewing and recommending to Council, funding sources, options, and a recommended budget.

Level of Service

One way to determine whether a street is functioning well is to identify the street's level of service (LOS) rating. Defined by the Transportation Research Board's Highway Capacity Manual, LOS ratings range from "A" to "F", with LOS "A" roads generally having the greatest amount of travel ease and LOS "F" roads generally having travel delay issues. The travel ease is in reference to travel times, freedom to maneuver, traffic interruptions, comfort, convenience and safety.

The standard acceptable LOS for urban areas is LOS "D."

Public Transportation
Valley Transit, a separate taxing district led by elected representatives from Walla Walla County, City of Walla Walla and City of College Place provides bus service for the general public. Valley Transit runs nine different routes throughout the City plus a connector route for those areas outside of the service area. General bus service runs from 6:15 a.m. to 5:50 p.m. Monday through Friday. Service extends from the Walla Walla Regional Airport to College Place. The transfer center is located along Fourth Avenue in downtown Walla Walla between Main Street and Rose Street.

The bus provides additional services including: a Para-transit service for ADA-certified individuals; persons aged 70+ years; others unable to use the fixed-route bus system; and Job Access program employees. This service is fare-free for transportation to work and employment related activities. The bus service also runs a more limited evenings and Saturday schedule for the general public.

Walla Walla Regional Airport
The Port of Walla Walla owns and operates the Walla Walla Regional Airport. This facility consists of more than 2,400 acres located about three miles northeast of the City's Central Business District. The airport operates three runways, connecting taxiways, a passenger terminal and general aviation facilities. Commercial service at Walla Walla Regional Airport serves the Seattle market through Alaska Airlines, operated by Horizon Air.

Rail Transportation
Rail Transportation in the City of Walla Walla includes a shortline railroad provided by the Blue Mountain Railroad (BLMR). BLMR transports mainly grain, forest products, frozen foods and other farm products. A train generally runs each day in one direction or another. There is no direct rail passenger transportation through Walla Walla. Amtrak provides regional passenger train service from the Tri-Cities.

Six-Year Comprehensive Transportation Program (CTP)/Transportation Improvement Plan (TIP)
The City reviews, conducts a public hearing and adopts an updated Six-Year Comprehensive Transportation Program/Transportation Improvement Plan (TIP) each year in accordance with RCW 35.77.010. However, amendments of the TIP may need to be addressed to match state or other local project needs.

The Six-Year CTP/TIP is divided into two parts:

- Current Six Year Cycle
- Long Range Program

The first four years of the TIP are intended to be definitive, specific and include those projects that have secured or expect to have secured funding. The last two years include projects that have a high probability of receiving funding.

Projects in the years beyond the first six years are listed in the Long Range Program as "Planned." These listings are intended to be more flexible and may be accelerated, delayed or canceled as funding opportunities arise or circumstances change. Projects in the Long Range Program may be advanced to a higher level of priority should circumstances dictate that necessity.

PROJECT SELECTION CRITERIA
The evaluation system is designed to provide the guidance in reviewing projects and determining their feasibility and applicability in the Six-Year Comprehensive Transportation Program. This plan assigns priority to projects that:

- Address high risk and collision locations – for motorist, bicyclists, and pedestrians;
- Assist in completing a transportation network that serves all modes of transportation;
- Allocate resources towards streets that do not provide adequate service;
- Leverage opportunities and have a positive impact on other planned projects in the City;
- If not funded would result in a lost funding opportunity or partnership, costly future construction, or costly repair; and
- Allocate resources to achieve parity of infrastructure among neighborhoods over time.

The Six-Year Comprehensive Transportation Program goal and strategies are consistent with the direction of the City's Comprehensive Plan. The State's

Growth Management Act (GMA) required local governments to develop and adopt Comprehensive Plans covering land use, housing, capital-facilities, utilities and transportation by July 1, 1993. The City of Walla Walla adopted its first Comprehensive Plan in 1999 and completed an update in 2008 and in 2018.

ARTERIAL STREET PROJECTS

Walla Walla's principal and minor arterial streets make up about 32 (about 26%) of the 138 miles of roadways. Over 75% of the total volume of vehicle miles traveled each year is made on these arterial streets. These streets are typically multi-lane sections with higher posted speed limits and traffic signals at key intersections to improve the flow of traffic, while reducing accidents.

All federal and state transportation funding sources are limited to application on principal and minor arterials and collector street projects.

STREET SIGNALS

Walla Walla operates and maintains 43 street signals for traffic flow and control. Efforts since 2010 have been to upgrade control systems to current technology and pursue upgrades for safety and efficiency.

STREET LIGHTING

The City owns and maintains approximately 800 street lights. Most of the city owned lights were retrofitted in 2010-11 to induction lights through a Department of Commerce grant. With the advancement in LED technology, all new installations are LED. Through a cooperative project with Pacific Power, all street lights within the City owned by Pacific Power were retrofitted to LED in 2020.

BICYCLE AND PEDESTRIAN

The goal of the City of Walla Walla is to develop a walkable, pedestrian friendly, ADA accessible and bike friendly community. Goals include connectivity between downtown, colleges, schools, parks, shopping centers and Bennington Lake Recreation Area.

The city has been collecting inventory information on the sidewalk network for the past several years as resources are available with the goal of updating the City's 1994 ADA Compliance/Transition Plan. Data collection is expected to be completed in 2016.

BRIDGES

The City has 30 National Bridge Inventory (NBI) bridges. Many of the City of Walla Walla's bridges were constructed in the early 1900's to the mid 50's. While some of these bridges have been upgraded or replaced, several bridges have exposed rusty rebar, spalling concrete, show signs of continued deterioration, exhibit channel scouring, and are in need of repair. Other Mill Creek bridges are not part of the transportation system or are privately owned, but still may need substantial improvements or maintenance to be safe.

The City has updated the ratings and postings of City owned bridges and completed an inspection of City owned off R/W bridges.

While 2/3 of the City's bridges have exceeded their 50-year designed life-span, below are the structures recommended prioritizations for renovations or replacements:

1. **Howard-Bryant Bridge over Garrison Creek (Project Complete - Replaced in 2019)**
   a. This bridge is located at the intersection of a minor arterial and collector. Built in 1936 and renovated in 1948, it has a sufficiency rating of 57.89, it is load posted/restricted and is both structurally deficient and functionally obsolete.

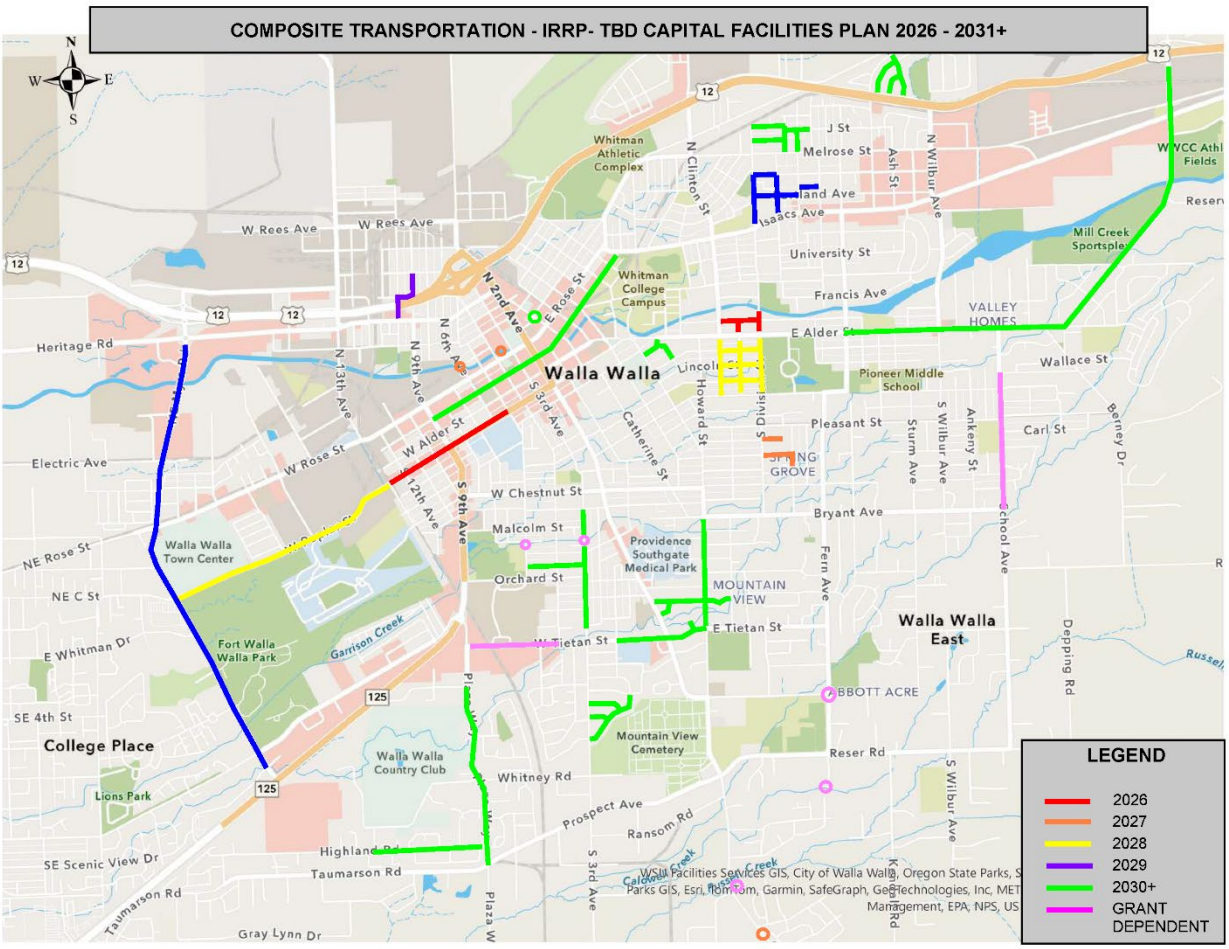
2. **Rose Street – Third Avenue over Mill Creek (Project Complete – Replaced in 2021)**
   a. This bridge dates from 1911 and is located at the intersection of a primary arterial and local street. It has a sufficiency rating of 54.49, it is load posted/restricted and is functionally obsolete.

3. **Main Street over Mill Creek**
   a. Built in 1902 and renovated in 1950 this structure is in the heart of downtown. While the sufficiency rating is 67.03, this bridge is load posted/restricted and is both structurally deficient and functionally obsolete.

4. **Spokane Street over Mill Creek (Project Complete – Replaced in 2020)**
   a. The City's oldest bridge, dating from 1905, this structure has a sufficiency rating of 53.29, it is load posted/restricted, and is structurally deficient.

The City is currently working to prioritize the 30 National Bridge Inventory (NBI) bridges for major renovation or replacement. The list above may change as a result of that effort.

Note - The sufficiency rating is the primary criteria for WSDOT's bridge program grant funding. The most recent call for projects required bridges have a rating below 40.


COMPOSITE TRANSPORTATION - IRRP- TBD CAPITAL FACILITIES PLAN 2026 - 2031+
N
W
E
S
Walla Walla
College Place
Walla Walla East
Whitman Athletic Complex
Whitman College Campus
Pioneer Middle School
Providence Southgate Medical Park
Mountain View Cemetery
Walla Walla Country Club
Walla Walla Town Center
Fort Walla Walla Park
Lions Park
Mill Creek Sportsplex
VALLEY HOMES
SPRING GROVE
MOUNTAIN VIEW
ABBOTT ACRE
W Rees Ave
Heritage Rd
Electric Ave
NE Rose St
NE C St
E Whitman Dr
SE 4th St
SE Scenic View Dr
Taumarson Rd
Gray Lynn Dr
Highland Rd
Whitney Rd
Prospect Ave
Ransom Rd
Reser Rd
Melrose St
Isaacs Ave
University St
Francis Ave
E Alder St
Wallace St
Carl St
Pleasant St
Bryant Ave
W Chestnut St
Malcolm St
Orchard St
E Tietan St
W Alder St
W Rose St
N 2nd Ave
N 6th Ave
N 9th Ave
N 13th Ave
12th Ave
S 9th Ave
S 3rd Ave
Catherine St
Howard St
Division St
N Clinton St
N Wilbur Ave
S Wilbur Ave
Ash St
Sturm Ave
Ankeny St
Fern Ave
School Ave
Berney Dr
Depping Rd
Garrison Creek
LEGEND
2026
2027
2028
2029
2030+
GRANT DEPENDENT

Transportation Benefit District (TBD)

Transportation Benefit District (TBD)

In 1987, the Legislature created TBDs as an option for local governments to fund transportation improvements. In 2005, the Legislature amended the TBD statute to expand its uses and revenue authority. In 2007, the Legislature amended the TBD statute to authorize the imposition of vehicle fees and transportation impact fees without a public vote. In 2010, the Legislature amended the TBD statute again to clarify project eligibility, the use of impact fees, and sales tax expenditures, and make TBD governance more flexible.

The City Council established the Walla Walla City Transportation Benefit District by Ordinance 2011-19 following a public hearing at its November 2, 2011 regular meeting. The principal purpose of the TBD was for raising revenues to preserve, maintain and operate existing and planned transportation infrastructure in the City of Walla Walla. The TBD Ordinance acknowledged that while dedicated revenues have decreased, the ongoing annual costs to preserve and maintain the City's Transportation infrastructure continue to rise, leaving the City unable to continue to adequately preserve and maintain the transportation facilities.

The establishment of the Walla Walla TBD, along with voter approved funding, would provide a dedicated, annual funding mechanism for transportation improvements. Further with the certainty of TBD funding in place, the City enhances its competitive ability for additional State and Federal grant funding.

All funds raised through the TBD shall be expended only for such construction, preservation, maintenance and operational efforts in protecting the transportation infrastructure, reduce the risk of facility failure, improve safety, continue the cost-effectiveness of infrastructure investments, and continue the optimal performance of the transportation system.

After following the necessary procedural actions that accommodate the TBD funding option, the TBD Board placed the 0.2% sales and use tax on the February 14, 2012 ballot for the voters to determine the viability of TBD funding. 6,929 votes were received, with 4,475 residents voting yes and 2,654 voting no. With 61.7% voter approval, the 0.2% sales tax increase passed, and Ordinance TBD-2012-01 was adopted, imposing the 0.2% sales and use tax within the City limits for a period of ten years. The TBD could be extended an additional 10-years by voter approval exceeding 50%.

In 2012, City staff updated the Pavement Condition Index (PCI) of the 25 Top Citizen Ranked Projects. PCI is a pavement rating of 0-100 with a perfect 100 given to a brand new road. A weighted prioritization of TBD projects was established and adopted by the Advisory Committee that used citizen votes as the highest weighting, and also included street classification, traffic volume, and the PCI score. The result is a prioritized list of the top 25 TBD streets.

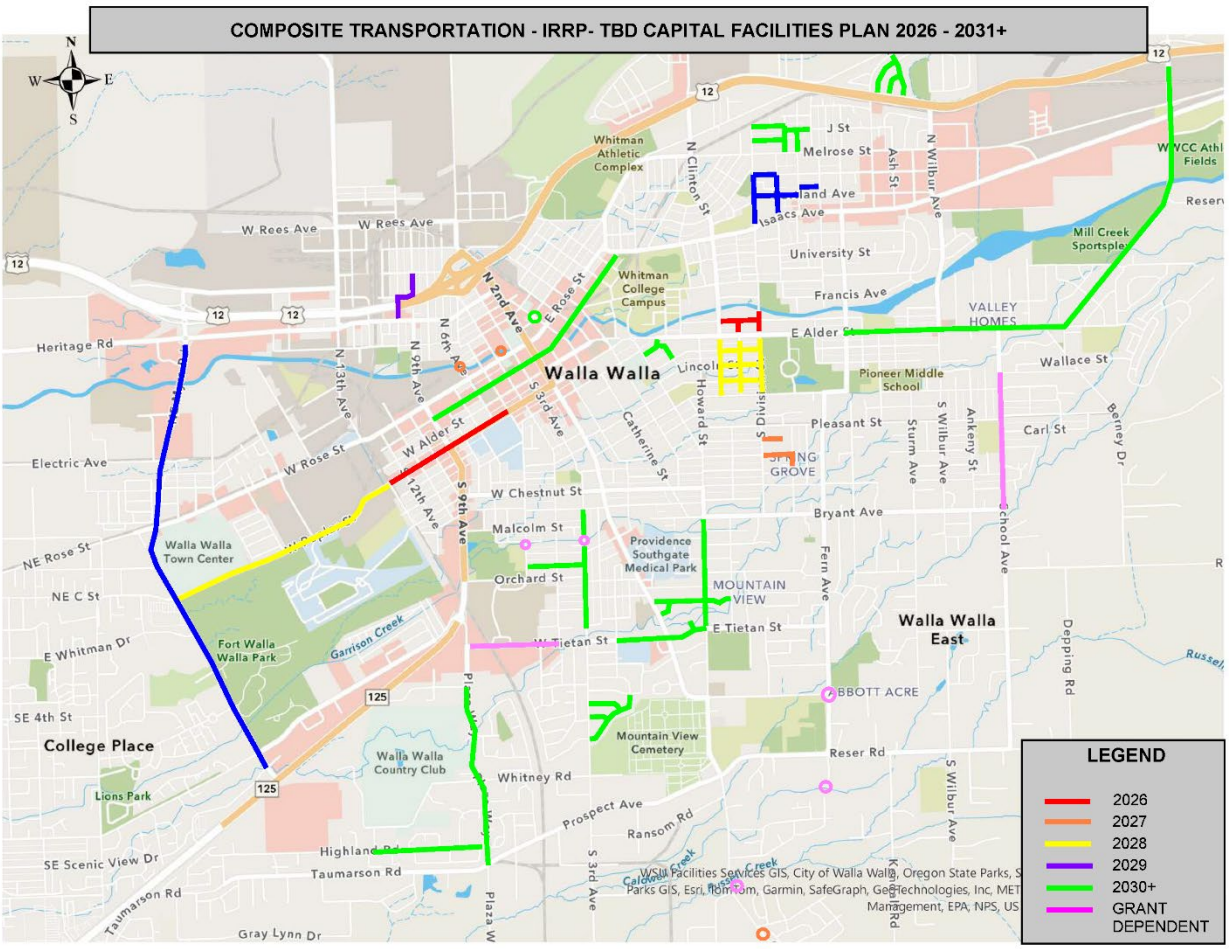
This ten-year term of the TBD sales tax began on July 1, 2012. Revenue generated to date:

2012 = $347,000	2019 = $1,463,400
2013 = $1,022,500	2020 = $1,469,300
2014 = $1,048,600	2021 = $1,820,300
2015 = $1,135,800	2022 = $1,980,000
2016 = $1,225,000	2023 = $2,063,000
2017 = $1,248,100	2024 = $2,112,200
2018 = $1,426,400	

On July 14, 2021, the City Council approved a ballot proposition for voters to authorize the continuation of the 0.2% TBD sales tax for an additional 10-year term.

In August 2021, the City conducted a statistically valid streets survey through Cobalt Community Research which included a new citizen priority list of the top 25 streets to be fixed should the TBD be extended.

On November 2, 2021, 7,840 votes were received with 5,804 residents voting for continuation, and 2,036 voting to end the TBD. With 74.03% voter approval the 0.2% sale tax for TBD is continued for an additional ten-year tern, from July 1, 2022, till June 30, 2032. This voter approval was adopted by City Ordinance No. 2022-05 on March 10, 2022.


COMPOSITE TRANSPORTATION - IRRP- TBD CAPITAL FACILITIES PLAN 2026 - 2031+
N
W
E
S
Walla Walla
College Place
Walla Walla East
Whitman Athletic Complex
Whitman College Campus
Pioneer Middle School
Providence Southgate Medical Park
Mountain View Cemetery
Walla Walla Country Club
Walla Walla Town Center
Fort Walla Walla Park
Lions Park
Mill Creek Sportsplex
VALLEY HOMES
SPRING GROVE
MOUNTAIN VIEW
ABBOTT ACRE
W Rees Ave
Heritage Rd
Electric Ave
NE Rose St
NE C St
E Whitman Dr
SE 4th St
SE Scenic View Dr
Taumarson Rd
Gray Lynn Dr
Highland Rd
Whitney Rd
Prospect Ave
Ransom Rd
Reser Rd
Melrose St
Isaacs Ave
University St
Francis Ave
E Alder St
Wallace St
Carl St
Pleasant St
Bryant Ave
W Chestnut St
Malcolm St
Orchard St
E Tietan St
W Alder St
W Rose St
N 2nd Ave
N 6th Ave
N 9th Ave
N 13th Ave
S 3rd Ave
S 9th Ave
12th Ave
Catherine St
Howard St
Division St
Fern Ave
Sturm Ave
S Wilbur Ave
Ankeny St
School Ave
Berney Dr
Depping Rd
Garrison Creek
Mill Creek
Russel
LEGEND
2026
2027
2028
2029
2030+
GRANT DEPENDENT

Infrastructure Repair and Replacement Plan (IRRP)

Infrastructure Repair and Replacement Plan (IRRP)

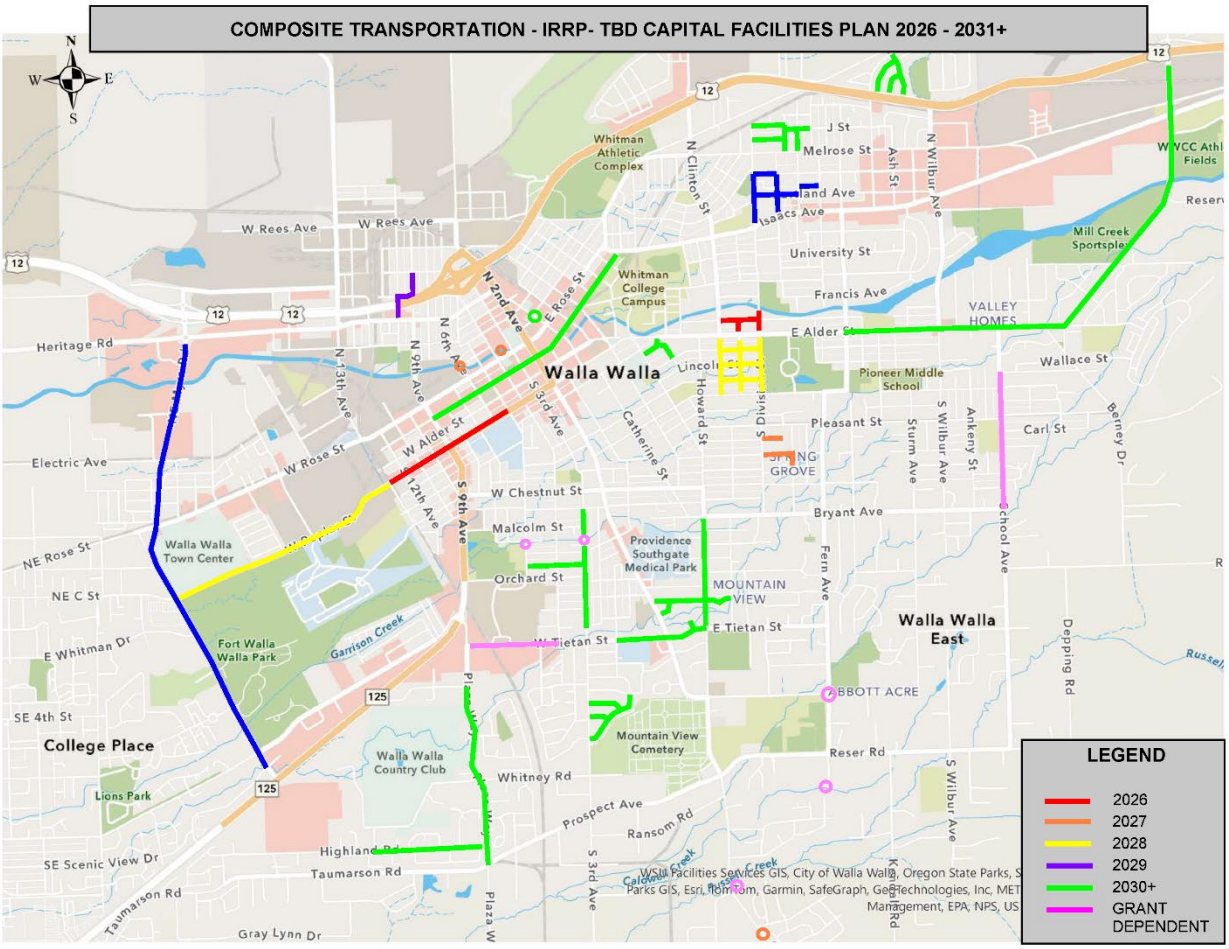
Walla Walla and much of the nation is facing a failure of three critical infrastructure systems: water, sewer and streets. The City has 115 miles of failing facilities and there are approximately 40 miles where all three are failing in the same stretch of road. To avoid costly consequences to human health and safety, the environment, and the local economy, the City adopted a systematic approach to the replacement of the infrastructure in this category referred to as the failing trifecta.

Established by the City Council in April 2010, the IRRP program was funded by a six-year stepped utility rate increase. Program funding included an $8.82M revenue bond that was re-paid over the first six-year period (2010 – 2015). With the bond paid off and the stepped utility rate increase fully implemented, the IRRP program generates approximately $5.1M per year in total revenue. This translates to approximately 1.3 linear miles of infrastructure (water, sewer, street) replaced per year in 2016 dollars. This predictable revenue source lends itself to provide matching funds for outside grant/loan funding sources. This funding has shown and will continue to show its ability to be leveraged against outside funds.

Project selection for IRRP is based on an equally weighted quantitative scoring system for street, water, and wastewater. Street scoring is based on the Transportation Benefit District (TBD) scoring criterion, which accounts for roadway classification, Average Daily Traffic (ADT), roadway condition rating, and citizen votes.

The water system scoring is based on leak history, pipe material type, age, and size.

The sewer system scoring is based on pipe material, maintenance history, claim history (back-ups), size limitations, age, and structural deficiencies.


COMPOSITE TRANSPORTATION - IRRP- TBD CAPITAL FACILITIES PLAN 2026 - 2031+
N
W
E
S
Walla Walla
College Place
Walla Walla East
Whitman Athletic Complex
Whitman College Campus
Pioneer Middle School
Providence Southgate Medical Park
Walla Walla Town Center
Fort Walla Walla Park
Walla Walla Country Club
Mountain View Cemetery
Mill Creek Sportsplex
VALLEY HOMES
MOUNTAIN VIEW
ABBOTT ACRE
Garrison Creek
Mill Creek
W Rees Ave
University St
Francis Ave
E Alder St
Wallace St
Pleasant St
Bryant Ave
W Chestnut St
Orchard St
Malcolm St
E Tietan St
W Tietan St
Reser Rd
Whitney Rd
Prospect Ave
Ransom Rd
Highland Rd
Taumarson Rd
Gray Lynn Dr
SE Scenic View Dr
Lions Park
Heritage Rd
Electric Ave
NE Rose St
NE C St
E Whitman Dr
SE 4th St
Melrose St
Isaacs Ave
Carl St
Berney Dr
Depping Rd
School Ave
Fern Ave
Sturm Ave
Ankeny St
S Wilbur Ave
N Wilbur Ave
N Clinton St
Ash St
N 2nd Ave
E Rose St
N 6th Ave
N 9th Ave
N 13th Ave
S 3rd Ave
S 9th Ave
S 12th Ave
Howard St
Catherine St
Plaza Way
12
125
LEGEND
2026
2027
2028
2029
2030+
GRANT DEPENDENT
WSU Facilities Services GIS, City of Walla Walla, Oregon State Parks, S
Parks GIS, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, MET
Management, EPA, NPS, US

Water

Walla Walla Water System

The City of Walla Walla operates a group A community water system, providing service to approximately 33,000 residents via 10,500 connections. The City's Mill Creek surface water supply is classified as an unfiltered supply and currently utilizes ozone for primary disinfection and chlorination to maintain distribution system residual disinfection. The Mill Creek Water Treatment Plant has a capacity of 24 Million Gallons per Day (MGD) and produces roughly four billion gallons of water per year.

Water System Planning (WSP)
A Comprehensive Water System Plan (WSP) update was prepared by HDR Engineering and adopted in 2013 by City Council (Resolution 2013-113).

The WSP did not note any system deficiencies related to the supply, storage, fire flow, or with the distribution capacity portions of the water system.

In 2020, the WSP was updated by Murray Smith & Associates.

Other documents pertinent to the City's Water System include:

- 1999 City of Walla Walla Urban Growth Area Water and Wastewater Study (Economic and Engineering Services, Inc.)
- 1994 Walla Walla/College Place Coordinated Water System Plan (Economic and Engineering Services, Inc.)
- 2006 Mill Creek Oregon and Washington Community Wildfire Protection Plan (Community Wildfire Protection Plan Steering Group, James H. Hulbert)

The emphasis of the Water System Capital Facilities Plan (CFP) is focused on addressing state regulatory requirements of the Washington Water Use Efficiency (WUE) rule and to upgrade the Mill Creek Water Treatment Plant to meet EPA requirements for the Long Term 2 Enhanced Surface Water Treatment Rule (LT2).

Sources, Treatment and Storage
Water is conveyed from 36 square mile Mill Creek Watershed at the city's the city's Mill Creek diversion structure in Oregon (1865 Oregon Water Right) down a 14.5 mile 30-inch diameter transmission line to the Mill Creek Water Treatment Plant. At the plant, energy is generated from the water by a 2.2 megawatt hydroelectric generator producing approximately 13,500 megawatts of electricity per year (roughly enough for 1,500 homes).

Seven deep basalt wells provide supplementary and secondary capacity during summer high use periods and emergency supply when surface water quality exceeds allowable quality standards (turbidity).

The Mill Creek Treatment Plant disinfects raw water from Mill Creek using ozone and stores finished water in the two 7 million gallon reservoirs at the plant and in the 10 million gallon Clinton Street reservoir. The capacity of the water treatment plant is 24 MGD, which is considered adequate to meet the demands through 2031. City well sources will be used to supplement the remainder of the demands.

Continually changing regulations for drinking water, as well as source vulnerability has influenced the City's treatment facility plan. In 2020, the City completed an Ultraviolet (UV) disinfection plant project to provide a cost effective, long-term treatment and operating solution to meet LT2 requirements.

Aquifer Storage and Recovery (ASR)
The City began the ASR program in the late 1990s and after a decade of pursuing a permit received one from the Department of Ecology in 2016. The ASR program provides the City the ability to draw, treat, and store more water during times of surplus and use it during times of unavailable surface water.

The City presently operates two ASR wells and hopes to expand ASR capabilities further.

Distribution
88 miles of the City's 191 miles of water mains in the distribution system are considered to be facing failure due to age, condition and material type. 38 miles are considered to be IRRP eligible putting the other 50 miles in the Water System's capital replacement program.

There are four pressure zones in the system isolated by 24 pressure reducing valves (PRVs).

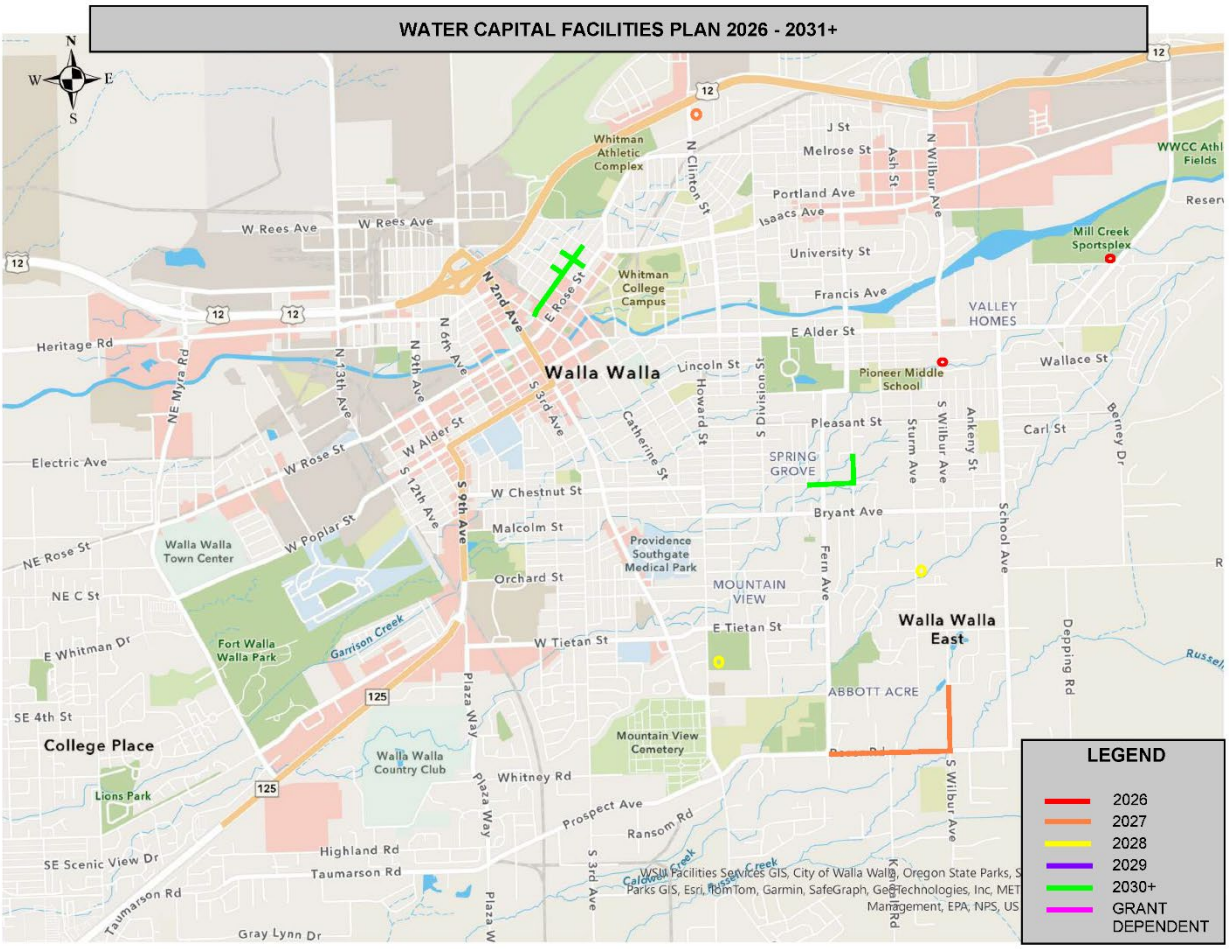
WUE and Water Loss Control Plan
Due to the age of the distribution system, water loss through system leaks has been a problem at least since the 1950s. Walla Walla's unaccounted for water exceeds 10%, so implementation of a Water Loss Control Plan is mandated by WAC 246-290-820(4).

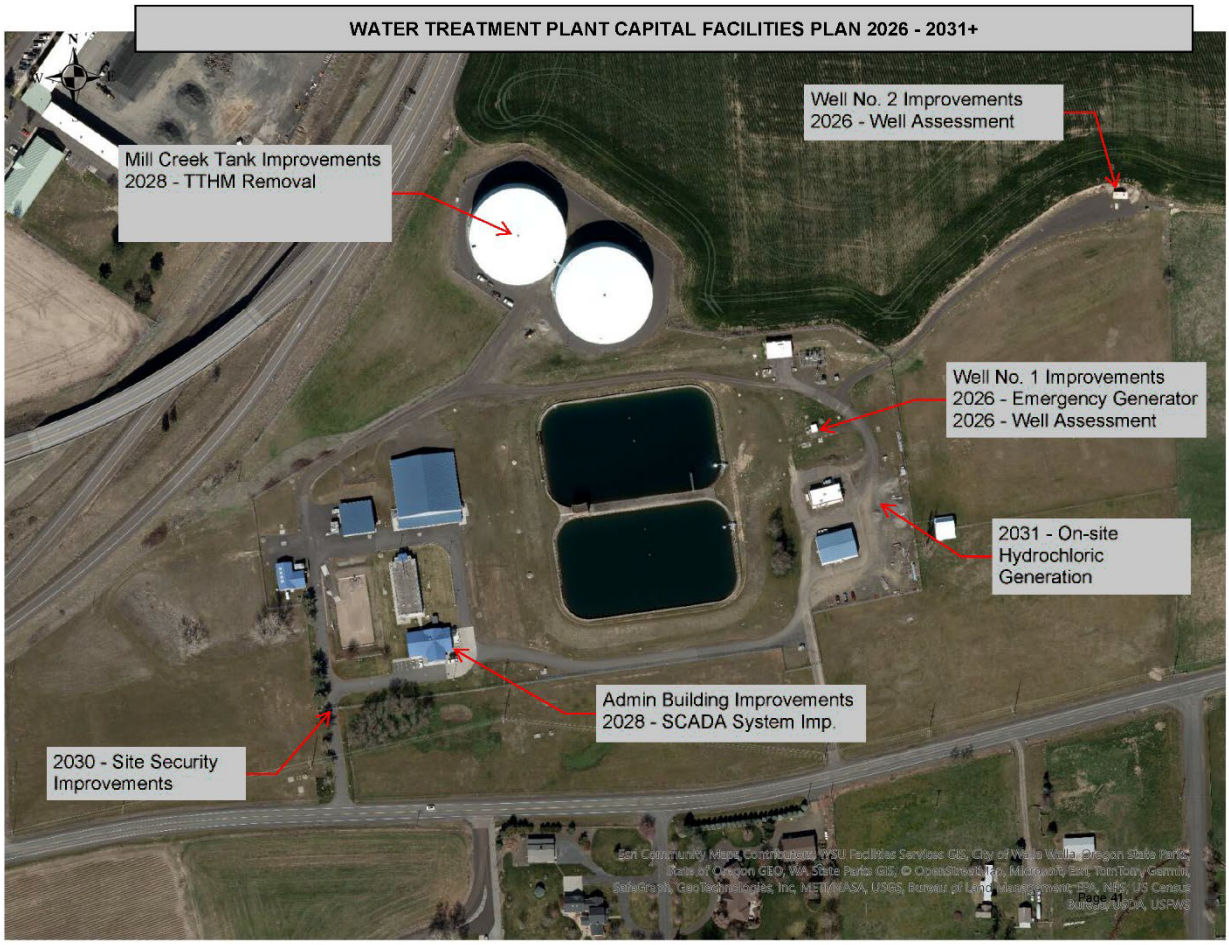
Currently, water use efficiency goals and programs that deal with major capital improvements and operation and maintenance expenses include:

- Meter testing program
- Capital Improvement Program – replacement of failing distribution piping
- Leak detection and repair
- Reduce water loss by 1% per year
- Leak notification to customers
- Development of a customer portal

Many of the projects in the Capital Facility Plan have been prioritized to replace leaking water mains and services. In 2018, the City completed the installation of a new advanced metering infrastructure (AMI) system that replaced all large and small water meters throughout the City. The AMI system provides more reliable usage data to improve water usage monitoring, and assist in reducing unaccounted water through more accurate metering.

Financial
In December 2015 and December 2021, City Council adopted a 6-year utility rate increase to in part, provide increased funding for the replacement of the City's failing water system.


WATER CAPITAL FACILITIES PLAN 2026 - 2031+
N
W
E
S
Walla Walla
College Place
Whitman Athletic Complex
Whitman College Campus
Mill Creek Sportsplex
WWCC Athl Fields
Pioneer Middle School
VALLEY HOMES
SPRING GROVE
MOUNTAIN VIEW
Walla Walla East
ABBOTT ACRE
Providence Southgate Medical Park
Walla Walla Town Center
Fort Walla Walla Park
Walla Walla Country Club
Mountain View Cemetery
Lions Park
Garrison Creek
Russel
W Rees Ave
N 2nd Ave
E Rose St
N Clinton St
J St
Melrose St
Ash St
N Wilbur Ave
Portland Ave
Isaacs Ave
University St
Francis Ave
E Alder St
Lincoln St
Wallace St
Heritage Rd
NE Myra Rd
N 13th Ave
N 9th Ave
N 6th Ave
S 3rd Ave
W Alder St
W Rose St
Electric Ave
S Division St
Howard St
Catherine St
Pleasant St
Sturm Ave
S Wilbur Ave
Ankeny St
Carl St
Berney Dr
W Chestnut St
S 12th Ave
S 9th Ave
Bryant Ave
School Ave
NE Rose St
W Poplar St
Malcolm St
Orchard St
NE C St
E Whitman Dr
W Tietan St
E Tietan St
Fern Ave
Depping Rd
SE 4th St
Plaza Way
Whitney Rd
Prospect Ave
Ransom Rd
Highland Rd
Taumarson Rd
SE Scenic View Dr
Gray Lynn Dr
S 3rd Ave
S Wilbur Ave
LEGEND
2026
2027
2028
2029
2030+
GRANT DEPENDENT
WSU Facilities Services GIS, City of Walla Walla, Oregon State Parks, S
Parks GIS, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, MET
Management, EPA, NPS, US


WATER TREATMENT PLANT CAPITAL FACILITIES PLAN 2026 - 2031+
Well No. 2 Improvements
2026 - Well Assessment
Mill Creek Tank Improvements
2028 - TTHM Removal
Well No. 1 Improvements
2026 - Emergency Generator
2026 - Well Assessment
2031 - On-site
Hydrochloric
Generation
Admin Building Improvements
2028 - SCADA System Imp.
2030 - Site Security
Improvements
Esri Community Maps contributors, WSU Facilities Services GIS, City of Walla Walla, Oregon State Parks, State of Oregon GEO, WA State Parks GIS, © OpenStreetMap, Microsoft, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USPWS

Wastewater

Wastewater

Planning Documents

- 2020 Amendment No. 1 to the 2015 General Sewer Plan Update (JUB Engineers)
- 2015 General Sewer Plan Update adopted by City Resolution 2015-129 (JUB Engineers)
- 1999 City of Walla Walla Urban Growth Area Water and Wastewater Study (Economic and Engineering Services, Inc.)
- 1997 Wastewater Treatment Facilities Plan (CH2M Hill)
- 1998 Wastewater Treatment Facilities Plan Addendum No. 1 (Kimball/Esvelt)

Treatment

The City of Walla Walla owns an advanced secondary domestic wastewater treatment plant, which provides Class A effluent. The facility is permitted by the Washington Department of Ecology (Ecology) under Permit WA-002462-7.

Construction of the facility began in 1928, with several expansions and/or modifications being constructed since its inception.

A 1927 court-ordered water rights agreement obligates Walla Walla to provide reclaimed water to two irrigation districts, Gose and Blalock. Prior to 1996, the effluent from the Wastewater Treatment Plant received only secondary treatment and disinfection before it was received by either of the irrigation districts. Since this reclaimed water was being used to irrigate food crops, the City's treatment facility had to be upgraded to meet the state's new Class A reclaimed water standards or the City had to provide the irrigation districts with an alternative source of water. Per court actions and previous agreements, Gose Irrigation District is entitled to 1.77 cubic feet per second (cfs) or 1.14 million gallons per day (MGD). Blalock Irrigation District's water right is 9.38 cfs or 6.06 MGD.

In 1996, Walla Walla and Ecology agreed that the preferred alternative would be to upgrade the facility to meet Class A reclaimed water standards for food crop irrigation. It was determined that the necessary upgrades to enhance water quality would be constructed under a three phased plan to meet the following criteria:

Walla Walla Water Reclamation Project – Summary of Improvements By Phase

Phase/Date	Description	Objective
Phase 1 12/31/2000 $19,829,000	*Fine Screening *Install Activated Sludge Advanced Secondary Treatment – Aeration Basin, Anoxic Basins, Clarifiers, RAS/WAS Pumps *Improved Sludge Treatment – Thickening, Upgrade Digestion, Dewatering, Storage facilities *Improve Disinfection System *Control Building & SCADA Upgrades *Standby Generator *Septage Receiving	*Remove Plastics, etc. *Effluent CBOD limits and interim effluent NH3 limits *Treat additional sludge from added BOD/NH3 removal processes *Eliminate toxic gas spill hazard *Upgrade lab & control system *Added reliability – backup power *New facility to accept septage
Phase 2A 12/31/2003 $1,128,000	*Added Fine Screening Unit *Effluent Filter Improvements *Added Sludge Dewatering	*Added reliability – screening *Ambient water quality NH3 limits *Sludge handling and treatment
Phase 2B 05/17/2005 $3,360,000	*Effluent & Irrigation Flow Meters *Sludge Mixing & Storage *Overflow and SCADA Improvements *Disinfection Improvements - UV	*Flow control/measurements *Sludge handling and storage *Control system upgrade *Improve pathogen removal
Phase 3 12/31/2008 $6,523,000	*Storage Lagoon (18 MG – 3 days) *Effluent Filter Additions *Side Stream Treatment Equalization *Waste Gas Scrubber	*Emergency Secondary Containment *Meet Class A Reclaimed Water Standards – improve effluent quality – NH3 limits *Accurate distribution of flow to Irrigation Districts *Reduce pollutants/corrosion – Improve air quality and reliability

Table taken from the City of Walla Walla Wastewater Facility Plan, Addendum No. 1, July 2003, Kimball Engineering/Esvelt Environmental Engineering

The updated wastewater treatment facility produces an advanced secondary treated Class A effluent that is discharged either to the Gose and Blalock (#3) Irrigation Districts or directly to Mill Creek. The discharge to Mill Creek is limited to the winter months (December through April), or when the irrigation districts don't elect to use the water.

Treatment Plant Operations
In 2000, the City contracted operation and maintenance of the plant and five sewage pump stations to the private plant operations firm CH2MHILL/OMI (now known as Jacobs).

Jacobs provides an annual report to the City summarizing plant activities and operations for the prior year.

Class B Biosolids
Approximately 520 (dry) tons of Class B biosolids are land applied at the Landfill property.

Future Growth and Permit Compliance Limitations
With the completion of Walla Walla's Class A-Water Reclamation Facility, the City is able to accommodate growth and treatment requirements within the Urban Growth Area well beyond 2032. The average daily flow design capacity of the treatment facilities is 9.6 MGD and current average daily flows are less than 6 MGD. The design population equivalent is 48,000 with a current City population estimated at about 33,000.

The two parameters of concern for future compliance with permit limitations include Total Nitrogen and PCBs. PCB concentrations are being monitored, and at times, have exceeded the identified limit of 0.0062 grams per day. The City, in partnership with Jacobs, monitor PCB concentrations and work with the public through the wastewater pretreatment program. The future Total Nitrogen Load, expressed as TKN in pounds per day (lbs/day) may exceed the NPDES permit that establishes the maximum average daily load to be less than 1,871 lbs/day, with the three maximum month average being less than 1,590 lbs/day. The current average TKN daily load is about 1,400 lbs/day.

The average daily load of TKN is expected to be less than 1,871 lbs/day until a population of 48,000 is reached (estimated 2070+/-). However, if the actual flow or waste load of TKN reaches 85% (1,590 lbs/day in 2032) of any one of the design criteria for three consecutive months, then a plan to address the objective of maintaining the plant capacity would be required to be prepared by the City per WAC 173-240-060. This would allow the City ample time to evaluate the facilities, various conditions, to schedule any necessary improvements, and to continue to achieve the conditions of the permit.

The Wastewater Treatment portion of the Capital Expenditure Plan focuses on improvements needed to upgrade some of the obsolete/aging equipment and to extend the operational life of certain facilities. Enhanced treatment needs are yet to be determined.

Collections System
Sewage generated in the City is collected and transported to the treatment plant via gravity service laterals, collection sewers, lift stations, force mains, and pump stations. The system contains approximately 144 miles of sewer mains and 2,700 manholes. The City has current contracts to accept sewage from the Port of Walla Walla and the US Veterans Medical Center. Both agencies have non-City water systems but transport their sewage into the City collection and treatment systems.

In 1978, the City realized that due to extended age, many of the collection system components have outlived their useful life and are beginning to fail. After recognizing that high inflow and infiltration (I/I) of rain and groundwater was a partial source of high treatment costs, the City initiated a sewer line replacement program. The initial six year program started in 1979 with funding set at $200,000 for replacement work per year. In 1993, the funding was increased to $400,000 per year for 1994 to 1998. The sewer replacement budget in 1998 was set at $631,000 for projects in 1999.

The investment for replacement of 81,600 feet of sewer mains from 1979 through 1993 totaled $2,800,000. From 1994 through 1997, 24,600 feet of mains were replaced for about $1,600,000. In 1998, approximately 5,200 feet of sewer main was replaced for the budgeted amount of $631,000. Between 1978 and 2011 about 45.8 miles of sewer mains have been installed, which represents about 32% of the total length of the collection system. This leaves about 2/3 of the collection system being over 35 years old.

Several portions of the sewer collection system consist of older, undersized 6" clay sewer mains that have exceeded their useful life. Over 12,100 LF of the collections system has structural damage, and needs to be replaced in the near future.

In 2013, several manholes along Cherry Street and other locations were chemically grouted with a polyurethane material to seal the infiltration of groundwater from entering the collection system. Other mains along Bryant Creek and Frazier Drive were lined with Cured-In Place-Pipe (CIPP) trenchless pipe technology. Initial reduction in infiltration from these projects and the IRRP program indicates that yearly average flows at the WW Treatment Plant have been reduced by about 0.8 million gallons per day (5.98 to 5.28 MGD).

Due to rapid growth and development from 2003 to 2008, the City developed a sewer model to better understand the impact of growth on downstream sewer collection main capacities. This model has helped to assure concurrency of necessary collection system improvements with potential growth in these underdeveloped areas.

City crews have been compiling a comprehensive library of videos of the sewer mains for the past several years. With the system televised, each pipe segment was evaluated and rated on a scale of 0 to 100 with 0 being a great condition pipe segment. Videos of over 2,050 sewer mains have been reviewed and scored based on the condition of the pipe. 319 of the 2,050+ mains reviewed have been scored between 75 and 100. 108,000 feet of the total sewer collection system (of 761,000 feet) is in need of major repairs or replacement. There were 34 sewer mains that scored 100, representing that 12,140 feet of the City's mains have serious defects. Over 45,000 feet of main scored over 90 and need to be addressed in the near future. Replacement of this portion of the system would require a total investment of approximately $27,000,000.

With the pipe segment scoring complete, a General Sewer Plan Update was able to take that data and finalize the Sewer Collection portion of the new General Sewer Plan, which will complement the Wastewater Treatment Facility Plan completed in 1996.

The General Sewer Plan Update included calibration of the existing sewer model to address flow capacity deficiencies, while the sewer videos document the extent of failing pipe conditions. Combined with known high maintenance sewer mains and recent sewage overflows, the prioritization of planned improvements has been scheduled to match available funding with the most efficient replacement program. Prevention of future sewage overflows are also a primary focus of this program.

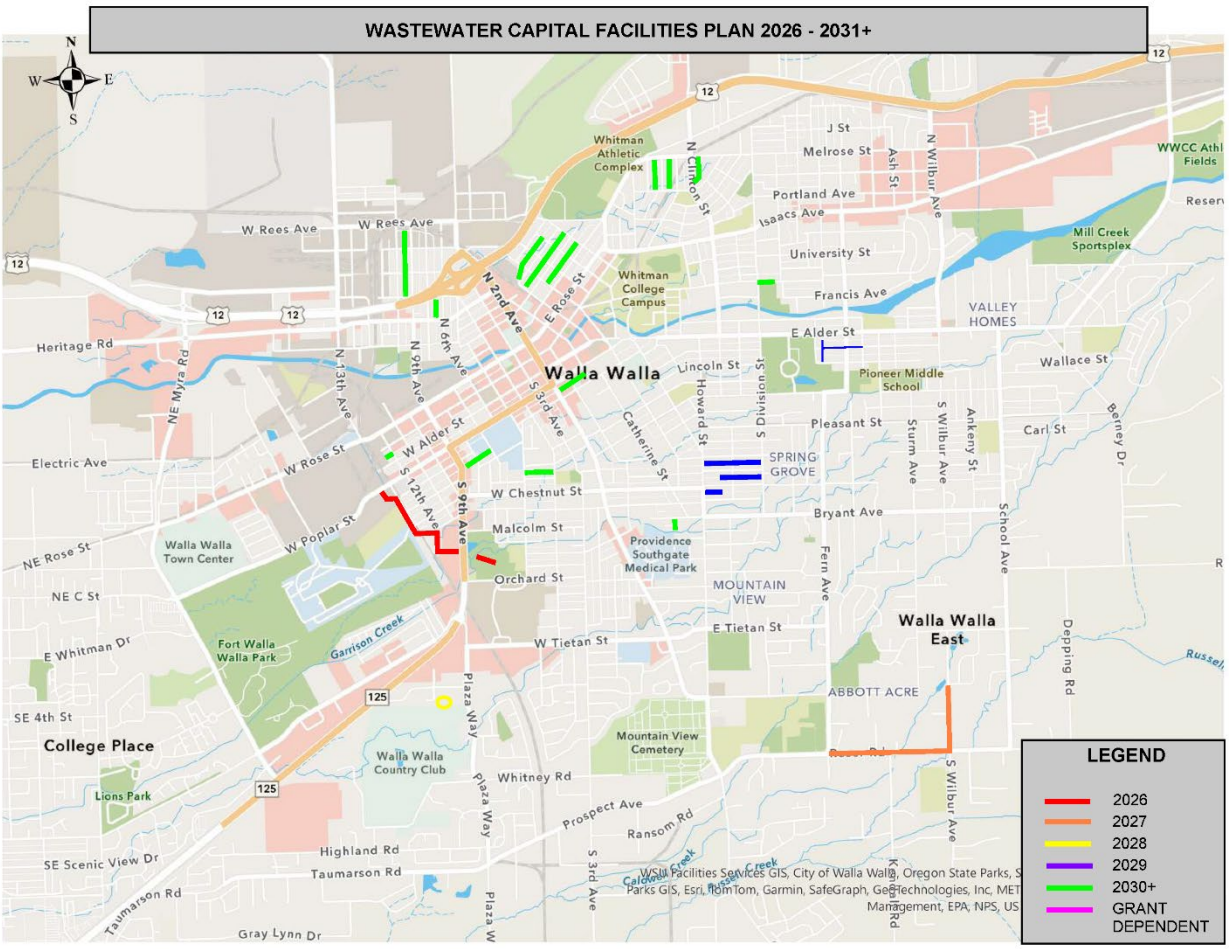
In 2010, the City initiated an Infrastructure Repair and Replacement Program (IRRP) sewer rate increase to be utilized to replace the sewer system in areas that also have failing water, stormwater and roadway facilities.

Several areas in the City have sewer mains in the alley, with water and storm facilities in the streets. This has precluded these areas from IRRP consideration and therefore, other funding sources must be dedicated towards addressing these alley sewer collection systems.

While Inflow and Infiltration (I/I) has been greatly reduced with the installation of almost 46 miles of collection mains since 1978, I/I remains a concern. Ecology requires the City file an annual report that addresses I/I flows by comparing the low flow (dry) season with flows during the high flow (wet) period. In 2000, Ecology established a base I/I of 2.7 MGD or 28% of the average design flow of 9.6 MGD at the treatment plant. In 2011, I/I was 23% of the average design flow, a decrease of 5%. Continued efforts to identify and replace the worst sewer mains has reduced this to 12%, a reduction of 16% below the 2007 mark (note: total rainfall in 2013 was 12.2" vs average of 19.3"). As the volume of I/I is decreased, pumping and treatment expenses are reduced, capacity for future growth will be increased and the need for future treatment facility expansion (flow capacity) will be delayed.

Financial

In December 2015 and December 2021, City Council adopted a 6-year utility rate increase to support on-going repair and replacement of wastewater facilities.


WASTEWATER CAPITAL FACILITIES PLAN 2026 - 2031+
N
W
E
S
Walla Walla
College Place
Walla Walla East
Whitman Athletic Complex
Whitman College Campus
Pioneer Middle School
Providence Southgate Medical Park
Mountain View Cemetery
Walla Walla Country Club
Walla Walla Town Center
Fort Walla Walla Park
Lions Park
Mill Creek Sportsplex
WWCC Athl Fields
VALLEY HOMES
SPRING GROVE
MOUNTAIN VIEW
ABBOTT ACRE
Garrison Creek
Mill Creek
Russel
W Rees Ave
N 2nd Ave
E Rose St
N 6th Ave
N 9th Ave
N 13th Ave
NE Myra Rd
Heritage Rd
Electric Ave
W Rose St
W Alder St
S 3rd Ave
S 12th Ave
S 9th Ave
W Chestnut St
Malcolm St
Orchard St
W Poplar St
NE Rose St
NE C St
E Whitman Dr
SE 4th St
W Tietan St
E Tietan St
Plaza Way
Whitney Rd
Prospect Ave
Ransom Rd
Highland Rd
Taumarson Rd
SE Scenic View Dr
Gray Lynn Dr
S 3rd Ave
Lincoln St
Howard St
S Division St
Catherine St
Pleasant St
Bryant Ave
E Alder St
Francis Ave
University St
Isaacs Ave
Portland Ave
Melrose St
J St
N Clinton St
Ash St
N Wilbur Ave
S Wilbur Ave
Sturm Ave
Ankeny St
Carl St
Wallace St
Berney Dr
School Ave
Fern Ave
Depping Rd
Kuhn Rd
Whitney Rd
Caldwell Ave
125
12
LEGEND
2026
2027
2028
2029
2030+
GRANT DEPENDENT
WSU Facilities Services GIS, City of Walla Walla, Oregon State Parks, S
Parks GIS, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, MET
Management, EPA, NPS, US

Stormwater

Stormwater

Walla Walla means "many small streams" as many small tributaries and spring-fed creeks flow through the valley. Many of these creeks are considered to be valued amenities in some neighborhoods, while in some areas they can be nuisances with overgrown vegetation, fences and other obstructions. These creeks are known to cause minor, localized flooding and property damage during heavy rainfall and peak snow melt runoff events. As the fifth oldest incorporated city in Washington State, much of the existing infrastructure of the community has been in service for over 100 years.

The City's Municipal Separate Storm Sewer System (MS4) serves a population of approximately 33,000 people within approximately 13.2 square miles (650 impervious acres). The system consists of approximately:

- 800 manholes
- 2,400 catch basins/inlets/bubble-ups
- 400 drywells
- 50 stormwater management facilities (ponds, bio-swales, oil/water separators)
- 50 miles of storm pipe
- 36 miles of open conveyance channels (ditches, streams, etc.)
- 200 outfalls
- 300 culverts

Planning Documents

- 2008 Walla Walla Watershed PCBs, Chlorinated Pesticides, Fecal Coliform, Temperature, pH & Dissolved Oxygen TMDL Water Quality Implementation Plan (Washington State Department of Ecology)
- 2009 Stormwater Program Implementation Plan (Otak, Inc.)
- 2011 Public Involvement and Education Plan (URS Corporation)
- 2011 Outfall Reconnaissance Inventory and Assessment for Mill, Yellowhawk and Garrison Creeks (URS Corporation)
- 2011 Underground Injection Control Inventory (URS Corporation)
- 2013 Outfall Reconnaissance Inventory and Assessment for Bryant, Butcher, Lincoln, Barber, Stone and remaining smaller creeks (URS Corporation)
- 2013 Underground Injection Control Facilities Assessment (URS Corporation)
- 2011 Service Center Stormwater Pollution Prevention Plan (URS Corporation)
- 2011 Illicit Discharge Detection and Elimination Program Manual (URS Corporation)
- 2011 Stormwater Pollution Prevention Operations and Maintenance Plan (URS Corporation)
- 2015 Comprehensive Stormwater Management Plan (URS Corporation)

Mill Creek Flood Control

Mill Creek flood control falls under the purview of the USACE though control of the Mill Creek diversion dam and Bennington Lake flood storage reservoir. Walla Walla County oversees the Mill Creek Flood Control District though the city.

NPDES Phase II Permit

The Phase II Permit outlines various stormwater program activities and implementation milestones that the City must follow to comply with the federal Clean Water Act (CWA). Walla Walla is expected to implement a SWMP that includes the required activities (minimum control measures), implement those activities within the required timeframes outlined in the permit term, and submit annual reports to Ecology each year to document compliance with permit requirements.

The Phase II Permit is broken down into the following components:

1. Public Education & Outreach
2. Public Involvement
3. Detect and Eliminate Polluted Illicit Discharges
4. Construction Site Pollution Prevention
5. Post-construction Pollution Prevention
6. Municipal Operations and Maintenance
7. Comply with Clean-up Plans for Polluted Waters
8. Record Keeping & Reporting
9. Pay Permit Fees and Program Costs

The initial Phase II Permit was issued in January 2007, reissued in August 2012, 2014, and in August 2019. The current permit expires July 31, 2024.

City of Walla Walla Stormwater Management Program (SWMP)
The City's SWMP consists of constructing the following elements:

1. Capital Improvement Program (CIP) – Ongoing capital repair and replacement program;
2. Operating & Maintaining Functional Stormwater Utility – Core management, maintenance, and operation functions necessary to provide a properly functioning utility to the public and;
3. Compliance with Minimum Regulatory Requirements – Required for the City to legally discharge stormwater to surface and ground waters.

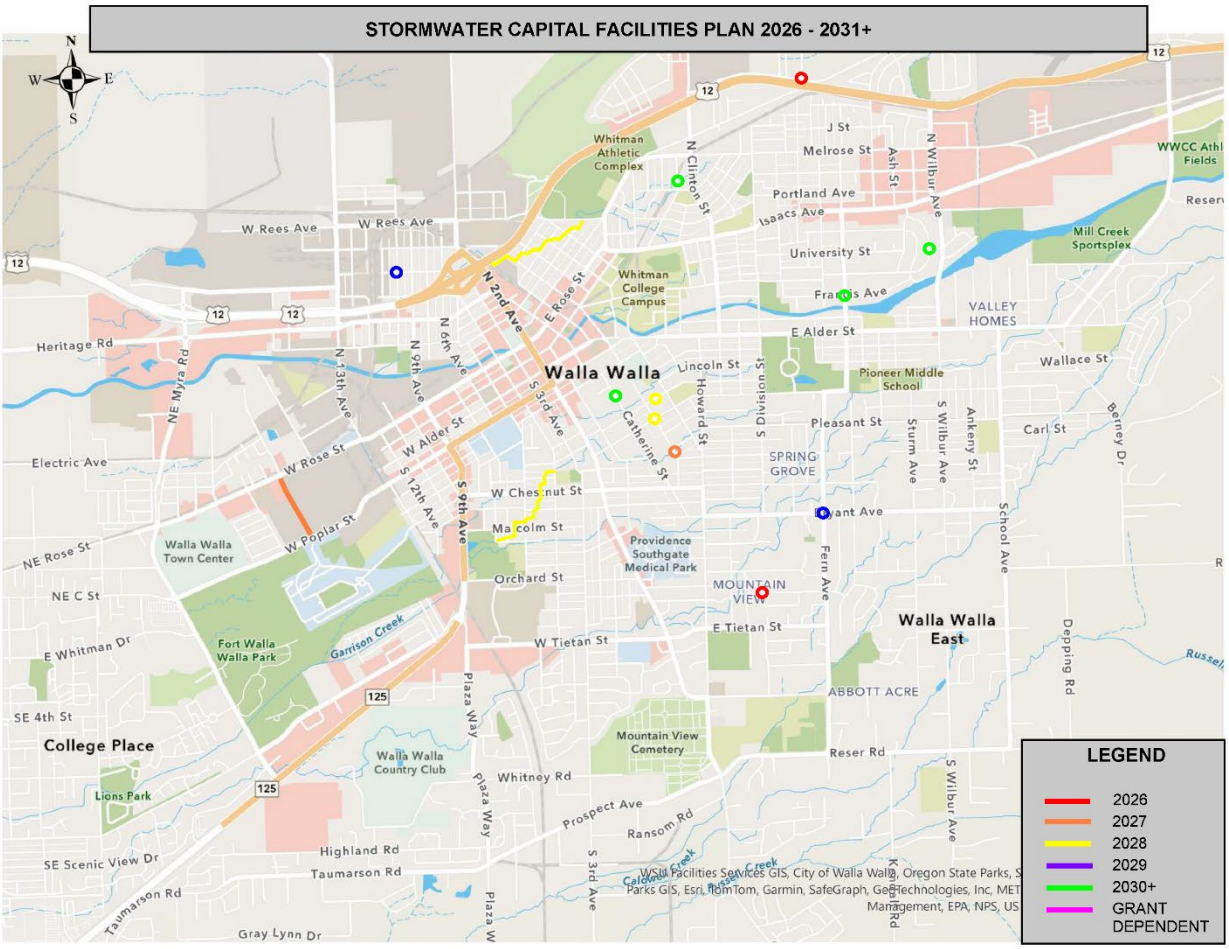
- Underground Injection Control (UIC) Rule, as required by the federal Safe Drinking Water Act (SDWA) and the Washington State Underground Injection Control Program (Chapter 173-218 WAC)

Underground Injection Control (UIC) Program
In addition to the Phase II Permit, Walla Walla must also address the requirements of Washington's UIC Program (RCW 90.48 and UIC Rule (Chapter 173-218 WAC)). The state's UIC program is designed to protect underground water sources from contamination by infiltration of pollutants from stormwater or other potential sources of spills or runoff.

To comply with the UIC Rule, URS Corporation was retained by the City to conduct risk-based UIC assessments for all existing (pre-2006) UIC wells to determine if they pose a potential threat to ground water quality. UIC wells that are determined to be a high threat to groundwater must be retrofitted or decommissioned to be protective of groundwater quality. High risk UICs require retrofits and are part of the Stormwater Capital Program.

An additional 89 UIC facilities (49 existing, 40 new) were estimated to be completed in, or within one foot of the seasonal high groundwater based on GIS based data. Site specific groundwater data and other site information will be compiled for these UIC's to determine the risk associated with these facilities. Following this, UIC's determined to be of high or moderate risk will be evaluated in more detail. Based on available funds, a more detailed program that accomplishes the retrofit or decommissioning program will be developed and implemented thereafter.

Financial
In December 2015 and December 2021, City Council adopted a 6-year utility rate increase to support on-going repair and replacement of stormwater facilities.


STORMWATER CAPITAL FACILITIES PLAN 2026 - 2031+
N
W
E
S
Walla Walla
College Place
Whitman Athletic Complex
Whitman College Campus
Providence Southgate Medical Park
Walla Walla Town Center
Fort Walla Walla Park
Walla Walla Country Club
Mountain View Cemetery
Pioneer Middle School
Mill Creek Sportsplex
WWCC Athl Fields
VALLEY HOMES
SPRING GROVE
MOUNTAIN VIEW
ABBOTT ACRE
Walla Walla East
Lions Park
Garrison Creek
Mill Creek
W Rees Ave
Heritage Rd
Electric Ave
NE Rose St
NE C St
E Whitman Dr
SE 4th St
SE Scenic View Dr
Taumarson Rd
Gray Lynn Dr
Highland Rd
Whitney Rd
Prospect Ave
Ransom Rd
Reser Rd
W Tietan St
E Tietan St
Orchard St
W Chestnut St
Malcolm St
W Alder St
W Rose St
W Poplar St
E Alder St
Lincoln St
Pleasant St
Carl St
Wallace St
Melrose St
Portland Ave
Isaacs Ave
University St
Francis Ave
Bryant Ave
J St
N 2nd Ave
N 6th Ave
N 9th Ave
N 13th Ave
S 3rd Ave
S 9th Ave
S 12th Ave
Plaza Way
N Clinton St
N Wilbur Ave
S Wilbur Ave
S Division St
Howard St
Catherine St
Ash St
Sturm Ave
Ankeny St
School Ave
Fern Ave
Depping Rd
Berney Dr
NE Myra Rd
E Rose St
S 3rd Ave
Kelly Rd
12
125
LEGEND
2026
2027
2028
2029
2030+
GRANT DEPENDENT
WSU Facilities Services GIS, City of Walla Walla, Oregon State Parks, S
Parks GIS, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, MET
Management, EPA, NPS, US

Solid Waste – Landfill

Solid Waste – Landfill

Solid Waste Management Plan
An update to the 1994 Solid Waste Management Plan was completed in 2014 with the City of Walla Walla (City) acting as the lead agency in accordance with the 2008 interlocal agreement with Walla Walla County.

The 2014 Walla Walla County Comprehensive Solid Waste and Moderate Risk Waste Management Plan (2014 Plan) provides background and guidance for a long-term approach to solid waste and moderate risk waste management in the region. This 2014 Plan comprises the combined comprehensive solid waste management plan (SWMP) and Local Hazardous Waste/Moderate Risk Waste (MRW) Plan for the incorporated and unincorporated areas of Walla Walla County.

An update to the 2014 Plan began in 2021 and is expected to be complete in 2023 once the landfill master plan update is finalized.

Sudbury Road Landfill (SRL) Master Plan
The City recently developed a comprehensive solid waste master plan (2024). The master plan produced a solid waste management alternatives analysis, looking at long-term needs over the next 50+ years, and developed a detailed 20-year capital improvement project list.

Sudbury Road Landfill (SRL)
The Sudbury Landfill is owned and operated by the City and receives approximately 60,000 tons of waste per year. All landfill facilities are permitted by the Walla Walla County Health Department with annual updates required.

The SRL was opened in 1978. The potential capacity of the existing landfill site is sufficient for at least another 200 years (HDR capacity evaluation, January 24, 2014).

Presently, the active landfill area is occurring in Cell 3 of Area 7. Area 7 is a lined landfill unit. Construction of a liner in the Cell 3 was completed in 2017. A gas collection and flare system was installed with the closure of Area 6, but presently landfill gas is only being flared.

Waste received by the landfill includes medical waste, household hazardous waste (HHW), municipal solid waste (MSW), tires, white goods (e.g.- refrigerators), concrete, and asbestos. The landfill does not accept hazardous wastes other than that from households.

A compost facility was constructed in 2009 to process green waste into compost. Approximately 6000 cubic yards of compost is produced each year. Sales have fluctuated greatly from year to year due to the types of construction or farming projects occurring at that time. Average sales fall into the 3000 - 3500 cubic yard range, which results in excess compost being surplused some years.

The HHW Facility at the SRL accepts and processes (for shipment/disposal) household hazardous waste for Walla Walla County residents. HHW products include motor oil, antifreeze, paint, solvent, gasoline, automotive and household batteries, pesticides, herbicides, household cleaners and white goods. Smoke detectors, ammunition and explosives are not accepted.

The Landfill has a staff of 12 FTEs that operate the scale house, hazardous waste facility, composting facility, and municipal solid waste facilities. Equipment used to manage the landfill operations includes a D8 Dozer, 23-yard scraper, 90-ton landfill compactor, road grader, two front end loaders, , drop box roll-off truck, water truck and several other small equipment items (compost mini loader, UTV, pickup trucks, etc.).

SRL Financial Assurance
Financial Assurance is a requirement of WAC 173-351-600. These regulations require that financial assurance is provided for closure of the largest area of all landfill units ever needing final cover, and that post-closure care financial assurance is prepared for all landfill units. The current Financial Assurance plan, dated February 12, 2015, was completed by HDR Engineering, Inc. (HDR) and then amended in 2016 by Environmental Information Logistics, LLC. (EIL) as part of the permit modification for Cell 3 of Area 7.

SRL Closure/Post-Closure Plan
HDR also prepared a revised Closure/Post-Closure Plan for SRL (October, 2015), which was amended in 2016 by EIL, and was used as the basis for the financial assurance estimates.

SRL Groundwater Remediation
The City has operated the SRL since 1977. In 2001, Volatile Organic Compounds (VOCs) were detected in a monitoring well just west of unlined landfill Areas 5 and 6. In 2004, the City prepared a historical study and draft Independent Remedial Investigation Work Plan (Work Plan). The 2004 Work Plan was not fully implemented due to budget constraints, but interim closure actions including grading, cover and drainage improvements were performed to protect groundwater.

On May 6, 2010, the Department of Ecology (DOE) sent the City a Potentially Liable Person (PLP) notice for the SRL. This notice prompted the City to explore implementation of an Agreed Order with DOE to address liability concerns.

On February 24, 2011, by Resolution No. 2011-21, the City retained Schwyn Environmental Services, Inc. (Schwyn Environmental Services) to perform consulting services associated with the proposed Agreed Order remediation work. City staff, in partnership with consulting attorney William Joyce of JOYCE, ZIKER, PARKINSON, PLLC, and Schwyn Environmental Services negotiated the details of the proposed Agreed Order with DOE. On May 26, 2011, the City entered into Agreed Order No. 8456 with DOE to address the matter of Remedial Action at the SRL.

The Remedial Investigation – Feasibility Study (RI/FS) was completed in September 2014, and in August 2015, the City (Resolution 2015-058) entered into a Consent Decree (No. 152005368) with DOE for clean-up actions. The Clean-up Action Plan was prepared in 2015. Design plans were prepared and construction completed in 2016. Monitoring extended through 2022, at which time cleanup goals were met. DOE has since reviewed the compliance history and reduced the monitoring that must be completed.

Funding for the remediation work at SRL has been provided by a Remedial Action Grant from the DOE, Landfill reserves, and some participation from a prior insurance policy of the City's. The City will continue to bill the insurance company for reimbursement of costs related to the remediation work.

SRL Historical Documentation
Schwyn Environmental Services prepared a Historical Study Report on behalf of the City for the SRL (January 2006). The report describes the historical activities that occurred at the landfill from its inception in the mid-1970s through 2005.

Tausick Way Landfill (TWL)
From approximately 1935 up until the mid-1970s, MSW was disposed at the City's Tausick Way Landfill (TWL) in the northeasterly portion of Walla Walla. The TWL site consists of 78 acres of previously excavated gravel/rock mining operations that was filled with MSW and capped with a soil cover. The site was closed in 1979, under WAC 173-304.

Isaacs Inert Waste Landfill (IIWL)/Burdine property
The 15-acre Burdine property, also known as the Isaacs Inert Waste Landfill (IIWL) is located north of the TWL and fronts the south side of Isaacs Avenue. This site was reportedly encroached upon by TWL and was purchased by the City in 1999.

The City completed a remedial investigation of the Burdine property in 2005, and worked with DOE to address the contamination in compliance with the Model Toxics Control Act (MTCA) requirements. The remedial action plan approved in 2006 included construction of a cover over the MSW using inert waste from City construction projects. An Inert Waste Landfill Permit was applied for in 2006 to allow the City to place the inert waste cover on the site.

In 2011, the City applied for and was awarded a $200,000 Integrated Planning Grant (IPG) for the Burdine property to complete the following:

- Complete site characterization studies
- Consolidate existing planning documents, summarize potential site uses, identify property development challenges, and create a comprehensive site vision

- Prepare several site development scenarios

Schwyn Environmental Services completed the IPG study of the Burdine site in 2013.

In 2021, the City completed filling the site with inert waste and provided notification to the Walla Walla County Department of Community Health of the closure of the landfill for inert filling purposes.

Sanitation

Sanitation

The City operates a Sanitation Division utilizing a fleet of 14 vehicles providing waste collection for:

- Residential refuse;
- Optional residential green waste;
- Commercial refuse;
- Rented drop boxes; and
- Medical waste

Residential Recycling
Basin Disposal is contracted by the City to operate the residential curbside recycling program within the City Limits.

Operations Overview

Residential
The residential routes consist of daily collection, Monday through Friday. Each daily route is divided into three sections, with one automated side loader collection vehicle and operator servicing that sector. Approximately 8,815 accounts are serviced each week, with a total of roughly 10,000 containers of various sizes being emptied. Each truck averages about 125 service calls (dumps) each hour and makes two roundtrips to the landfill each day.

Green Waste
The green waste program runs from March through October. There are roughly 1266 participants that subscribe to this voluntary program. The program is seasonal due to difficulty of emptying wet or frozen waste from the containers during the winter months. The green waste containers are picked up on the same day of the week that the participant's regular and recycling containers are serviced. While participation in the Green Waste program is becoming more popular each year, the service does cost $25.50 per month, with less than 15% of the accounts currently subscribing to this service.

The Green Waste truck is a side loader collection vehicle and operator that averages about 45 dumps per hour, as the customers are further apart. Due to fewer dumps to make, one truck is able to service all three sectors on that daily route and it makes a single roundtrip to the landfill.

Commercial
The commercial route services over 505 accounts, many of these accounts are serviced multiple times a week and many have multiple containers. The number of accounts serviced per day ranges from 106 to 115 stops. Two crews consisting of two employees and one rear load collection truck for two routes work Monday through Friday (and holidays) and dump 127 to 145 bins per day. Bin sizes range from 1 to 8 cubic yards, with a few 30-gallon cans that are manually dumped for the smaller waste accounts.

Drop Box
The drop box route has 35 scheduled service calls each week. In addition, there are 42 accounts that are unscheduled on-call. The City has 21 spare boxes that are available for temporary commercial, industrial and residential use. One crew and truck service this route each day.

Medical Waste
The Medical Waste route has 30+ accounts, with some being collected weekly, while others only require collection once or twice a year. Medical pickups are scheduled each Friday.

Community Programs
In addition to the daily servicing of various waste collection routes, the Sanitation Division also supports a variety of programs that benefit residential and commercial customers, including:

- Downtown Bird Control: control of bird and tree rodent populations in the Downtown area
- Annual Leaf Collection Program: City wide leaf collection by the Street Division
- Landfill Pass Program: residential customers receive one free landfill pass each year
- Downtown Trash Collection: collect and dispose of trash from the Downtown area

Facilities

City Hall

Walla Walla's City Hall, located at 15 North 3rd Avenue, houses several general governmental offices including:

- City Council Chambers
- City Attorney's office
- City Manager's office
- City Clerk's office
- Finance/Payroll/Utility Billing
- Human Resources
- Technology Services
- Communications

The building was constructed in 1910 and has three floors of general office space totaling 22,170 square feet. Prior to 2012, the basement/garden level served as the City's Police Headquarters.

There have been a number of various changes made to the building over its 100+ years. However, in 2016 the City commissioned a seismic/fire suppression study to identify critical life safety upgrades. Implementation of those upgrades will be phased over serval years along with a number of other cosmetic, restorative and technology improvements needed in the building.

Service Center

General

The City of Walla Walla Service Center is located on an 8.7 acre site at 55 East Moore Street. The facility is a former cannery that the City acquired and consolidated many of their operations at this site in 1986. Several improvements were made in 1999, including the construction of the 14,750 sq ft main office building and upgrades to other maintenance facilities.

There are seven buildings that total about 106,680 square feet. There are 85 full-time, (and several part time/temporary), employees that utilize these facilities as their base of operations.

- Public Works
  - Administration (4)
  - Engineering (15)
  - Sanitation (11)
  - Streets/Wastewater Collections/Stormwater (18)
  - Water Distribution (12)
- Parks & Recreation
  - Administration (1.5)
  - Parks (7)
  - Recreation (2)
  - Facility Maintenance (3.5)
- Fleet Services (5)
- Development Services (8)
- Finance (1)

Activities that are currently supported at these facilities include equipment storage; vehicle repair, maintenance, and washing; heavy equipment and vehicle parking; welding shop; storage of construction materials; bulk ground maintenance supplies; decant facility; fueling station for city fleet vehicles; archive record storage; police evidence and impoundment storage; conference and meeting rooms; and various offices for administrative activities.

On April 1, 2003, a fire burned much of the central section of Building 65, where Sanitation was housed at the time. Ten sanitation trucks were destroyed in the fire. This section of the building was reconstructed in the months that followed.

This newer portion of the shop building was remodeled in 2010 to include offices and fleet maintenance facilities.

The Police Evidence Storage building was remodeled in 2011/2012 to improve security and address other building and electrical deficiencies.

In 2012, a structural assessment was completed for the space occupied by the Water Distribution Division (Building 65A). The engineer recommended several structural repairs, which were completed in 2013. However, the Structural Engineer also

recommended a follow up structural assessment be performed within ten years (2022). That follow up structural assessment was completed in 2020 and identified a roof replacement and additional structural repairs, which are completed in 2021.

In 2015, Street Operations (Streets, Wastewater Collections, Stormwater, Traffic and Supervisory offices) were consolidated to Service Center Building 65D. Prior to this, supervisory and admin support offices were located with the Fleet Services offices on the second floor of Building 65B, Traffic was located in Building 75B, and operations was located in Building 65D/E. Office space was constructed in Building 65D and the shop area reconfigured to minimize vehicle operations within the shop area of Building 65D/E. Street operations also utilizes the Barrel Building (65F) to protect equipment subject to freezing (sweepers, vactors, etc.).

Sanitation has largely consolidated operations in Building 75A, constructing break and meeting room space within the building. However, Sanitation's welding shop is still located in Building 65C. Sanitation intends to expand the existing covered parking area on the east side of the Service Center site to provide covered parking with engine block and hydraulic system heaters for collections equipment.

Parks operations is largely located in Building 75D including the space formerly occupied by Traffic Operations 75B. This space provides restrooms and office/meeting/breakroom space for Parks personnel.

Facilities Maintenance is located in Building 75C.

Stormwater Pollution Prevention

Since diesel fuel and gasoline are stored in underground storage tanks (UST's) and other solvents, oils, and hazardous fluids (that are regulated by EPA) were stored in tanks and drums at various locations throughout the site, the City was required to have a Spill Prevention, Control and Countermeasures (SPCC) Plan. The SPCC Plan was prepared by EMCOM/OWT, Inc. in 2004, in accordance with 40 CFR 112 of EPA's regulations effective August 16, 2002. The SPCC Plan established the procedures and equipment required to prevent discharge of oil and hazardous substances in quantities that violate applicable water quality standards.

In January, 2011, City Engineering staff re-evaluated the 2004 SPCC Plan utilizing the EPA's December 2006 SPCC Rule Amendments – Streamlined Requirements for Regulated Facilities. Many of the 2004 recommendations have been addressed by replacing critical single wall tanks with double walled tanks and storing the tanks inside.

In February, 2009, Northwest Pump and Equipment Company inspected, tested and found the three UST fuel storage tanks and piping to be in compliance with Chapter 173.360 W.A.C. The two 10,000 gallon oil storage tanks 17 and 18 were declared as surplus, sold, and removed from the site in 2013.

Washington Department of Ecology (Ecology) issued the City of Walla Walla, NPDES Permit # WAR04-6508. This Permit required that Stormwater Pollution Prevention Plan (SWPPP) be completed for City owned material storage, heavy equipment storage, and maintenance areas by August of 2011. The Service Center SWPPP of the overall site was completed July 6, 2011 by URS Corporation.

The 2011 site assessment evaluated the following areas for compliance with Best Management Practices: 1) Building and ground maintenance; 2) Floor drains; 3) Loading and unloading of materials; 4) Outdoor storage of raw materials; 5) Storage of liquids, solid waste, and hazardous materials; 6) Vehicle and equipment (V&E) Cleaning; 7) V&E Fueling; 8) V&E Maintenance and Repair; 9) V&E parking and storage; and 10) Vegetation Management. No major problems were observed in 5 of the 10 categories listed. Other problems identified were fairly minor items, such as a trash

receptacle was found with its lid left open, or equipment axes were laying on top of a floor drain.

Decant Facility

The Service Center site includes a decant facility located along the western side of the property. The decant facility contains a concrete pad that is separated onto decant bays #2, #3 or #4 (for WSDOT use) and the northerly smaller bay #1 for storage of potential "hot loads" (contaminated). These decant pad(s) allow liquids to drain from the solids that are generated from street sweepings and vactor waste collection. Solids remaining on the concrete pad are allowed to dry, stockpiled, and then hauled to the landfill for disposal.

Liquid drained from stored material is decanted through clarifiers, then into an oil/water separator prior to being discharged into the sanitary sewer. As oily water flows through the separator, the lighter-than-water oil wastes rise to the surface and are trapped in the exit chamber. Sediments settle to the bottom of the entrance chamber. Both chambers are vactored out during regular scheduled cleaning of both chambers.

The decant facility is permitted in accordance with Chapter 70.95, WAC 173-304 and 173-350 as issued by the Walla Walla County Health Department. The Washington State Department of Ecology permits the discharge of these liquids into the sewer system by a State General Discharge permit.

Service Center Improvements

In 2004, a master plan for the service was prepared that developed a circulation plan for the expansion of the Service Center.

The main administrative building houses:

- Water Distribution Supervisory and Administrative support personnel
- Cross-connection/FOG personnel
- Public Works Administration
- Parks & Recreation Administration
- Development Services
- Engineering

Additional office space is needed within the main building as follows:

- Water Distribution – Have 7 – Need 8
- Engineering – Have 15 – Need 17
- Development Services – Have 9 – Need 10
- Additional Conference Rooms

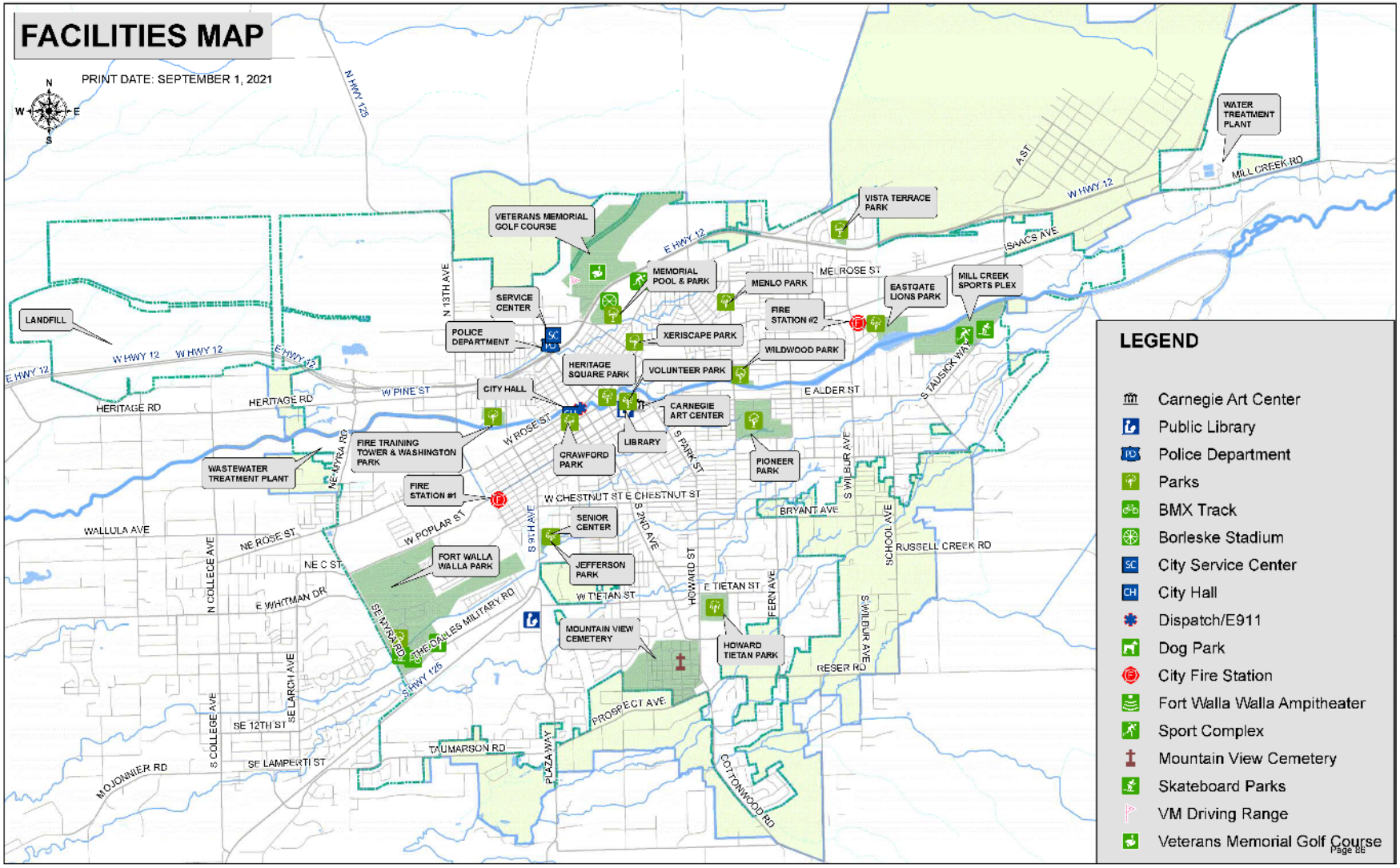
The City hired BLRB Architects to perform design of a service center remodel. That design is complete and construction is pending.

Carnegie Center

The Carnegie Center, located at 109 South Palouse Street was built in 1905 and originally served as the Walla Walla Public Library. The building consists of 8,000 square feet on two floors.

Senior Center

The Senior Center, located at 720 Sprague Avenue was built in 1996, consists of 15,000 square feet and serves as a gathering social place and offers meals for seniors during the daytime.


FACILITIES MAP
PRINT DATE: SEPTEMBER 1, 2021
N
W
E
S
LANDFILL
VETERANS MEMORIAL GOLF COURSE
SERVICE CENTER
POLICE DEPARTMENT
MEMORIAL POOL & PARK
XERISCAPE PARK
HERITAGE SQUARE PARK
VOLUNTEER PARK
CITY HALL
CARNEGIE ART CENTER
LIBRARY
CRAWFORD PARK
FIRE TRAINING TOWER & WASHINGTON PARK
WASTEWATER TREATMENT PLANT
FIRE STATION #1
SENIOR CENTER
JEFFERSON PARK
FORT WALLA WALLA PARK
MOUNTAIN VIEW CEMETERY
VISTA TERRACE PARK
MENLO PARK
FIRE STATION #2
WILDWOOD PARK
PIONEER PARK
EASTGATE LIONS PARK
MILL CREEK SPORTS PLEX
WATER TREATMENT PLANT
HOWARD TIETAN PARK
W HWY 12
E HWY 12
N HWY 125
S HWY 125
HERITAGE RD
W PINE ST
W ROSE ST
E ROSE ST
NE MYRA RD
WALLULA AVE
NE ROSE ST
NE C ST
E WHITMAN DR
SE MYRA RD
THE DALLES MILITARY RD
SE 12TH ST
SE LAMPERT ST
MOJONNIER RD
TAUMARSON RD
PLAZA WAY
PROSPECT AVE
COTTONWOOD RD
RESER RD
W CHESTNUT ST
E CHESTNUT ST
W POPLAR ST
W TIETAN ST
E TIETAN ST
BRYANT AVE
RUSSELL CREEK RD
E ALDER ST
S TAUSICK WAY
ISAACS AVE
MILL CREEK RD
N 13TH AVE
S 9TH AVE
S 2ND AVE
S PARK ST
HOWARD ST
FERN AVE
SCHOOL AVE
S WILBUR AVE
N COLLEGE AVE
S COLLEGE AVE
SE LARCH AVE
LEGEND
Carnegie Art Center
Public Library
Police Department
Parks
BMX Track
Borleske Stadium
City Service Center
City Hall
Dispatch/E911
Dog Park
City Fire Station
Fort Walla Walla Ampitheater
Sport Complex
Mountain View Cemetery
Skateboard Parks
VM Driving Range
Veterans Memorial Golf Course

Fire

Fire & Emergency Medical Services (EMS)

The Walla Walla Fire Department (WWFD) dates back to 1903, when three separate volunteer fire departments were joined together. WWFD endeavors to minimize the loss of life and property, pain and suffering by residents of the City of Walla Walla and surrounding areas as a result of accidents or natural disaster.

The Walla Walla Fire Department operates two fire stations with a full time staff of 47 employees, many of whom are cross trained as firefighters and paramedics.

The current long-term debt for the 2004 General Obligation (GO) bond for construction of Station No. 2 was approximately $4.5M, which was refinanced in 2013 for $2.84M with payments of approximately $335,000 due each year until the bond is retired in 2023.

Services Provided

- Fire Department Administration
- Suppression
- EMS response
- Training
- Public education
- Prevention
- Inspection
- Technical response team (TRT) with capabilities including:
  - Hazardous materials response
  - High/low angle rope rescue
  - Swift water rescue
  - Confined space rescue

The City's EMS and TRT service emergency calls throughout Walla Walla County, with a total coverage of approximately 1,200 square miles. The Department also responds to emergency medical calls in a portion of Umatilla County: Ambulance Service Area #6, Mill Creek.

Level of Service

The WWFD responds to between 5,500 and 6,000 medical emergency calls each year, over 60% of these responses end with a patient being transported to a medical facility.

Facilities

Walla Walla operates two fire stations that house the emergency response equipment and on-duty responding members of the Department. The main 14,220 sq ft administration station (Fire Station No. 1), located at 200 S. 12th Avenue, was officially dedicated in 1975. The second station is a 15,260 sq ft facility located at 170 N. Wilbur Avenue. Station No. 2 is a fairly new facility completed in 2006, as a result of the bond levy that was approved by voters in 2004.

The department also maintains a drill and training facility at 300 Cayuse Street. The facility was also dedicated in 1975 and is an older four story masonry training tower with separate props which provide hands-on training for ventilation, high/low angle rope rescue, confined space rescue and hazardous materials response. The Walla Walla Fire Department partnered with Fire District #4 and the College Place Fire Department to replace the drill tower in 2022.

Equipment

WWFD operates several pieces of specialized equipment, the largest vehicles being:

- Engine 3911: 2018 Pierce Enforcer Pumper
- Engine 3951: 2008 Ford C4500 Type V Wildland Pumper
- Engine 3912: 2021 Pierce Enforcer pumper
- Ladder 3911: 2011 Rosenbauer Ladder Truck pumper
- Engine 3913: 2002 Pierce Quantum pumper

EMS

- 2016 Dodge D4500 Braun NW Ambulance
- 2013 Dodge D3500 Braun NW Ambulance
- 2014 Dodge D4500 Braun NW Ambulance
- 2011 Ford F-350 Braun NW Ambulance
- 2010 Ford F-350 Braun NW Ambulance

Facility Needs

Continued growth through annexation of the City's Urban Growth Area (UGA), particularly to the South of the City and areas north of US 12 will increase the

distribution of the WWFD resources. To ensure proper response standards are maintained, the City may need to address additional fire stations, equipment and staff to serve this growth. A smaller two bay satellite station with living quarters to service the south end of the City where most of the growth and annexations have been and are expected to continue to occur.

The training tower is also showing signs of wear. Repairs to address ongoing heat damage were completed about 18 years ago, however, those repairs are failing, rendering the tower unusable for live fire training. To provide long term life safety status of the structure in compliance with WAC 296-305 – Safety Standards for Firefighters and safe operational needs for firefighter training, the City of Walla Walla, Fire District #4 and the City of College Place partnered to replace the training tower in 2022. This regional facility is a more prudent solution for the long-term training needs of communities in the area.

The Fire Department has numerous support vehicles, response trailers and light/generator plants that are not currently stored undercover due to inside storage constraints. There is a need to build a covered parking structure at fire station #1 to keep these vehicles out of the weather and provide the ability to keep heated during the winter months.

Future Equipment Needs (items not included in the City's Vehicle Replacement Fund, 518)

As fire suppression vehicles require a large investment, ongoing replacement of the fleet will continue to be a financial challenge. A new ladder truck was added in April 2012 at a cost of $801,500 and a two engines have been replaced since 2018.

Attempts have been made to fund the replacement of these large vehicles including grant applications. Due to extensive competition from other communities, recent grant application attempts have not been successful. Establishment of a similar replacement fund for the fire suppression equipment has been discussed to assure a cost-effective rotation of these expensive vehicles.

Fleet Services

Vehicle and Equipment Replacement

In 1999, the City established a vehicle and equipment (V/ER) replacement program (fund 518, Ordinance 99-06, WWMC 3.21.050), to annually set aside funds for the planned replacement of vehicles and equipment included in the fund. Replacement costs are established for V/ER and then adjusted for inflation (presently using 3% per year) for a future replacement date as established by Fleet Services.

There are approximately 315 vehicles included in the replacement schedule. Each Department/Division annually deposits funds for the future replacement costs for V/ER. Fleet Services manages the schedule in partnership with the Departments/Divisions and City's Finance Department. Fleet Services establishes and monitors replacement cycles and costs providing a systematic approach for replacements.

Departments/Divisions are encouraged to review the schedules annually or biannually with Fleet Services to ensure schedules and the types of equipment continue to meet Department/Division needs in the future, and where feasible, to extend the "planned" life of equipment.

In 2015, a review process was established with Public Works to ensure input was received from Supervisors, front-line staff, Managers and Directors, before a purchase was made. The goal of this process was to make certain the V/ER met the needs of the direct users. Demonstrations are also sometimes scheduled to review new features/capabilities.

Starting in 2012, rebuilds for certain types of equipment are also being considered. Examples of equipment benefiting from rebuilds include the landfill's compactor, grader, dozer and scraper, which are high cost, critical, but non-emergency equipment. A one-time rebuild extends the life of a piece of equipment at a lower cost than replacement and helps ensure continued operational reliability. When considering a rebuild, the life cycle plan (set-aside plan) for that equipment should include the rebuild cost and the full future replacement following the rebuild.

Including these two expenditures (rebuild + replacement) in the lifecycle and then spreading the costs over the full lifecycle provides a stable, balanced annual set aside with little cost fluctuation.

Rebuilds are also subject to the joint recommendations of Fleet Services and the Department/Division based on the historical reliability of that particular piece of equipment.

In cases where actual purchase and/or outfitting costs come in higher than projected, the gap can either be covered by a Department/Division's 518 contingency fund or by seeking a balance transfer from the Department/Division's operating fund/fund balance, subject to approval by the Department Director. It is recommended that each Department/Division establish a 2-5% contingency fund for the equipment in the 518 fund to address unforeseen costs.

There are some vehicles that are not included in the V/ER fund, namely fire engines. These items are included as part of the Fire Department's overall Capital Facilities needs and are funded through the Fire Department's own capital plan.

Vehicles that are included in the V/ER fund are not listed in this plan but are instead accounted for in the Operations and Maintenance bi-annual budget.

Library

Walla Walla Public Library

Serving the people of Walla Walla as a community information and lifelong learning center, the Walla Walla Public Library (WW Public Library) acquires, organizes, provides, and promotes informational, educational, recreational, and cultural materials for people of all ages. Located at 238 East Alder Street, the Library serves the Walla Walla area providing free Library cards to individuals owning property or living within the City limits.

In 1905, the WW Public Library opened the doors of a new building built by funding from Andrew Carnegie. The Library outgrew the Carnegie Building and moved into the new 16,000 square foot facility in 1970. Since that time, the Library has continued to grow. In 2006, a 3,067 square foot Young People's addition was completed. Today the Library circulates over 350,000 items annually, including books, cds, dvds, downloadable books and magazines.

Services Provided
The WW Public Library staff focus on providing guidance and assistance for people to obtain the information they seek. They initiate programs and exhibits that stimulate the use of Library materials, promote literacy and encourage lifetime learning for people of all ages.

The WW Public Library provides free programs throughout the year including youth and adult reading programs, preschool story times, elementary school-age story times, day care story times, internet access, internet classes, classes for downloading audible and e-books, word processing and document scanning.

The maker-space and media lab, CrewSpace, provides both instruction in and access to the latest in technology which enables both children and adults to share information using various mediums such as music and video production. Acquiring these skills will increase employment opportunities and will support creative expression and lifetime learning.

Existing Facilities
The original 16,000 square foot Library was constructed in 1970. With continued growth and increases in programs, computer based information sources, quantity and breadth of materials, the facilities were unable to accommodate the demand.

In June 2004, a Library Expansion Master Plan for the WW Public Library was completed. The expansion plan addressed a variety of issues including capacity constraints, available funding and phased implementation of proposed improvements. Phase I improvements included Young People's Services Renovation and Addition. Phase II addressed the Maximization of Interior Space and Phase III was Library Expansion to achieve the goal of a 33,000 square foot facility to accommodate growth to serve an estimated population of 68,000 (by 2020).

In 2005, the Sherwood Trust awarded the Library a $300,000 grant toward the renovation and expansion of the Young People's department. This grant represented about one half of the estimated $713,000 required to fund the project. The community provided the necessary funding match and the 3,067 square foot facilities expansion to the northwest corner of the Library was completed in 2006.

A media lab, CrewSpace, was built in 2014 in the existing Board Room space. It was built with a grant of $136,000 from the Paul Allen Family Foundation.

A replacement of the Library's original HVAC System with an energy efficient system was completed in 2016.

The WW Public Library added two study rooms in 2013 to address the need for small groups to meet in a quiet area.

Level of Service
With the 2006 expansion, the Library has 19,067 square feet, serving a City population base of about 32,237 for a Level of Service (LOS) ratio of 0.59 square feet per capita. Comparable LOS for other single outlet municipal libraries in similar sized communities in Washington have a ratio of 0.84 square feet per capita (source: Washington Public Library Statistical Report, 2014).

Future Needs

The 2004 Library Expansion Plan did not predict the recent advancements in technology, nor the current use and future growth needs for the WW Public Library. In 2016, the WW Public Library serves an average of 771 people daily. An update to the plan is needed to address the daily use, the changes in the way we use the WW Public Library and to re-examine future needs.

The current Plan for Phase II improvements, which includes interior space maximization, will be included in the Phase III portion which is the expansion and renovation of the entire Library, maximizing the use of the existing site and increasing the area of the Library from 19,000 to 20,000 square feet.

Many of the deficient conditions of the existing facility that were identified in the 2004 evaluation remain to be addressed.

There are a total of 5 emergency exists now, including one in the adult reading area of the Library with was added in 2016.

The Young People's addition provided needed shelf space for books and other materials, but the increase in programming makes the need for a designated program space crucial for both adults and young people. There is little expansion space due to the limits of the facility's present site.

The lack of a designated program space has caused wear and tear to both the carpeting and the furniture. As the tables are pulled across the carpet to make room for programs, not only is the furniture weakened, but the carpet is showing wear. The furniture (tables and chairs) were purchased by the Sherwood family in 1970, nearly 50 years ago, and is in need of replacement. The chairs were replaced in 2018 but there was not enough money to cover the cost of the tables. The carpet has been replaced in stages over the last 20 years and the design is not cohesive. The carpet on the east side of the Library is showing extreme wear.

Lighting within the Library is inadequate. The ceiling is original and the component tiles are no longer replaceable. It does not allow for improved and energy efficient lighting to be installed. A replacement of the ceiling and new lighting is needed.

To increase security at the Library, the existing security cameras have been updated and additional cameras have been added to the exterior perimeter of the building.

The Library's landscape plants are 50 years old and need to be replaced. The irrigation system has been patched and added on to and has reached the state where it is both inefficient and can no longer accommodate additions. It has been assessed for its ability to be upgraded and for plantings to be replaced. The Parks Department has stated that the irrigation system must be replaced along with most of the landscaping plantings. The estimated cost in 2018 costs would be $100,000.

Rapid changes in technology are evident in library services where acquisition, organization and retrieval are all dependent on technology. Predicting future changes in technology is difficult, but libraries anticipate the continued and expanded use of radio frequency. RFID (Radio Frequency Identification) allows libraries to inventory, circulate and sort materials through radio frequency tagging. The WW Public Library has not been able to acquire this technology due to its cost. Libraries also foresee a wireless environment within the next five years necessitating new equipment and security considerations.

Drive-up services have been requested. As our population ages, more individuals could benefit from drop-off and pickup services. Services of this type would need to be part of the planning for a new building.

Parks & Recreation

Parks and Recreation

Walla Walla's long term commitment to parks began in 1901 when land that is currently Pioneer Park was acquired. A group of prominent women formed the Park Civic and Arts Club in 1907 and began raising money for park improvements. The Club's dedication to park development and City beautification led to the hiring of the Olmsted Brothers landscape architecture firm to help plan the parks system in Walla Walla. The Club continued their effort to provide parkland dedications and to improve park facilities by adding shrubs, trees, flowers, play equipment and other park amenities throughout the City. The influence of this early devotion to parks is reflected in the wealth of City parkland that exists today.

City Parks and Recreation Facilities
City Parks are divided into three categories: community parks, neighborhood parks and mini-parks.

Community parks provide for diverse multi use recreational opportunities and may include natural areas for outdoor recreation. This type of park includes parking facilities, restrooms, and is easily accessible to the community served. The desirable size for a community park is typically 25 acres or more with a service area radius of two miles.

Neighborhood parks provide for both active and passive recreational uses. The desirable size for a neighborhood park is typically five to ten acres with a service area radius of one half mile.

Mini-parks provide specialized facilities or passive recreation to serve a concentrated or limited population. The desirable size for a mini-park is typically one acre or less with a service area radius of less than one quarter mile.

Community Parks
- Borleske Stadium/Veterans Memorial Pool (12 Ac)
- Fort Walla Walla Park (205 Ac)
- Mill Creek Sportsplex (50 Ac)
- Pioneer Park (58 Ac)

Neighborhood Parks
- Eastgate Lions Park (12 Ac)
- Howard-Tietan Park (19 Ac)
- Jefferson Park (9 Ac)
- Menlo Park (7 Ac)
- Vista Terrace Park (7 Ac)
- Washington Park (12 Ac)
- Wildwood Park (6 Ac)

Mini-Parks
- Crawford Park (1.2 Ac)
- Heritage Square (0.7 Ac)
- Volunteer Park (0.1 Ac)
- Xeriscape Park (0.2 Ac)

Other City Park Facilities
- Mountain View Cemetery (65 Ac)
- Veterans Memorial Golf Course (135 ac)

City Trails
- Mill Creek Trail
- Fort Walla Walla Trail
- US 12 Trail (Moore Street to Vista Terrace Park)

Buildings/Facilities
- Carnegie Center
- Garden Center at Pioneer Park
- Aviary at Pioneer Park

The City also partners with the Walla Walla School District to utilize indoor and outdoor school facilities for Recreation programs.

Conditions
During the last 14 years, park irrigation systems have been automated to improve efficiency. Most of the City's parks have restroom facilities. The City of Walla Walla, in partnership with

local neighborhoods and civic groups such as Rotary, Sherwood Trust, etc. continue to install, replace and/or enhance playground equipment. Replacements/enhancements have been completed at Pioneer, Howard-Tietan, Washington, Wildwood, Fort Walla Walla, Vista Terrace, and Jefferson Parks.

Facility Needs

City Council approved the Parks and Recreation Department's Comprehensive Plan in June of 2018. This document will guide the planning and operation of the Department through June of 2024. Having an approved plan will also allow the City to apply for grants through the Washington State Recreation and Conservation Office for future park development.

The Parks and Recreation Comprehensive Plan identified a need for the City to establish a park in the southwest section of the City. The City has expanded in this quadrant of the City and many new homes have been built and there is not a park within a ½ mile for these families to access.

The Department has been very successful in funding new playgrounds over the last twenty years. The latest park to receive new playground equipment was Vista Park, which was completed in 2022. Staff is now working on grants and private donations to begin reconstructing the playgrounds that were installed over twenty years ago, starting with Pioneer Park.

Many of the parking lots in the City's parks are at the end of their useful life and are in need of rehabilitation. A plan should be developed to repair and/or replace these parking lots.

Level of Service

The acres per capita Level of Service (LOS) is the most common benchmark used for whether a community has enough park lands, but this metric fails to address the distribution of those lands in a community and the type of (park) demand within a community. The historic standard referenced 10 acres of park and/or open space per 1,000 persons, but most communities simply try to maintain their current ratio as they grow in population.

Other references have indicated the LOS for Community Parks would be 9.3 acres per 1,000 and 2.1 acres per 1,000 for neighborhood Parks.

Police

Police Facilities

In 2009, a General Obligation (GO) bond was passed to build new Police facilities and in 2012 the WWPD moved into a new 30,170 square feet Headquarters (HQ) building at 54 E. Moore Street, across the street from the City Service Center. The new facilities were designed to provide enough space for a future staff level of 54 sworn officers and 43 civilian staff. The 3,330 square feet Police Evidence Storage Building located north of the City Service Center was renovated at the same time to bring that building up to current codes and to improve security, fire alarms, address structural deficiencies, doors, windows, unit heaters and video monitoring.

The new building and renovation of the storage facility was designed to accommodate: Police administration; Police operations; small emergency operations and Police training room; Records storage and retrieval; Investigations; Police community and Crime prevention programs; Property storage/retrieval and evidence processing; Fingerprinting lab; Suspect processing and interviewing; Police support services, Patrol shift briefings, Staff meetings and also features a Community meeting/multi-purpose room (Chuck Fulton Community Room).

Secure areas were provided for safety including: interview rooms; conference rooms; suspect processing rooms; locker rooms; and lunch and kitchen facilities. Non-secure interview rooms were also included to allow the public to talk with the officers or to make reports in privacy. The new headquarters building features advanced electronics, video monitoring, communications, air handling and emergency systems. The facility has a back-up generator for power capable of running all of the lights, computers, and critical functions of the building. It does not operate the HVAC system.

Police Services
Currently, there are 48 commissioned officers and 14 civilian employees with the Walla Walla Police Department. Services provided include animal control, crime prevention, investigations, patrol, and parking and code enforcement. Community programs provided by the Police Department include Washington State Crime Prevention Association activities, the Crime Free Rental Housing Program, Child Passenger Safety Program and a Special Teams Unit that is focused on Gang and Drug related activities.

Public Safety Communications (WESCOMM)
Emergency services communications in Walla Walla County are provided by Walla Walla Emergency Services Communications (WESCOMM). Under a contract with Walla Walla County, the WWPD operates the Enhanced 911 center for all law enforcement, fire services, and ambulance services within Walla Walla County (WWPD, WWFD, WW County Sheriff's office, City of College Place Police and Fire Departments, Rural Fire Districts 1, 2, 3, 4, 6, 7 and the Walla Walla Airport Fire Department) except for Rural Fire District 5, covering the western portion of Walla Walla County near the Wallula/Burbank area which utilizes Franklin County's 911 call center due to logistics and phone service coverage. There are 17 employees with WESCOMM.

In 1997, the center moved from City Hall into the current 3,000 square foot facility at the SW corner of Rose Street and 2nd Avenue. This building also serves as the headquarters for the Walla Walla County Department of Emergency Management and the Emergency Operations Center. The current facility is located over Mill Creek and should be considered for relocation due to its vulnerability to impacts from flooding and/or earthquake damage. The building is owned by Walla Walla County and leased to WESCOM.

Level of Service and Future Needs
As the population and community's socio-economic mix change and the land area serviced by the department grows, the number of law enforcement personnel and the location of those personnel will also need to be addressed. The Department will need to adjust and adapt to these changes in order to maintain public safety and respond to calls in a timely manner. At present, with 48 commissioned officers and a population estimate of 33,390, the ratio is 1.43 officers per 1,000 people. Although this ratio is a common measurement used by agencies to evaluate the number of officers in a community, it does not address the actual amount of police time required to handle calls for service from inception to completion. The International City/County Management Association (ICMA) recommends that

workload be used to determine the number of officers required for a community. This assessment should consider workload, deployment and response times for patrol officers. This assessment method is recommended because the ratio approach to level of service does not factor in the type of service requests. A more holistic approach to level of service would be to analyze the type of 911 calls from the CAD system to assess needs. It is recommended that the Police Department utilize ICMA's Patrol Workload & Deployment Analysis System to conduct an assessment of the number of officers needed in the city.

Service calls between 2009 and 2017:

Walla Walla Police Department

Year	Requests For Service
2009	19,320
2010	19,879
2011	18,537
2012	19,701
2013	20,355
2014	18,820
2015	20,911
2016	19,128
2017	22,801

With the new police station and upgraded Evidence Storage renovations in place, a majority of the Police Department's future needs have been addressed. However, as the service population grows through annexation and in-fill on the Southside of town, it becomes more difficult geographically for timely police response to this area. The Fire Department is faced with the same dilemma. A small police satellite out-station as part of any new fire station built in the area would help the Police Department meet the needs of this growing area of the City.

Firearms Range

Currently, the Police Department is able to use the firearms range at the Washington State Penitentiary or the College Place Police Department range (which is for pistols only). Both locations are getting more and more difficult to schedule due to use from other competing entities. In order to sustain the highest possible training standards with regard to the extremely high liability issue of firearms use, the Police Department, in coordination with Public Works, has developed a plan for a firearms range located on some un-used land at the landfill. The initial cost estimates place this project at right around $300,000.

Appendix XII. 20-Year Funding Forecast

	Annual Escalation: 0%	Annual Escalation: 1%	Annual Escalation: 0%	Annual Escalation: 1%	Total
2026	$650,000.00	$2,000,000.00	$1,000,000.00	$4,000,000.00	**$7,650,000.00**
2027	$650,000.00	$2,020,000.00	$1,000,000.00	$4,040,000.00	**$7,710,000.00**
2028	$650,000.00	$2,040,200.00	$1,000,000.00	$4,080,400.00	**$7,770,600.00**
2029	$650,000.00	$2,060,602.00	$1,000,000.00	$4,121,204.00	**$7,831,806.00**
2030	$650,000.00	$2,081,208.02	$1,000,000.00	$4,162,416.04	**$7,893,624.06**
2031	$650,000.00	$2,102,020.10	$1,000,000.00	$4,204,040.20	**$7,956,060.30**
Subtotal 2026-2031 CFP	$3,900,000.00	$12,304,030.12	$6,000,000.00	$24,608,060.24	**$46,812,090.36**
2032	$650,000.00	$2,123,040.30	$1,000,000.00	$4,246,080.60	**$8,019,120.90**
2033	$650,000.00	$2,144,270.70	$1,000,000.00	$4,288,541.41	**$8,082,812.11**
2034	$650,000.00	$2,165,713.41	$1,000,000.00	$4,331,426.82	**$8,147,140.23**
2035	$650,000.00	$2,187,370.55	$1,000,000.00	$4,374,741.09	**$8,212,111.64**
2036	$650,000.00	$2,209,244.25	$1,000,000.00	$4,418,488.50	**$8,277,732.75**

2037	$650,000.00	$2,231,336.69	$1,000,000.00	$4,462,673.39	**$8,344,010.08**
2038	$650,000.00	$2,253,650.06	$1,000,000.00	$4,507,300.12	**$8,410,950.18**
2039	$650,000.00	$2,276,186.56	$1,000,000.00	$4,552,373.12	**$8,478,559.68**
2040	$650,000.00	$2,298,948.43	$1,000,000.00	$4,597,896.85	**$8,546,845.28**
2041	$650,000.00	$2,321,937.91	$1,000,000.00	$4,643,875.82	**$8,615,813.73**
2042	$650,000.00	$2,345,157.29	$1,000,000.00	$4,690,314.58	**$8,685,471.87**
2043	$650,000.00	$2,368,608.86	$1,000,000.00	$4,737,217.73	**$8,755,826.59**
2044	$650,000.00	$2,392,294.95	$1,000,000.00	$4,784,589.90	**$8,826,884.85**
2045	$650,000.00	$2,416,217.90	$1,000,000.00	$4,832,435.80	**$8,898,653.70**
Total	**$13,000,000.00**	**$44,038,007.99**	**$20,000,000.00**	**$88,076,015.98**	**$165,114,023.97**
Total (without 2026-2031 CFP Funds)	**$9,100,000.00**	**$31,733,977.87**	**$14,000,000.00**	**$63,467,955.74**	**$118,301,933.61**

Appendix XIII. Transportation Elements Project List

Project ID	Project Name	Project Type	Evaluation Rating	Cost Estimate	Estimated Costs Borne by Develop-ment	Develo-pment Comm ent	Estimated Costs Borne by City	In 2026-2031 CFP? (CFP Project Number)	Sponso-ring Agency (ies)	Priorit-ized Project	Estimated Prioritized Project Expendit-ure	Project Description
BR-01	6th Avenue/ Mill Creek	Bridge	14	$7,300,000	$0		$7,300,000	BR2701	City	Yes	$7,300,000	BR915-001
BR-02	4th Avenue/ Mill Creek	Bridge	14	$5,550,000	$0		$5,550,000	BR2701	City	Yes	$5,550,000	BR915-003
BR-03	2nd Avenue/ Mill Creek	Bridge	14	$8,350,000	$0		$8,350,000		City		$0	BR818-016
BR-04	Main Street/ Mill Creek	Bridge	14	$8,350,000	$0		$8,350,000		City		$0	BR915-005
BR-05	Otis Street/ Mill Creek	Bridge	14	$2,000,000	$0		$2,000,000		City		$0	BR916-004
BR-06	Merriam Street/ Mill Creek	Bridge	14	$2,000,000	$0		$2,000,000		City		$0	BR916-006
BR-07	3rd Avenue/ Garrison Creek	Bridge	14	$3,250,000	$0		$3,250,000	2028-XX	City	Yes	$3,250,000	BR716-007
BR-08	Chase Avenue/ Garrison Creek	Bridge	14	$1,250,000	$0		$1,250,000		City		$0	BR715-007

BR-09	Rustic Place/ Yellowhawk Creek	Bridge	14	$1,000,000	$0		$1,000,000		City		$0	BR718-008
F-01	Myra Road Freight Reroute from 9th Avenue	Freight	9	$500,000	$0		$500,000		City		$0	Reroute freight traffic from 9th Ave to SE Myra Rd. (Wayfinding and guide signage)
FS-01	2nd Avenue	Future Study	18	$40,000	$0		$40,000		City		$0	Conduct a study to evaluate offset intersections between Stahl St and Whitman St and identify location(s) for crosswalk improvements. once the location is determined, install enhanced crosswalk.
FS-02	Main Street	Future Study	13	$50,000	$0		$50,000		City		$0	Future study to establish street cross section. Reconstruct road to consistent cross section and restore curbs. Evaluate parking to see if diagonal parking could be converted to parallel parking, and consider bike lanes or turn lanes if parallel parking
FS-03	Melrose Street Corridor Study	Future Study	20	$150,000	$0		$150,000		City	Yes	$150,000	Improve pedestrian crossing and evaluate curb extensions at public street intersections for traffic calming and pedestrian safety. Corridor analysis to consider design elements like turn lanes, bike lanes, and on-street parking where land use creates
INT-01	Alder Street Division Street	Intersect ion	17	$1,300,000	$0		$1,300,000		City		$0	Construct a new traffic and pedestrian actuated signal at the intersection of Alder

												Street and Division Street adjacent to Pioneer Park.
INT-02	Bryant Avenue Howard Street	Intersection	18	$3,200,000	$0		$3,200,000		City		$0	Install compact roundabout
INT-03	U.S. 12/ Harbert Road	Intersection	9		$0		$0		City		$0	Install left turn lane on US 12 WB with development
INT-04	9th Avenue/ Birch Street	Intersection	17	$360,000	$0		$360,000		City		$0	Install RRFB improved pedestrian crossing; restricted intersection - right-in/right-out for vehicles
INT-05	9th Avenue/ Emma Street	Intersection	20	$320,000	$0		$320,000		City	Yes	$320,000	Install RRFB improved pedestrian crossing w/ refuge island
INT-06	9th Avenue/ Main Street	Intersection	20	$1,650,000	$0		$1,650,000	2028-XX	City	Yes	$1,650,000	Traffic signal improvement - full replacement
INT-07	9th Avenue/ Alder Street	Intersection	19	$1,650,000	$0		$1,650,000		City	Yes	$1,650,000	Traffic signal improvement - full replacement
INT-08	9th Avenue/ Poplar Street	Intersection	19	$2,800,000	$0		$2,800,000		City	Yes	$2,800,000	Traffic signal improvement - full replacement
INT-09	9th Avenue/ Chestnut Street	Intersection	19	$1,700,000	$0		$1,700,000		City	Yes	$1,700,000	Traffic signal improvement - full replacement
INT-10	9th Avenue/ Willow Street	Intersection	7	$70,000	$0		$70,000		City		$0	Restricted intersection - right-in/right-out for vehicles
INT-11	2nd Avenue/ Tietan Street	Intersection	18	$1,000,000	$0		$1,000,000		City	Yes	$1,000,000	Construct a new traffic and pedestrian actuated signal at the intersection of 2nd Avenue and Tietan Street.

INT-12	4th Avenue/ Alder Street	Intersection	18	$1,000,000	$0		$1,000,000		City		$0	Traffic signal improvement - full replacement
INT-13	5th Avenue/ Main Street	Intersection	18	$1,000,000	$0		$1,000,000	2028-XX	City	Yes	$1,000,000	Traffic signal improvement - full replacement
INT-14	Bryant Avenue/ Fern Avenue	Intersection	5	$50,000	$0		$50,000		City		$0	Removal of all way stop flasher and span wire
INT-15	Wilbur Avenue/ Highway 12 Interchange	Intersection	24		$0		$0		WSDOT, City		$0	Grade separated interchange to improve north-south connections, including multimodal connections
INT-16	Reser/Howard/ Cottonwood/Prospect Intersection	Intersection	17	$3,850,000	$0		$3,850,000		City		$0	Reconfigure the existing intersection with a roundabout to improve traffic flow and safety.
INT-17	Main Street/ 3rd Avenue	Intersection	18	$1,000,000	$0		$1,000,000	2028-XX	City	Yes	$1,000,000	Traffic signal improvement - full replacement
INT-18	Main Street/ 4th Avenue	Intersection	18	$1,000,000	$0		$1,000,000	2028-XX	City	Yes	$1,000,000	Traffic signal improvement - full replacement
INT-19	Main Street/ Colville Street	Intersection	19	$1,000,000	$0		$1,000,000	2028-XX	City	Yes	$1,000,000	Traffic signal improvement - full replacement
INT-20	Main Street/ Spokane Street	Intersection	19	$1,000,000	$0		$1,000,000	2028-XX	City	Yes	$1,000,000	Traffic signal improvement - full replacement
INT-21	Pleasant Street/ Fern Avenue	Intersection	7	$150,000	$0		$150,000		City		$0	Span wire/pole replacement and advanced signage

INT-22	9th Ave/ Orchard Street	Intersection	21	$4,250,000	$0		$4,250,000		City	Yes	$4,250,000	Install roundabout
INT-23	Plaza Way Taumarson Road	Intersection	19	$4,250,000	$0		$4,250,000		City		$0	Install compact roundabout
INT-24	Fern Ave/ Abbott Road	Intersection	18	$3,200,000	$0		$3,200,000		City		$0	Install compact roundabout
MM-01	9th Avenue	Multimodal	16	$9,300,000	$0		$9,300,000		City		$0	Corridor improvements - update cross section, install 10-foot wide multi-use paths on each side, ADA upgrades as per S 9th Avenue Pedestrian and Bicycle Safety Study
MM-02	Poplar Street	Multimodal	19	$15,000,000	$0		$15,000,000	IRRP028	City	Yes	$15,000,000	Corridor improvements - install bike lanes, update cross section as per Poplar Corridor Study
MM-03	Poplar Street	Multimodal	19	$26,600,000	$0		$26,600,000	IRRP028	City	Yes	$26,600,000	Corridor improvements - install bike lanes, update cross section as per Poplar Corridor Study
MM-04	Isaacs Avenue	Multimodal	23	$51,000,000	$7,750,000	3700 feet between Looking Glass Road and Harbert Road on north side	$43,250,000		City, Development		$0	Improve Isaacs Avenue from Tausick Way/Airport Road to the WWCC east entrance to principal arterial standards. This would be a joint City/County project to reconstruct the roadway, including turn lanes, curb and gutter, drainage facilities, sidewalks, and bicycle lanes.

MM-05	Harbert Road	Multimodal	14	$11,900,000	$11,900,000	Entire project length from US12 to Mill Creek Road	$0		City, Development	Yes	$0	Corridor improvements - install bike lane, install sidewalk
MM-06	Kendall Road	Multimodal	17	$3,450,000	$2,600,000	3500 feet on west side north of Cottonwood Road; 900 feet on east side	$850,000		City, Development		$0	Corridor improvements - install bike lane, install sidewalk
MM-07	Cottonwood Road	Multimodal	17	$4,200,000	$2,100,000	2800 feet west of Kendall Road on northeast side	$2,100,000		City, Development		$0	Corridor improvements - install bike lane, install sidewalk
MM-08	School Avenue	Multimodal	18	$13,100,000	$0		$13,100,000	TBD - Grant Dependent	City	Yes	$13,100,000	Reconstruct the roadway including realignment of the Pleasant Street intersection, utility improvements, pedestrian improvements, illumination, and school speed zone flashers.
MM-09	Offner Road	Multimodal	20	$400,000	$0		$400,000		City	Yes	$400,000	Complete sidewalk connection on east side

MM-10	Plaza Way	Multimodal	23	$5,300,000	$0		$5,300,000	TBD9024	City	Yes	$5,300,000	Corridor improvements - improve to arterial standards
MM-11	3rd Avenue	Multimodal	21	$600,000	$500,000	700 feet north of Whitney Road on both sides	$100,000		City, Development	Yes	$100,000	Add sidewalks
MM-12	1st Avenue/ Main St	Multimodal	15	$1,650,000	$0		$1,650,000		City		$0	ADA accessibility improvements and pedestrian countdown timers.
MM-13a	4th AveŲMĴ Extension (North)	Multimodal	29	$9,000,000	$2,450,000	400 feet north of railroad crossing	$6,550,000		City, Development, Railroad	Yes	$6,550,000	Reconstruct N 4th Avenue to minor arterial standards including sidewalks and a railroad crossing.
MM-13b	4th AveŲMĴ Reconstruction (South)	Multimodal	29	$5,500,000	$0		$5,500,000		City, Railroad	Yes	$5,500,000	Reconstruct N 4th Avenue from W Moore to Rees Avenue to minor arterial standards including sidewalks and a railroad crossing.
MM-14	Alder Street - Roosevelt to Brock IRRP	Multimodal	21	$5,250,000	$0		$5,250,000	TBD9030	City	Yes	$5,250,000	Roadway and utility improvements from Roosevelt St to Brock St. Work also includes new traffic signal or roundabout at Roosevelt Street.
MM-15	Berney Drive	Multimodal	17	$3,800,000	$600,000	800 feet on southwest side north of Pleasant Street	$3,200,000		City, Development		$0	Widen Berney Dr for bike lanes. Add sidewalks from Russell Creek Rd to UGA south of Delmont Pl

MM-16	Boyer Avenue Bike Boulevard	Multimodal	17	$450,000	$0		$450,000		City		$0	Reconstruct Boyer Avenue and create a bike route connecting downtown to Mill Creek Trail
MM-17	Cottonwood Road Bicycle and Pedestrian Facilities	Multimodal	20	$650,000	$325,000	400 feet north of Canberra Drive on both sides	$325,000		City, Development	Yes	$325,000	Extend sidewalk, trail, and bike lanes from Austin Street to Kendall Road, and widen roadway.
MM-18	Edison Trail	Multimodal	19	$2,200,000	$0		$2,200,000		City	Yes	$2,200,000	Connect Edison Elementary School to Cambridge Dr through bike lanes and/or trail
MM-19	Fern Avenue	Multimodal	20	$4,650,000	$0		$4,650,000		City	Yes	$4,650,000	Install sidewalks on east side of Fern Ave to close gaps
MM-20	Highway 12 Trail	Multimodal	18	$550,000	$0		$550,000		City, WSDOT		$0	Trail Rehabilitation
MM-21	Main/Palouse/ Boyer	Multimodal	14	$700,000	$0		$700,000	2028-XX	City	Yes	$700,000	Modify traffic signal to include audible pedestrian signal
MM-22	Rees and Sumach Sidewalks	Multimodal	18	$1,000,000	$0		$1,000,000		City		$0	Installation of sidewalk and curb/gutter on Sumach Street and Rees Avenue from DeSales High School to Memorial Pool.
MM-23	Mill Creek Bike Path Repaving	Multimodal	14	$200,000	$0		$200,000		City		$0	Bike path repaving to improve pavement conditions
MM-24	Tausick Way Trail Crossing (Mill Creek Bridge)	Multimodal	18	$400,000	$0		$400,000		City		$0	Enhance trail crossing at Tausick Way. To be completed as part of Alder-Tausick preservation project.

MM-25	Municipal Golf Course Trail	Multimodal	11	$9,050,000	$3,000,000	Rail to trail through Veterans Memorial Golf Course	$6,050,000		City, Development		$0	Construct trail
MM-26	Reser Road	Multimodal	18	$4,550,000	$0		$4,550,000		City		$0	Improve Reser Road from Wilbur Avenue to School Avenue to minor arterial standards. This will be a joint City/County project.
MM-27	Roosevelt Street	Multimodal	18	$1,150,000	$0		$1,150,000		City		$0	Reconstruct roadway and extend bike lanes
MM-28	Avery Street	Multimodal	18	$1,000,000	$250,000	850 feet on east side of Avery Street north of Electric Avenue; 200 feet on west side of Avery	$750,000		City, Development		$0	Improve Avery Street north of Rose Street.
MM-29	Cherokee Street	Multimodal	19	$1,050,000	$0		$1,050,000		City	Yes	$1,050,000	Reconstruct Cherokee Street from 2nd Avenue to 3rd Avenue to collector standards including sidewalks.
MM-30	Clinton Street	Multimodal	24	$8,650,000	$605,000	700 feet between US12 and	$8,045,000	IRRP027	City, WSDOT, Development	Yes	$8,045,000	Improve Clinton St to minor arterial standards

						Sumach St on west side						
MM-31	Dell Avenue	Multimodal	31	$4,050,000	$0		$4,050,000		City	Yes	$4,050,000	A Port of Walla Walla sponsored project to create a new commercial district on Dell Avenue from 13th Avenue to the west city limits. This project will provide a new streetscape which will complement the 13th Avenue ARRA improvements.
MM-32	Electric Avenue	Multimodal	26	$7,900,000	$7,900,000		$0		City, Development	Yes	$0	Extend Electric Avenue from Myra Road to Woodland Avenue to collector standards, consistent with the Myra Road sub-area master plan.
MM-33	Melrose Street	Multimodal	28	$8,350,000	$1,250,000	1400 feet east of Frontier Street on north side of Melrose Street	$7,100,000		City, Development	Yes	$7,100,000	Reconstruct Melrose Street from Wilbur Avenue to Airport Road to minor arterial standards, including frontage improvements.
MM-34	Orchard Street	Multimodal	23	$3,900,000	$0		$3,900,000		City	Yes	$3,900,000	Upgrade to collector standards
MM-35	Clinton Street/ Highway 12 Interchange	Multimodal	31	$75,000,000	$0		$75,000,000	ST2411	WSDOT, City		$0	Grade separated interchange to improve north-south connections, including multimodal connections

MM-36	Wilbur Avenue	Multimodal	20	$3,700,000	$0		$3,700,000	2027-XX	City	Yes	$3,700,000	Improve Wilbur Avenue to minor arterial standards from approximately Pleasant Street to Bryant Avenue. This would be a joint City/County project.
MM-37	Sumach Street IRRP	Multimodal	18	$3,000,000	$1,100,000	1200 feet on south side of Sumach Street; 800 fee on north side	$1,900,000		City, Development		$0	Full roadway and utility improvements on Sumach Street from Clinton Street to East end of road.
MM-38	Village Way Improvements	Multimodal	21	$2,150,000	$195,000	350 feet on northwest side	$1,955,000		City, Development	Yes	$1,955,000	Improve Village Way from Plaza Way to the end, including new sidewalks.
MM-39	Chase Avenue Reconstruction	Multimodal	24	$5,900,000	$0		$5,900,000		City	Yes	$5,900,000	Reconstruct Chase Avenue from Birch Street to Orchard Street to collector standards including sidewalks.
MM-40	Alder and Main Re-striping	Multimodal	11	$200,000	$0		$200,000	2031-XX	City	Yes	$200,000	Re-stripe Alder Street and Main Street to 2 lane roads with angled parking from 5th Avenue and 6th Avenue to 9th Avenue.
MM-41	Mill Creek Trail Repave and Improvements	Multimodal	14	$3,600,000	$0		$3,600,000		City		$0	Repave and widen the Mill Creek Trail from Cambridge Street to Tausick Way. Improve accessibility to the trail from the west end.

MM-42	Washington Park Bike Trail	Multimodal	13	$2,350,000	$0		$2,350,000		City		$0	A BPAC sponsored project to construct a bike trail through Washington Park from 9th Avenue to 13th Avenue.
MM-43	Fort Walla Walla Bicycle Links	Multimodal	13		$0		$0		City		$0	A BPAC sponsored project to construct bike links to Fort Walla Walla from The Dalles Military Road, Myra Road and Chestnut Street.
MM-44	Bridge Street Sidewalk Replacement	Multimodal	19	$1,050,000	$0		$1,050,000		City	Yes	$1,050,000	Replace the ADA deficient and deteriorating sidewalks north of Pioneer Middle School.
MM-45	Park Street Bike and Pedestrian Improvements	Multimodal	21	$2,700,000	$0		$2,700,000		City	Yes	$2,700,000	Improve bicycle and pedestrian infrastructure on Park Street from Rees to Alder Street.
MM-46	Pine Street Sidewalk Infill	Multimodal	21	$1,600,000	$0		$1,600,000		City	Yes	$1,600,000	Sidewalk infill along Pine Street where needed.
MM-47	Odd Fellows Home Area - Boyer Avenue - Clinton Avenue	Multimodal	19	$350,000	$0		$350,000		City	Yes	$350,000	ADA accessibility upgrades.
MM-48	Rees/Par 72 Bike and Pedestrian Enhancements	Multimodal	17	$500,000	$0		$500,000		City		$0	Improve pedestrian accessibility to the crossing between the multi-use path and the sidewalks on Rees Avenue.
MM-49	Garrison Village Way at Myra Road Intersection Improvements	Multimodal	19		$0		$0		City		$0	Improve pedestrian crossing safety at the intersection of Myra Road and Garrison Village Way/Fort Walla Walla Entrance.

MM-50	DeSales School Zone Safety Enhancements	Multimodal	19	$400,000	$0		$400,000		City	Yes	$400,000	Improve pedestrian crossing safety near DeSales Catholic High School.
MM-51	Stevens Street Sidewalks	Multimodal	18	$1,150,000	$350,000	600 feet on west side north of Lodge Drive	$800,000		City, Development		$0	Sidewalk infill from Tietan Street to Lodge Drive.
MM-52	Fern Avenue Pedestrian Bridge	Multimodal	13	$750,000	$0		$750,000	TBD - Grant Dependent	City	Yes	$750,000	Construct a pedestrian bridge over Caldwell Creek connecting Fern Avenue and Klingman Court.
MM-53	Tietan Street Sidewalks - 4th to Plaza	Multimodal	21	$1,800,000	$450,000	430 feet on south side; 550 feet on north side west of 4th Avenue	$1,350,000		City, Development	Yes	$1,350,000	Install new sidewalk, ADA ramps, curb and gutter, illumination, and stormwater improvements.
NR-01	Myra Road Extension (North)	New Roadway	12	$20,800,000	$20,800,000	Entire project length	$0		City, Development, WSDOT	Yes	$0	Extend Myra Rd as a principal arterial connection to SR 125
NR-02	Wilbur Avenue Extension (South)	New Roadway	21	$10,250,000	$5,000,000	Will be accomplished through some combination of future City/Cou	$5,250,000		City, Development, County		$0	Extend and improve Wilbur Avenue to minor arterial standards from Bryant Avenue to Reser Road. This will be a joint City/County project and will require a bridge over Yellowhawk creek.

						nty partners hips and/or construc ted as part of future develop ment.						
NR-03	Futura Road Extension	New Roadway	19	$5,000,000	$5,000,000	1500 feet west of Myra Road on both sides	$0		City, Developm ent	Yes	$0	Construct a new road from Myra Road to Avery Street to collector standards in compliance with the Myra Road sub-area master plan.
SA-01	Middle Waitsburg Road/Blue Mountain Drive	Safety	14	$1,050,000	$0		$1,050,000		City		$0	Reconfigure the existing intersection and surrounding roadways to improve traffic flow and safety.
SA-02	Pine Street	Safety	16	$2,100,000	$0		$2,100,000		City		$0	Improve safety, capacity and freight mobility along W Pine St
			Total Cost	**$447,490,000**						**Total Cost**	**$164,395,000**	



References

Walla Walla County 2018 Continuity of Operations Plan, (COOP)
The COOP is subject to review and updated annually as needed by Walla Walla County.

City of Walla Walla 2026 Watershed Master Resiliency Plan,
https://www.wallawallawa.gov/government/public-works/watershed-resiliency-plan

Blue Mountain Regional Trails Plan,
https://nebula.wsimg.com/d66270b6a5a4e767a987e961dbdc06c0?AccessKeyId=3DA9BECDE71EAFF19021&disposition=0&alloworigin=1

City of Walla Walla 2020 Water Systems Plan,
https://www.wallawallawa.gov/home/showpublisheddocument/10131/638574981780070000

City of Walla Walla Water 2050 Water Management Plan,
https://www.wallawallawa.gov/home/showdocument?id=12436&t=639204905226782006

City of Walla Walla 2019 Comprehensive Stormwater Management Plan,
https://www.wallawallawa.gov/home/showpublisheddocument/10356/638638924647070000

City of Walla Walla 2015 General Sewer Plan & 2021 Amendment 1,
https://www.wallawallawa.gov/home/showpublisheddocument/10047/638544963411900000

Walla Walla County Solid & Hazardous Waste Management Plan (2024-2029),
https://www.wallawallawa.gov/home/showpublisheddocument/11379/638900001902270000

City of Walla Walla 2023 Landfill Facility Master Plan,
https://www.wallawallawa.gov/home/showpublisheddocument/10083/638561341662630000

City of Walla Walla 2024 Library Expansion and Renovation,
https://www.gowallawalla.us/current-projects/library-renovation

City of Walla Walla 2020 Mobility for All- ADA Self-Evaluation and Transition Plan,
https://www.wallawallawa.gov/home/showpublisheddocument/5084/637492401622230000

City of Walla Walla Tourism Master Plan of 2024,
https://www.wallawallawa.gov/home/showpublisheddocument/11821/639062430113070000

City of Walla Walla 2023 Shoreline Master Program,
https://www.wallawallawa.gov/home/showpublisheddocument/11691/639020038651600000

City of Walla Walla 2022 Historic Preservation Plan,
https://www.wallawallawa.gov/home/showpublisheddocument/8289/638152547551270000

City of Walla Walla 2021 Urban Forestry Management Plan,
https://www.wallawallawa.gov/home/showpublisheddocument/12077/639118449354300000

City of Walla Walla 2024 Parks and Recreation Comprehensive Plan,
https://www.wallawallawa.gov/home/showpublisheddocument/11785/639046797012770000

City of Walla Walla 2004 Downtown Master Plan,
https://www.wallawallawa.gov/home/showpublisheddocument/10041/638544955747000000

Walla Walla County 5-Year Homeless Housing Plan (2026-2030),
https://dch.wwcowa.gov/human_services/homeless_housing/5_year_homeless_housing_plan_(2026-2030).php#docaccess-ef4bdf106e1af425b8d347a3311582cf369830c7e42519b3ef53446eb8aaf4a4

Walla Walla County Multi-Jurisdictional Hazard Mitigation Plan,
https://www.wwcowa.gov/government/emergency_management/hazard_identification_and_vulnerability_analysis_(hiva)_and_hazard_mitigation_plan_(hmp).php#docaccess-b4667e1439d0cf79fb0421d9b854f8aa

City of Walla Walla 2026-2031 Capital Facilities Plan,
https://www.wallawallawa.gov/home/showpublisheddocument/11681/639016534614870000

City of Walla Walla Transportation Impact Analysis (TIA) Guidelines,
https://www.wallawallawa.gov/home/showpublisheddocument/2344/636784108380470000

ORDINANCE NO. 2026-xx

AN ORDINANCE ADOPTING AMENDMENTS TO THE CITY OF WALLA WALLA COMPREHENSIVE PLAN – WALLA WALLA 2040 PURSUANT TO THE PROVISIONS OF RCW CHAPTER 36.70A AND TAKING SUCH OTHER ACTION RELATED THERETO

WHEREAS, the City of Walla Walla passed Municipal Ordinance A2405 on May 13, 1970, which classified the City of Walla Walla as a non-chartered code city under Title 35A of the Revised Code of Washington (RCW); and

WHEREAS, the Walla Walla County Board of Commissioners passed County Resolution 90-449 on October 30, 1990, opting into planning activities under the Washington Growth Management Act, Chapter 36.70A RCW; and

WHEREAS, the Walla Walla City Council passed previous city ordinances adopting a comprehensive plan including: City Ordinance 2008-25 on November 5, 2008, and Ordinance 2018-15 on June 13, 2018; and

WHEREAS, the City of Walla Walla is required to conduct a periodic review of its comprehensive plan and development regulations every ten years pursuant to Chapter 36.70A RCW and complete the periodic review no later than December 31, 2026; and

WHEREAS, the City of Walla Walla published in the Union Bulletin and on the City's website an advertisement that the City was accepting comprehensive plan map amendment applications as part of the City's required periodic update and established a deadline for submittal of July 1, 2025; and

WHEREAS, the City of Walla Walla began its early and continuous public participation process in January 2025, with orientation interviews with key stakeholders; on June 11, 2025, with digital flyer distribution to the community, with community presentations from August 5, 2025, to March 18, 2026, along with public open houses on July 10, 2025 and October 15, 2025, surveys from June 2025 through January 2026, and mini poll surveys from January to February 2026; and

WHEREAS, the City of Walla Walla presented a preliminary public review draft of the comprehensive plan to the Planning Commission on June 1, 2026; and

WHEREAS, the notice of application and public hearing notice were published on March 12, 2026 in the Union Bulletin, posted on the City's website at least 14 days prior to the date of hearing, posted at City Hall, and provided to applicants and interested parties for the Planning Commission public hearings on June 1, 2026, June 22, 2026, and July 6, 2026; and

WHEREAS, the draft comprehensive plan update and development regulations were transmitted to the Washington State Department of Commerce, Growth Management Services

Division, and other state agencies for the 60-day state review period in accordance with RCW 36.70A.106 on April 2, 2026; and

WHEREAS, the Walla Walla Planning Commission held public meetings on the 2026 comprehensive plan update on March 3, April 13, May 4, June 1, June 22, July 6, and August 3, 2026; and

WHEREAS, the City of Walla Walla issued an adoption addendum to its SEPA determination on April 30, 2026; and

WHEREAS, at the public hearings, the City of Walla Walla Planning Commission heard and considered the public testimony and the evidence and exhibits presented to it; and

WHEREAS, the Walla Walla City Council and Planning Commission held a joint work session reviewing the draft comprehensive plan on November 3, 2025; and

WHEREAS, the Walla Walla Valley Metropolitan Planning Organization Policy Board approved the plan review and certification on July 1, 2026; and

WHEREAS, the City of Walla Walla Planning Commission thereafter made its recommendation on the periodic update to the comprehensive plan and development regulations on August 3, 2026; and

WHEREAS, the Walla Walla City Council reviewed the Planning Commission's recommendations and deliberated upon the draft comprehensive plan and development regulations at a regular work session on August 24 and September 21, 2026; and

WHEREAS, a duly noticed public hearing on the proposed periodic comprehensive plan update and development regulations was published on August 27, 2026, and September 24, 2026; and

WHEREAS, the Walla Walla City Council has considered the matters on the proposed periodic comprehensive plan update and development regulations during a regularly and duly called public meeting of said Council, has given said matter careful review and consideration, and finds that good government and the best interests of the City of Walla Walla will be served by passage of this ordinance.

NOW THEREFORE, the City Council of the City of Walla Walla do ordain as follows:

Section 1: Legislative Findings. The City Council of the City of Walla Walla hereby makes the following legislative findings in support of this ordinance. These findings form the factual and policy basis for adopting the comprehensive plan amendment and are part of the record of legislative action:

1. The Walla Walla City Council finds that the amendment adopted herein advances state interests identified in Section 36.70A.010 of the Revised Code of Washington.

2. The Walla Walla City Council finds that the public outreach activities held and outlined below, as well as the process used to consider and adopt this ordinance, satisfy the City's public participation procedures adopted pursuant to Section 36.70A.035 of the Revised Code of Washington:

Event Date	Event Type	Event Location
November 4, 2024	City Council Work Session and Planning Commission Workshop	City Hall
January 28 – February 6, 2025	Orientation interviews with 20 key community stakeholders	Virtual
March 3, 2025	Planning Commission Workshop	City Hall
May 17, 2025	Return to the River Event	Walla Walla Community College
June 5, 2025	West Ward Community Party and Townhall	Washington Park
June 10, 2025	Windermere "State of the City" Presentation	Windermere Real Estate Office
June 17, 2025	Presentation to City Leadership Team	City Hall
July 10, 2025	Kick off Open House	Walla Walla Public Library
August 5, 2025	Presentation to Hayden Homes	Virtual
September 8, 2025	Presentation to Blue Mountain Action Council	Virtual
September 18, 2025	Presentation to Walla Walla Valley Association of Realtors	Association of Realtors' Office
September 25, 2025	Presentation to Walla Walla Noon Rotary	Elks Lodge
October 1, 2025	Presentation to Walla Walla Sunrise Rotary	St Francis Church
October 15, 2025	Open House	Walla Walla Public Library
November 3, 2025	Joint Planning Commission and City Council Work Session	City Hall
November 4, 2025	Presentation to Home Builder's Association of Tri-Cities and Walla Walla	Community Room at Police Station
March 5, 2026	Presentation to Walla Walla High School Latino Club	Walla Walla High School
March 18, 2026	Presentation to Walla Walla Downtown Foundation and Downtown stakeholders	Marcus Whitman Hotel

3. The Walla Walla City Council finds that the periodic update to the comprehensive plan is consistent with the Countywide Planning Policies.

4. The Walla Walla City Council finds that the periodic update to the comprehensive plan is consistent with the Walla Walla Valley Metropolitan Planning Organization 2045 Plan and Future Network Plan.

5. The Walla Walla City Council hereby approves and adopts the future land use map incorporated into the comprehensive plan as well as the following described site-specific amendments to the comprehensive plan land use map for the City of Walla Walla:

File # Applicant	**General Location / Parcel Number(s)**	**Current Land Use Designation and Zoning**	**Proposed Land Use Designation**	**Proposed Zoning Designation**
CPA-25-0001 Tovah Ahdut	1500 The Dalles Military Road 360731210005	Residential and Multi-Family Residential	Commercial	Highway Commercial
PLN6-25-0001 Tarragon NW	171 Middle Waitsburg Road 360716650003, 360716650004, 360716650005	Industrial and Light Industrial/ Commercial	Commercial 360716650003 Residential 360716650004 360716650005	Highway Commercial 360716650003 Multifamily Residential 360716650004 360716650005
PLN6-25-0001a City of Walla Walla	Lower Waitsburg Road 360717440028 360717450001 to 360717450012, 360717450014 to 360717450027, 360717470001 to 360717470021, 360717470026, 360717470027 360717470036, 360717470037, 360717470046 to 360717470049, 360717480038, 360717480016 to 360717480018,	Commercial	Residential	Neighborhood Residential

File # Applicant	General Location / Parcel Number(s)	Current Land Use Designation and Zoning	Proposed Land Use Designation	Proposed Zoning Designation
	360717470054 1177, 1181, 1189, 1193 and 1197 Ava St. 1472 to 1496 Theresa Ave 1474, 1478, 1482, 1486, 1490, 1494, 1498 Michele Ave. 1306, 1320, 1334 and 1335 Pat Ave. 1311 and 1312 Lillian Ave. 1307 and 1308 Bill Ave. 611, 619,627,635,643,651, 659,667,675,683,691, 705, 713,725, 726, 731,736, 745, 750,753,765,768, 783, 795 Ava St/ 360716650002 360716320029	Industrial and Light Industrial/Commercial	Residential	Neighborhood Residential
PLN6-25-0002 Tarragon NW and WinCo Foods	1700 Block of Highland Road, Hwy 125 at Myra Road 360731320071, 360731310053	Residential and Neighborhood Residential 360731310053 360731320071	Commercial 360731310053 360731320071	Highway Commercial 360731310053 360731320071
PLN6-26-0001 City of	1300 Block of The Dalles Military Road 360730560321-26	Commercial and Highway Commercial	Manufactured Home Park Community	Mobile/ Manufactured Home Park

File # Applicant	General Location / Parcel Number(s)	Current Land Use Designation and Zoning	Proposed Land Use Designation	Proposed Zoning Designation
Walla Walla	360730560401-05, 22-26			Community
PLN6-26-0002 City of Walla Walla	North of Rees Ave North & South of George Street 909 Jefferson St. 360720530209 911 Jefferson St. 360720530207 915 Jefferson St. 360720530206, 360720530205, 360720530204 927 Jefferson St. 360720530203, 360720530202 935 Jefferson St. 360720530201 503 (incorrect) Jefferson St. 360720530110 1009 Jefferson St. 360720530109 1011 Jefferson St. 360720530107 1017 Jefferson St. 360720530105 114 W George St. 360720530112 111 W George St. 360720530221 224 (incorrect) Burns St. 360720742149, 360720742150 236 (incorrect) Burns	Industrial and Heavy Industrial	Residential	Neighborhood Residential

File # Applicant	General Location / Parcel Number(s)	Current Land Use Designation and Zoning	Proposed Land Use Designation	Proposed Zoning Designation
	St. 360720742143, 360720742144 920 Burns St. 360720742128 926 Burns St. 360720742141 930 Burns St. 360720742142 931 Annie Laurie St. 360720742123 927 Annie Laurie St. 360720742125, 360720742126 924 N. 4th Ave. 360720530217 928 N. 4th Ave. 360720530218 930 N. 4th Ave. 360720530220 1002 N. 4th Ave. 360720530112			
PLN6-26-0003 City of Walla Walla	North of Moore Street. 903 N 9th Ave., 360719590501 916 N 9th Ave., 360719590414 910 N 9th Ave, 360719590415 925 N 8th Ave., 360719590405 913 N 8th Ave., 360719590403 919 N 8th Ave., 360719590404	Industrial and Heavy Industrial	Residential	Neighborhood Residential

File # Applicant	General Location / Parcel Number(s)	Current Land Use Designation and Zoning	Proposed Land Use Designation	Proposed Zoning Designation
	932 N 8th Ave., 360719590312 934 N 8th Ave., 360719590311 904 N 8thAve., 360719590316 910 N 8th Ave., 360719590315 914 N 8th Ave., 360719590314 508 W Moore St., 360719590318 502 W Moore St., 360719590317 807 N 7th Ave, 360719590320 809 N 7TH Ave., 360719590319 825 N 7thAve., 360719590305 821 N 7th Ave., 360719590321 810 N 7th Ave., 360719590216 and 360719590215 816 N 7th Ave., 360719590214 820 N 7th Ave, 360719590213 and 360719590218			

6. The Walla Walla City Council finds that the passage of this ordinance constitutes final adoption of the privately initiated comprehensive plan map amendment requests approved by Section 5 herein, because the properties involved in those applications are located entirely within the city limits of Walla Walla. Passage of this ordinance constitutes final adoption of all the amendments approved herein for the incorporated City of Walla Walla Future Land Use Map, FLUM.

7. The City of Walla Walla finds that the comprehensive plan, as adopted by this Ordinance and development regulation amendments adopted by Ordinance No. 2026-XX confirm to the requirements of Chapter 36.70A and Chapter 43.21C RCW and has been prepared with appropriate public participation and has complied with the Level VI review, Chapter 20.30 of the Walla Walla Municipal Code, for the City of Walla Walla's process to amend the comprehensive plan, and the City of Walla Walla has complied with Level V review. Chapter 20.28 of the Walla Walla Municipal Code for amendment of development regulations.

Section 9: Transmittal. Pursuant to RCW 36.70A.370, the City of Walla Walla Development Services Department is hereby directed to transmit a copy of this ordinance and the finalized amended Comprehensive Plan to Walla Walla County for informational purposes and to provide those portions of the Comprehensive Plan that apply to land outside the City's boundaries.

In accordance with RCW 36.70A.106, the City shall also transmit a complete and accurate copy of the adopted Comprehensive Plan amendment and this ordinance to the Washington State Department of Commerce within ten (10) days after final adoption.

Section 10: Severability. If any part of this ordinance is for any reason declared or held to be invalid or unconstitutional by any court or tribunal of competent jurisdiction, such part shall be deemed a separate and distinct and independent provision and such holding shall not affect the validity of the remaining parts hereof.

Section 11: Authority of City Manager. The City Manager or designee is authorized to implement such administrative procedures as may be necessary to carry out the directions of this legislation, including preparing and publishing the amended Comprehensive Plan.

Section 12: Effective Date. This ordinance shall take effect and be in force five days from and after its passage, approval, and publication as provided by law.

Section 13: Publishing. The Walla Walla City Clerk is directed to publish a copy of a summary and notice of adoption of this ordinance as permitted by section 35A.12.160 of the Revised Code of Washington.

Section 14: Appeals. Notice is hereby given that any petition for review of the City of Walla Walla's comprehensive plan or comprehensive plan map amendment must be filed with the Eastern Washington Growth Management Hearings Board within sixty (60) days following publication of the ordinance, or summary of the ordinance, adopting the amendment, in accordance with Chapter 36.70A RCW.

PASSED by the City Council of the City of Walla Walla, Washington, October 28, 2026.

_____

Mayor

Attest:

_____

City Clerk

Approved as to form:

_____

City Attorney

City of Walla Walla
Development Services

Washington State Environmental Policy Act – SEPA

Adoption/Addendum of an existing Environmental Document

File# PLN1-26-0017

Date of Issuance: April 30, 2026

Description of Proposal: City of Walla Walla Comprehensive Plan 2026-2046- Update to the City of Walla Walla Comprehensive Plan in accordance with the Washington State Growth Management Act (GMA), including revisions to plan elements and amendments to the Comprehensive Plan Land Use Map and Zoning Map.

Proponent: City of Walla Walla, 15 N. 3rd Avenue, Walla Walla, WA 99362

Location of current proposal: All of the City of Walla Walla and City of Walla Walla Urban Growth Area (UGA).

Title of document being adopted: The City of Walla Walla Comprehensive Plan, Walla Walla 2040, and the Final Environmental Impact Statement (FEIS).

The agency that prepared the document being adopted: City of Walla Walla

Date the adopted document was prepared: 5/18/2018

Description of document (or portion) being adopted: The City of Walla Walla Comprehensive Plan, Walla Walla 2040, and the Final Environmental Impact Statement (FEIS), dated May 22, 2018.

Addendum to the FEIS: Pursuant to WAC 197-11-600(4)(c) and the addendum procedures in WAC 197-11-625, the City is issuing this Addendum to the 2018 FEIS. This Addendum provides additional information and analysis based on the April 23, 2026, Environmental Checklist. The information presented does not substantially change the analysis of probable significant adverse impacts or the range of alternatives considered in the 2018 FEIS. The original FEIS remains valid and is not modified or replaced by this Addendum.

If the document being adopted has been challenged (WAC 197-11-630), please describe: No.

The document is available to be read at: City of Walla Walla Development Services office at 55 East Moore Street, Walla Walla, WA.

The City of Walla Walla has identified, adopted, and incorporated by reference this document as being appropriate for this proposal, after independent review. The document meets our environmental review needs for the current proposal and will accompany the proposal to the decision makers. We have determined that this proposal will not have a probable significant adverse impact on the environment. An Environmental Impact Statement (EIS) is not required under RCW 43.21C.030(2)(c).

Name of agency adopting document: City of Walla Walla

Contact person: Jon Maland, AICP, Sr. Planner, Email jmaland@wallawallawa.gov
Phone:(509) 524-4710

Responsible Official: J Preston Frederickson, Director

Address: City of Walla Walla Development Services
55 East Moore Street, Walla Walla, WA 99362

Issue Date: April 30, 2026

Signature: _____ **Date:** April 30, 2026

2026 Draft Comprehensive Plan Future Land Use Map Amendments

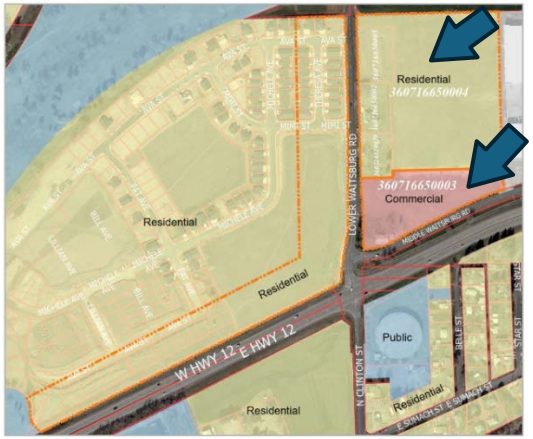
City Council Public Hearing October 14, 2026

Key:	
C:	Commercial land use
R:	Residential land use
RM:	Multi-Family Residential zoning
RN:	Neighborhood Residential zoning
MHC:	Mobile/Manufactured Home Park Community zoning
CH:	Highway Commercial zoning
IL/C:	Light Industrial/Commercial zoning
IH:	Heavy Industrial zoning
Category:	Clarification (**C**), State-Mandated Consistency (**SMC**)

Future Land Use Map Amendment	Location	Proposed Change	Category and Notes
	1500 The Dalles Military Road	Land Use: R → C Zoning: RM → CH	**SMC** RCW 36.70A.115 – Sufficient Land Capacity Note: Multi-family development would still be permitted within the Highway Commercial zoning.

Future Land Use Map Amendment	Location	Proposed Change	Category and Notes
	1300 Block of The Dalles Military Road	Land Use: C → MHC Zoning: CH RN → MHC	**C** Note: The property is under development for manufactured homes. The land use designation would reflect the current development type.
	SR 125 and Myra Road	Land Use: R → C Zoning: RN → CH	**SMC** RCW 36.70A.115 – Sufficient Land Capacity Note: To allow new Commercial development along the South Myra Road extension, and to provide greater continuity to the already existing and developing Commercial zoning.

Future Land Use Map Amendment	Location	Proposed Change	Category and Notes
	North of Moore Street	Land Use: I → R Zoning: IH → RN	**SMC** RCW 36.70A.020(4) Housing Goal, RCW 36.70A.115 – Sufficient Land Capacity

Future Land Use Map Amendment	Location	Proposed Change	Category and Notes
	North of Rees Avenue (North and South of George Street)	Land Use: I → R Zoning: IH → RN	**SMC** RCW 36.70A.020(4) Housing Goal, RCW 36.70A.115 – Sufficient Land Capacity
	171 Middle Waitsburg Road	Land Use: I → C, R Zoning: IL/C → CH, RM	**SMC** RCW 36.70A.020(4) Housing Goal, RCW 36.70A.115 – Sufficient Land Capacity

Future Land Use Map Amendment	Location	Proposed Change	Category and Notes
	Lower Waitsburg Road "Harvey Ranch Area"	Land Use only: C → R	**C** Note: The subject property has always maintained a residential zoning designation. A 2018 amendment changed this to Commercial. No rezone occurred.

ar-6052 **Pgs. 737-900**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: 2026 Municipal Code Amendments Implementing the 2046 Comprehensive Plan - Public Hearing

Submitted For: Lisa Wasson-Seilo, Development Services Department

Add'l Contributors: Jon Maland, Senior Planner; Emily Arteche, Deputy Director

Financial Comments:

N/A

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

Public Hearing on the code amendments implementing the 2046 Comprehensive Plan.

Information

HISTORY:

In accordance with Walla Walla Municipal Code (WWMC) Section 20.02.130, one of the responsibilities of the Development Services staff, working in partnership with the Planning Commission, is to periodically review the Municipal Code and provide a report to City Council outlining proposed items, concerns, or recommended amendments. As part of its ongoing work program, the Planning Commission reviews regulations annually through a formal code amendment process. Staff presented the 2026 draft comprehensive plan implementing municipal code amendments to the Planning Commission at their July 6, 2026 workshop.

The proposed 2026 implementing code amendments fall into the categories of outdated, clarification, and state-mandated. Many of the proposed amendments are related to the renaming of the Development Services Department to the Community Development Department, as well as state laws that passed over the recent legislative sessions. Additionally, there are several code amendments related to the *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)* case law, which held that specific zoning or land use regulations take precedence over comprehensive plans, which serve as a general guide rather than rigid regulations.

Other amendments include clarification relating to where and under what conditions the City is permitted to provide water and sewer services; annexation petition periods; and other minor clarifications and relocations. A complete list can be found in the attached Planning Commission meeting packet.

The Planning Commission held a public hearing on the code amendments on September 14, 2026, and recommended approval as written.

POLICY ISSUES:

The proposed code amendments will revise and update sections of the Municipal Code to improve clarity and usability for the public and for staff, to comply with recently passed state legislation, to remove and update outdated language, and to ensure that the Municipal Code continues to meet the needs of the Walla Walla community without creating confusion or redundancy. Additionally, the code amendments will implement the 2046 comprehensive plan.

PLAN COMPLIANCE:

COMPREHENSIVE PLAN:
The proposed code amendments implementing the 2046 comprehensive plan are supported by the following Comprehensive Plan - Walla Walla 2046 Goals and Policies:

Community Character (CC) 4.1: Carefully protect and enhance Downtown's visual character, the most important single aspect of the city's identity, through historic preservation activities, complementary infill development, and sensitively designed public works.

Land Use (LU) Policy 1.1: Accommodate new residential and commercial development in areas with available infrastructure and services.

LU Policy 1.4: The City will coordinate with Walla Walla County to plan for the delivery of urban services within unincorporated UGAs prior to annexation.

LU Policy 1.5: The City supports Walla Walla County's goal that, where feasible, all land within unincorporated Urban Growth Areas will be annexed to the City or incorporated within the 20-year planning horizon.

LU Policy 1.6: Encourage infill development that provides additional housing in the city.

LU Policy 2.2: Coordinate planning in the Urban Growth Area with Walla Walla County to ensure orderly, sustainable development consistent with City standards, and discourage development of subdivisions using septic systems and private water systems.

LU Policy 3.7: Support a variety of housing types such as tiny homes, duplexes, multi-family development, cottage housing, and single-family residential.

Housing (H) Policy 1.1: Provide an array of housing choices such as apartments, small lot single-family housing, accessory dwelling units, townhomes, manufactured homes, and cottages to meet the needs of people of all incomes throughout their lifespan.

Economic Development Policy 5.1: Regularly review development regulations, evaluate the impact of regulations, and the needs of local businesses.

ALTERNATIVES:

Public hearing only at this time.

STAFF RECOMMENDATION:

Staff recommends that the City Council open the public hearing and receive all public testimony.

CITY MANAGER COMMENTS:

Concur with the staff recommendation and approved to hold the public hearing.

Attachments

Ordinance 2026-XX - Code Amendments Implementing Comp Plan

PC Meeting Packet 09.14.2026 - Code Amendments Implementing Comp Plan

Public Comment - RL McFarland - 9.4.2026

ORDINANCE NO. 2026-XX

AN ORDINANCE ADOPTING AND IMPLEMENTING CODE AMENDMENTS FOR THE 2046 COMPREHENSIVE PLAN TO TITLES 2, 3, 5, 10, 12, 13, 15, 19, 20, and 21 OF THE WALLA WALLA MUNICIPAL CODE AND TAKING SUCH OTHER ACTION RELATED THERETO

WHEREAS, the City of Walla Walla passed Municipal Ordinance A-2405 on May 13, 1970 which classified the City of Walla Walla as a non-chartered code city under Title 35A of the Revised Code of Washington (RCW); and

WHEREAS, the Walla Walla County Board of Commissioners passed County Resolution number 90-449 on October 30, 1990, opting into planning activities under the Washington Growth Management Act, Chapter 36.70A RCW; and

WHEREAS, the Walla Walla City Council passed City Ordinance 2026-XX on October 28, 2026, adopting an updated Comprehensive Plan for the City of Walla Walla; and

WHEREAS, RCW 36.70A.130 provides that development regulations shall be subject to continuing review and evaluation by the city that adopted them; and

WHEREAS, RCW 35A.63.100 authorizes the Walla Walla City Council, by ordinance or other action to the extent the Walla Walla City Council deems necessary or appropriate, to implement or give effect to the comprehensive plan or parts thereof in developing the City of Walla Walla and in regulating the use of land herein; and

WHEREAS, the City of Walla Walla issued a Notice of Application on August 18, 2026 with comments due September 14, 2026; and

WHEREAS, the City of Walla Walla issued an Adoption/Addendum of an existing Environmental Document on August 17, 2026 and posted it on the City website and circulated it with the SEPA contact list on August 17, 2026, and published the Adoption/Addendum in the Walla Walla Union Bulletin on August 18, 2026; and

WHEREAS, the City of Walla Walla Planning Commission reviewed the draft development regulations on July 6, 2026, and

WHEREAS, the Notice of Public Hearing was posted on the City's website on August 18, 2026, at least 14-days prior to the date of hearing, published in the Union Bulletin on August 18, 2026; and

WHEREAS, the proposed code amendments were transmitted to the Washington State Department of Commerce, Growth Management Services Division, and other state agencies for the 60-day state review period in accordance with RCW 36.70A.106 on August 4, 2026; and

WHEREAS, the proposed amendments to Titles 2, 3, 5, 10, 12, 13, 15, 19, 20, and 21 were presented to the Planning Commission at the July 6, 2026 work session before formal application and the September 14, 2026 public hearing; and

WHEREAS, at the public hearing, the City of Walla Walla Planning Commission heard and considered the public testimony and the evidence and exhibits presented to it; and

WHEREAS, the City of Walla Walla Planning Commission thereafter made its recommendation on the proposed code amendments on September 14, 2026; and

WHEREAS, the Walla Walla City Council reviewed the Planning Commission's recommendations at a regular work session on September 21, 2026; and

WHEREAS, the Walla Walla City Council conducted a duly noticed public meeting on the proposed code amendments on October 14, 2026; and

WHEREAS, the Walla Walla City Council has considered the matter during a regularly and duly called public meeting of said Council, has given said matter careful review and consideration, and finds that good government and the best interests of the City of Walla Walla will be served by passage of this ordinance.

NOW THEREFORE, the City Council of the City of Walla Walla does ordain as follows:

Section 1: Section Titles 2, 3, 5, 10, 12, 13, 15, 19, 20, and 21 of the Walla Walla Municipal Code are hereby amended as follows:

(add red bold and delete red strikethrough):

Title 2: Administration

Chapter 2.17 City Departments

2.17.010 Created.
There are created the following departments:
A. Support services;
B. Fire;
C. Police;
D. Parks and recreation;
E. Public works;
F. **Community** ~~D~~development ~~services~~;
G. Public library;
H. Human resources;
I. Finance; and
J. Technology services.

2.17.070 Director of community development ~~services~~ – Appointment – Duties.

The director of **community** development ~~services~~ shall be appointed by the city manager. The director of **community** development ~~services~~ shall be responsible for supervising all employees of the divisions of planning**, permitting,** ~~and~~ **building** inspection**, code compliance, and community development**. It shall be the duty of the director of **community** development ~~services~~ to promote, develop and supervise all planning, **permitting,**~~development and~~ building inspection**, code compliance, and community development** services in the city in compliance with all applicable laws, ordinances, resolutions, rules and regulations, and to perform such additional duties as are determined by the city manager.

2.27.040 Walla Walla historic preservation commission.

A. Creation and Size. There is hereby established a Walla Walla historic preservation commission consisting of seven members. Members of the commission shall be appointed by the Walla Walla city council and at least five of the members shall be residents of the city of Walla Walla. The Walla Walla city council, in its discretion, may appoint as many as two members with professional expertise or experience identified herein who are not residents of the city of Walla Walla but reside within Walla Walla County.

B. Composition of the Commission. All members of the commission must have a demonstrated interest and competence in historic preservation, possess qualities of impartiality and broad judgment, and be residents of the city of Walla Walla or possess professional expertise or experience as identified below and be residents of Walla Walla County.

1. The commission shall include at least two professionals who have expertise or experience in identifying, evaluating, and protecting historic resources and are selected from among the disciplines of architecture, history, architectural history, planning, prehistoric and historic archaeology, folklore, cultural anthropology, curation, conservation, and landscape architecture, or related disciplines. The commission action that would otherwise be valid shall not be rendered invalid by the temporary vacancy of one or all of the professional positions, unless the commission action is related to meeting certified local government (CLG) responsibilities cited in the certification agreement between the city and the State Historic Preservation Officer on behalf of the state.

2. In making appointments, the city council may consider names submitted from any source, but the city manager shall notify history and local development related organizations of vacancies so that names of interested and qualified individuals may be submitted by such organizations for consideration along with names from any other source.

C. Terms. The original appointment of members to the commission shall be as follows: three for two years, two for three years, and two for a four-year term. Thereafter, appointments shall be made for a three-year term. Vacancies shall be filled by the city council for the unexpired term in the same manner as the original appointment.

D. Powers and Duties. The major responsibility of the historic preservation commission is to identify and actively encourage the conservation of the city's historic resources by initiating and maintaining a register of historic places and reviewing proposed changes to register properties; to raise community awareness of the city's history and historic resources; and to serve as the city's primary resource in matters of history, historic planning, and preservation.

In carrying out these responsibilities, the historic preservation commission shall engage in the following:

1. Conduct and maintain a comprehensive inventory of historic resources within the boundaries of the city of Walla Walla and known as the city of Walla Walla historic inventory, and publicize and periodically update inventory results.

2. Initiate and maintain the city of Walla Walla register of historic places. This official register shall be compiled of buildings, structures, sites, objects, and districts identified by the commission as having historic significance worthy of recognition and protection by the city and encouragement of efforts by owners to maintain, rehabilitate, and preserve properties.

3. Review nominations to the city of Walla Walla register of historic places according to criteria in Section 2.27.050 and adopt standards in its rules to be used to guide this review.

4. Review proposals to construct, change, alter, modify, remodel, move, demolish, or significantly affect properties or districts on the register as provided in Section 2.27.060; and adopt standards in its rules to be used to guide this review and the issuance of a certificate of appropriateness or waiver.

5. Provide for the review either by the commission or its staff of all applications for approvals, permits, environmental assessments or impact statements, and other similar documents pertaining to local register listed historic resources or adjacent properties.

6. Conduct all commission meetings in compliance with Chapter 42.30 RCW, Open Public Meetings Act, to provide for adequate public participation and adopt standards in its rules to guide this action.

7. Participate in, promote and conduct public information, educational and interpretive programs pertaining to historic and prehistoric resources.

8. Establish liaison support, communication and cooperation with federal, state, and other local government entities which will further historic preservation objectives, including public education, within the local area.

9. Review and comment to the city council on land use, housing and redevelopment, municipal improvement, and other types of planning and programs undertaken by any agency of the city, other neighboring communities, Walla Walla County, and the state or federal governments, as they relate to historic resources of the city of Walla Walla.

10. Advise the city council generally on matters of Walla Walla history and historic preservation.

11. Perform other related functions assigned to the commission by the city council or city manager.

12. Provide information to the public on methods of maintaining and rehabilitating historic properties. This may take the form of pamphlets, newsletters, workshops, or similar activities.

13. Officially recognize excellence in the rehabilitation of historic buildings, structures, sites and districts, and new construction in historic areas; and encourage appropriate measures for such recognition.

14. Be informed about and provide information to the public and city departments on incentives for preservation of historic resources including legislation, regulations and codes which encourage the use and adaptive reuse of historic properties.

15. Review nominations to the State and National Registers of Historic Places.

16. Investigate and report to the city council on the use of various federal, state, local or private funding sources available to promote historic resource preservation in the city.

17. Serve as the historic preservation commission for special valuation and:

a. Make determination concerning the eligibility of historic properties for special valuation;

b. Verify that the improvements are consistent with the Washington State Advisory Council's Standards for Rehabilitation and Maintenance;

c. Enter into agreements with property owners for the duration of the special valuation period as required under WAC 254-20-070(2);

d. Approve or deny applications for special valuation;

e. Monitor the property for continued compliance with the agreement and statutory eligibility requirements during the ten-year special valuation period; and

f. Adopt bylaws and/or administrative rules and comply with all other historic preservation commission responsibilities identified in Chapter 84.26 RCW.

18. The commission shall adopt rules of procedure to address subsections (D)(3), (4), (6) and (17) of this section, inclusive.

E. Compensation. All members shall serve without compensation.

F. Rules and Officers. The commission shall establish and adopt its own rules of procedure, and shall select from among its membership a chairperson and such other officers as may be necessary to conduct the commission's business.

G. Commission Staff. Commission and professional staff assistance shall be provided by the **community** development ~~services~~ department with additional assistance and information to be provided by other city departments as may be necessary to aid the commission in carrying out its duties and responsibilities under this chapter.

2.28.050 Application procedure.

A property owner who wishes to propose a project for a tax exemption shall complete the following procedures:

A. File with the Walla Walla **community** development ~~**services**~~ department the required application along with the required fees. The application fee shall be five hundred dollars. An additional one hundred dollar fee to cover the Walla Walla County assessor's administrative costs shall also be paid to the city. If the application shall result in a denial by the city, the city will retain that portion of the fee attributable to its own administrative costs and refund the balance to the applicant.

B. A complete application shall include:

1. A completed city of Walla Walla application form setting forth the grounds for the exemptions;

2. Preliminary floor and site plans of the proposed project;

3. A statement acknowledging the potential tax liability when the project ceases to be eligible under this chapter; and

4. Verification by oath or affirmation of the information submitted.

C. For rehabilitation projects, or where demolition or new construction is required, the applicant shall also submit an affidavit that existing dwelling units either have been unoccupied for a period of twelve months prior to filing the application, or that relocation requirements have been satisfied. At the city's discretion, the applicant shall either secure from the city prior to commencement of rehabilitation improvements verification of property noncompliance with Title 15, or file with the affidavit a report prepared by a registered architect identifying property

noncompliance with Title 15 which shall identify specific code violations and must include supporting data that satisfactorily explains and proves the presence of a violation.

2.28.060 Application review and issuance of conditional twelve-year certificate.

The director of the city of Walla Walla's **community** development ~~services~~ department or designee will review an application for a twelve-year certificate for completeness and fulfillment of eligibility requirements and approval criteria, return incomplete applications for correction or supplementation, and may approve eligible applications.

A. The director or designee may approve the application if the application meets the requirements of Chapter 84.14 RCW and this chapter, and the director or designee finds that:

1. A minimum of four new units are being constructed or in the case of occupied rehabilitation or conversion within twelve months of occupancy, a minimum of four additional multifamily units are being developed;

2. The applicant has committed to rent or sell at least twenty-five percent of the multifamily housing units as affordable housing units to low-income households and establish the rents consistent with Housing and Urban Development's fair market rent threshold for Walla Walla County;

3. The proposed project either is, or will be at the time of completion, in conformance with all applicable local plans and regulations that apply at the time the application is approved;

4. The owner has complied with all standards and guidelines adopted by the city under this chapter; and

5. The site is located within residential targeted area as defined in Section 2.28.020.

B. If an application is approved, the applicant shall enter into a contract with the city regarding the terms and conditions of the project. Upon city approval of the contract, the director or designee shall issue a conditional certificate of acceptance of tax exemption which shall contain a statement by the director or designee that the property has complied with the requirements of this chapter. The conditional certificate expires three years from the date of approval unless an extension is granted as provided in this chapter.

C. If the application is denied, the director or designee shall state in writing the reasons for denial and shall send notice to the applicant at the applicant's last known address within ten days of the denial.

D. A decision to approve or deny an application shall be made within ninety days of receipt of a complete application.

E. An applicant may appeal a denial to the city council within thirty days of receipt of notice. On appeal, the director's decision will be upheld unless the applicant can show that there is no substantial evidence on the record to support the director's decision. The city council's decision on appeal will be final.

Title 3: Revenue and Finance

3.23.130 Code enforcement revolving fund.

There is created and established the code enforcement revolving fund, which fund shall be utilized in compliance with the Uniform Code for the Abatement of Dangerous Buildings

(adopted by Section 15.04.010) for the purpose of funding and financing private contractors who are engaged by the city to demolish unsafe structures and clean unkempt properties when the owners of such structures or properties fail to respond to notices from the city that such action is needed.

A. The **community** development ~~services~~ director and police chief are directed to coordinate and make a recommendation to the city manager and council concerning the amount of such code enforcement revolving fund and the source of the funds, and are further directed to provide that a primary source of such funds shall be recovery of costs from the owners of unsafe structures and unkempt properties as provided by the above-referenced code provisions.

Title 5: Business Licenses and Regulations

5.02.450 Application process.

A. Overview. In order to manage its rights-of-way in a thoughtful manner which balances the need to accommodate new and evolving technologies with the preservation of the natural and aesthetic environment of the city, the city of Walla Walla has adopted this administrative process for the deployment of small wireless facilities. The city and applicant for a franchise and other permits associated with the deployment of small wireless facilities face challenges in coordinating applicable legislative and administrative processes under the Federal Communications Commission (FCC) regulations. A franchise for the use of the city's right-of-way is a contract which requires approval by the city council. The small wireless permits are issued by the director of the **community** development ~~services~~ department or his/her designee. Applicants are encouraged and expected to provide all related applications in one submittal, unless they have already obtained a franchise.

B. Application Process. The director of the **community** development ~~services~~ department or his/ her designee is authorized to establish franchise and other application forms to gather the information required by this chapter from applicants and to determine the completeness of the application process as provided herein. The application shall include Parts A, B, and C as described below.

1. Franchise. The process typically begins with and depends upon approval of a franchise for the use of the public right-of-way to deploy small wireless facilities if any portion of the applicant's facilities are to be located in the right-of-way. A complete application for a franchise is designated as Part A. An applicant with a franchise for the deployment of small wireless facilities in the city may proceed to directly apply for a small wireless facility permit/right-of-way permit and related approvals (Parts B and C). An applicant at its option may utilize phased development. Because franchises are required by federal law to be competitively neutral, the city has established a franchise format for use by all right-of-way users.

2. Small Wireless Facility Permits/Right-of-Way Permits. Part B of the application requires specification of the small wireless facility components and locations as further required in the small wireless permit application described in Section 5.02.460.

3. Associated Permit(s). Part C of the application shall attach all associated permits' requirements such as applications or checklists required under the critical areas, shoreline or SEPA ordinances. Applicants for deployment of small wireless facilities in city design zones or for new poles shall comply with the requirements in Chapter 20.171.

4. Leases. An applicant who desires to attach a small wireless facility to any utility pole or light owned by the city shall include an application for a lease as a component of its application. The director is authorized to approve leases in the form approved for general use by the city council for any utility pole or light pole in the right-of-way. Leases for the use of other public property, structures or facilities shall be submitted to the city council for approval.

5.02.470 Review process.

A. Review. The following provisions relate to review of applications for a small wireless facility permit:

1. Only complete applications for a small wireless permit containing all required submission elements described in Section 5.02.460 shall be considered by the city. Incomplete applications that are not made complete by the applicant within sixty days of initial submission of the application materials shall be deemed withdrawn.

2. In any zone, upon application for a small wireless permit, the city will permit small wireless deployment on existing or replacement utility poles conforming to the city's generally applicable development and design standard adopted pursuant to Chapter 20.171, except as provided in subsection B of this section.

3. Vertical clearance shall be reviewed by the director to ensure that the small wireless facilities will not pose a hazard to other users of the rights-of-way.

4. Replacement poles and new poles shall comply with the Americans with Disabilities Act (ADA), city construction and sidewalk clearance standards, traffic warrants, city ordinances, and state and federal statutes and regulations in order to provide a clear and safe passage within the rights-of-way. Further, the location of any replacement pole or new pole must: be physically possible, cannot obstruct vehicular or pedestrian traffic or the clear zone, not interfere with utility or safety fixtures (e.g., fire hydrants, traffic control devices), and not adversely affect the public welfare, health, or safety.

5. No equipment shall be operated so as to produce noise in violation of Chapter 8.13.

6. Small wireless facilities may not encroach onto or over private property or property outside of the right-of-way without the property owner's express written consent.

7. The city shall make every reasonable effort, consistent with any applicable provisions of state or federal law, and the preservation of the city's health, safety and aesthetic environment, to comply with the federal presumptively reasonable time periods for review of facilities for the deployment of small wireless facilities to the fullest extent possible.

B. **Community** Development ~~services~~ Department. Small wireless deployment in areas designated as design zones pursuant to Section 20.171.050, as well as new non-city-owned poles, or replacement poles deviating from the pole design standards adopted pursuant to Section 20.171.060, are subject to review pursuant to Chapter 20.171.

C. Eligible Facilities Requests. The design approved in a small wireless facility permit shall be considered concealment elements and such facilities may only be expanded upon an eligible facilities request described in Section 20.171.080 when the modification does not defeat the concealment elements of the small wireless facility.

D. Review of Facilities. Review of the site locations proposed by the applicant shall be governed by the provisions of 47 U.S.C. Sections 253 and 332 and other applicable statutes, regulations and case law. Applicants for franchises and the small wireless facility permits shall

be treated in a competitively neutral and nondiscriminatory manner with other service providers, utilizing supporting infrastructure which is functionally equivalent, that is, service providers whose facilities are similarly situated in terms of structure, placement, or cumulative impacts. Small wireless facility permit review under this chapter shall neither prohibit nor have the effect of prohibiting the ability of an applicant to provide telecommunications services.

E. Final Decision. Any decision by the director shall be final and not be subject to administrative appeals.

F. Public Comment. The city shall provide notice of a complete application for a small wireless facility permit on the city's website with a link to the application. The notice shall include an email contact and telephone number for the applicant to answer citizen inquiries. The applicant is encouraged to host informational meetings for the public regarding the deployment. The city shall post meeting notices, if any, for informational meetings on its website. These meetings are for the public's information and are neither hearings nor part of any land use appeal process.

G. Withdrawal. Any applicant may withdraw an application submitted pursuant to Section 5.02.460 at any time, provided the withdrawal is in writing and signed by all persons who signed the original application or their successors in interest. When a withdrawal is received, the application shall be deemed null and void. If such withdrawal occurs prior to the director of **community** development**'s** ~~services'~~ or his/her designee's decision, then reimbursement of fees submitted in association with said application shall be prorated to withhold the amount of city costs incurred in processing the application prior to time of withdrawal. If such withdrawal is not accomplished prior to the director of **community** development**'s** ~~services'~~ or his/her designee's decision, there shall be no refund of all or any portion of such fee.

5.02.500 Consolidated permit.

A. The issuance of a small wireless permit grants authority to construct small wireless facilities in the rights-of-way in a consolidated manner to allow the applicant, in most situations, to avoid the need to seek duplicative approval by both the public works and the **community** development ~~services~~ departments. If the applicant requires a new franchise to utilize the right-of-way, the franchise approval may be consolidated with the small wireless facility permit review if requested by the applicant. As an exercise of police powers pursuant to RCW 35.99.040(2), the small wireless facility permit is not a right-of-way use permit, but instead a consolidated public works and land use permit and the issuance of a small wireless facility permit shall be governed by the time limits established by federal law for small wireless facilities.

B. The general standards applicable to the use of the rights-of-way described in Title 12 shall apply to all small wireless facility permits.

5.04.020 Mobile and street vendor – License required.

No person, firm or corporation shall engage in the business of a mobile vendor without having first obtained a license therefor from the licensing agent issued by the department of **community** development ~~services~~. This chapter shall not apply to vendors operating in conjunction with events holding a valid city of Walla Walla special event permit or the farmers' market. Mobile or street vendors shall also obtain a city endorsement on a state issued business license as required by Chapter 5.05, General Business License.

5.05.050 Business license application, renewal, delinquency, and cancellation.

A. A person must register a business with the city program by submitting a business license application to the BLS in coordination with the **community** development ~~services~~ department, giving such information as is deemed reasonably necessary to enable the enforcement of this chapter and to complete the application process through

B. When a taxpayer operates two or more businesses, a license is required for each business.

C. If a business is operated in two or more locations and is the same business, a separate application filing and business license is required for each business.

D. If a single business has at least one permanent location in the city and also conducts business on a temporary or seasonal basis from temporary or mobile locations, such as from portable stands or vehicles, the taxpayer must obtain a mobile vendor's license as provided in Chapter 5.04 or a peddler/hawker/transient business license as provided in Chapter 5.27, whichever is applicable, for each such location or stand or vehicle. The chief of police may temporarily suspend or relocate a secondary location license allowing business activity on or adjacent to a public street or other public place when such business activity may endanger public safety or conflict with a permitted special event.

E. A person who has registered a business under the city's program must renew the license on an annual basis, on or before the expiration date established by the Business Licensing Service, in order to continue conducting business in the city.

1. Renewal requires payment of the city license fee, all other license fees due, and the BLS handling fee authorized by RCW 19.02.075.

2. Failure to renew the license by the expiration date may accrue the BLS late renewal penalty authorized under RCW 19.02.085. In addition to the penalties provided for failure to obey the municipal code or a municipal ordinance, failure to pay any charge imposed by this chapter when due subjects the taxpayer to a minimum penalty of ten dollars or five percent of the amount of the license fee for each month, or part thereof, of delinquency, whichever is greater. Interest will accrue on the unpaid fee plus the penalty levied thereon at the rate of one percent of the amount of the unpaid charge plus penalty for each month, or part thereof, of delinquency.

3. A license that remains delinquent for at least one hundred twenty days past expiration is considered to be abandoned and may be cancelled by the city. A cancelled license may require submitting a new application to the Business Licensing Service and reapproval of the business by the city to resume conducting business in the city.

5.05.120 Rules and regulations.

The **community** development ~~services~~ department may adopt and promulgate rules and regulations for administration and enforcement of this chapter which are not inconsistent herewith or with superior law. The purpose of such rules and regulations is to carry out the provisions of this chapter, and it shall be unlawful to fail to comply with any such rule or regulation.

5.09.015 Fixed place of business required – Development permit.

No person may operate as a pawnbroker unless the person maintains a fixed place of business within the city, and has further obtained a development permit issued by the department of **community** development ~~services~~.

Title 10 Vehicles and Traffic

10.17.010 Issuance of construction vehicle parking permits.

A. The **community** development ~~services~~ department may issue a construction vehicle parking permit to any licensed contractor, with a city business license, who is engaged in the construction, alteration, or repair of a building or property, or the installation or repair of equipment in such building or on such property, which requires vehicle parking in a parking zone for time periods longer than regularly permitted under this code.
B. Anyone who desires a construction vehicle parking permit must apply in writing to the **community** development ~~services~~ department on such form that the department may require and provide such information and verifications that the department may demand. Applicants must submit evidence of a work contract, job order, or other documentation required by the department. Verification of need may be demonstrated by the issuance of an approved building permit issued by the **community** development ~~services~~ department. Each permit issued by the department shall bear the license number and other identifying data of the vehicle for which it is issued. The permit shall not be transferable between vehicles.
C. The **community** development ~~services~~ department may renew or extend a permit beyond its initial term upon a showing of need.

10.17.040 Penalties.

Anyone who violates or fails to comply with any of the provisions of this chapter shall be guilty of an infraction punishable in accordance with Section 1.24.010. Anyone who violates or fails to comply with any of the provisions of this chapter may have any permits revoked by the **community** development ~~services~~ department and may also be prohibited by the department from purchasing future permits.

10.27.040 Definitions.

Whenever used in this chapter, the following words shall have the following meanings:
A. "Applicant" means the authorized agent of the sponsor who completes the application and acts as primary contract for the special event.
B. "Application" means a notice to stage a parade or special event submitted by an applicant which informs the city of a proposed event.
C. "Block party" means an event involving the closure of a one block residential street, for no more than eight hours, ending no later than ten p.m., for the purpose of a neighborhood crime watch meeting or social activity primarily involving the residents in the immediate area.
D. "Chief of police" means the chief of police of the Walla Walla Police Department or his/her designee.
E. "Event participant(s)" means a person in attendance at an event, including spectators, vendors, event staff, city staff, and all others present for the purpose of the event.

F. "Exempt closures or uses" means exempt from the provisions of this chapter, and includes:

1. Public or private street uses or closures related to construction activity or right-of-way improvements or maintenance, as authorized by the public works department;

2. Long-term uses of the public right-of-way between the curb and property line approved by permit issued by the **community** development ~~services~~ department, such as, but not limited to, sidewalk restaurants; and

3. Short-term or long-term uses of the public right-of-way as approved by the **community** development ~~services~~ department to support activities occurring primarily on adjacent private property, such as, but not limited to, furniture moving and building repairs.

G. "Parade" means any march or procession consisting of people, animals, vehicles or combinations thereof, except funeral processions, upon any public street, sidewalk or alley, which affects the ordinary use of said public right(s)-of-way.

H. "Parks and recreation director" means the director of parks and recreation of the city or his/her designee.

I. "Permit" means a parade, or a special event permit issued pursuant to this chapter.

J. "Private event" means an event which uses the public property for the purpose of monetary or personal gain by any person, partnership, group, organization, company or corporation or which is closed to the general public.

K. "Procedure" means a procedure adopted by the city administrative staff to implement this chapter, or to carry out other responsibilities as may be required by this chapter or by other codes, ordinances or resolutions of the city or other agencies.

L. "Risk manager" means the individual designated by the city manager to act as risk manager for the city.

M. "Special event" means any activity of a temporary nature which affects the ordinary use of public rights-of-way, public parking lots, public parks, intersections, sidewalks or streets for a short duration of time, or which would significantly impact the need for city-provided emergency services such as police, fire or medical aid, for purposes which include, but are not limited to, parades, dances, sales in commercial zones, auctions, bikeathons, shows or exhibitions, filming/movie events, carnivals, circuses, fun runs, fairs and block parties.

N. "Sponsor" means the person or group responsible for the special event to be held.

O. "Traffic engineer" means the public works director of the city or his/her designee.

Title 12 Streets and Sidewalks

12.14.040 Public fixtures and street furniture, standardized design and location.

A. Street benches, litter containers, light poles, bicycle racks, information kiosks, drinking fountains, street trees, irrigation facilities, pedestrian bollards, tree well/ grate assemblies, and other streetscape fixtures shall be of the type and design specified in the downtown master plan. Location shall be as shown on the standard streetscape template in the downtown master plan upon approval of a permit.

B. Where the fixture being proposed is not represented on the current adopted City Standard Plans for Downtown as provided in Section 12.01.040, is not included in the downtown master plan, or is a variation on existing designs, the city engineer shall determine acceptability of

design and proposed location after consultation with **community** development ~~services~~ and organizations concerned with development of downtown. The site plan review committee may be engaged if the city engineer or the **community** development ~~services~~ director feels that additional formal input is necessary.

12.64.020 Official map.

The official map of the city of Walla Walla shall be the Walla Walla ~~urban area~~ comprehensive plan **Future Land Use** ~~m~~**M**ap adopted by resolution of the Walla Walla city council. The Walla Walla city manager may adopt, maintain, and modify a building number axis map which is consistent with the Walla Walla ~~urban area~~ comprehensive plan **Future Land Use** ~~m~~**M**ap. The official map ~~and the building numbering axis map~~ shall be available for public inspection.

Title 13 Water and Sewers

13.03.601. Service – Provided where.

A. The council will provide sanitary sewer service to all ~~that~~ area**s** within the boundaries of the city where facilities are available and to such other areas as, in its sole discretion, may be in the best interest of the city to serve.

B. **Unless otherwise approved by the City Manager, pursuant to (C) below** ~~P~~**p**roperty within the UGA shall annex prior to connection to the city sewer system. It must also be developed in compliance with city development standards, and its utilities must be constructed in compliance with city standards.

C. The city retains discretion, on a case-by-case basis, to review connection to single-family residences or other approved uses in the UGA. ~~Consideration~~ **Subject to City Manager approval,** ~~C~~consideration **may be given to** ~~in the event the~~ property **that** experiences a failed septic system, and ~~when~~ **a** connection to the city sanitary sewer system is necessary to maintain the existing use. **Other connection considerations may include property proximity to existing sewer and pollution potential, especially for properties near waterways.** In such cases, **a** connection may not be made to the city's system unless the property owner has first executed and recorded an irrevocable agreement in a form acceptable to the city, consenting to annex the property to the city of Walla Walla**, and agreeing not to further subdivide the property until such annexation occurs. Agreements are binding upon successors and assignees**.

D. The city shall not provide service to any property or premises that has been condemned by the city council.

13.04.040 Service – Provided where.

A. The council will furnish service to all ~~that~~ area**s** within the boundaries of the city where facilities are available and to such other areas as, in its sole discretion, may be in the best interest of the city to serve.
B. **Unless otherwise approved by the City Manager,** ~~P~~**p**roperty within the UGA shall annex prior to connection to the city water system. **It must also be developed in compliance with city development standards, and its utilities must be constructed in compliance with city standards.**
C. The city retains discretion, on a case-by-case basis, to review **new** connection**s** to single-family residences or other approved uses in the UGA. **Consideration may be given** ~~in the event that~~ **to** property **that** experience**s** a failed well, and **a** connection to the city water system is necessary to maintain the existing use.~~New connections will not be allowed in support of further subdivision.~~
D. The city shall not provide service to any property or premises that has been condemned by the city council.

13.04.150 Service – Extension outside city limits – Furnished when.

A. Upon the application of any person to be furnished
water outside the city limits, the city shall, at its discretion, determine whether the water applied for is available and whether it is in the best interests of the city to furnish the water. Water from the city's system shall not be furnished to any property unless such property has been annexed, except as determined **by the City Manager** ~~council~~ per Section 13.04.040(C), and it is developed in compliance with city development standards and its utilities are constructed in compliance with city standards.
B. If service is approved per Section 13.04.040(C), water from the city's system shall not be furnished to any property unless the property owner has first executed and recorded an irrevocable agreement in a form acceptable to the city consenting to annex the property to the city of Walla Walla**, and agreeing not to further subdivide the property until such annexation occurs. This agreement shall be** ~~**which is**~~ binding upon successors and assigns.

13.05.060 Backflow prevention requirements.

All cross-connections are prohibited, whether or not they are controlled by automatic devices. Unless otherwise approved by the cross-connection control specialist, backflow preventers shall be installed on the customer side at or as near as possible to the meter of any premises where in the judgment of the cross-connection control specialist the nature and extent of activity or use on the premises could present a health or connection does not exist at the time the backflow prevention assembly is required to be installed. In all cases, the cross-connection control specialist shall determine the appropriate level of backflow prevention required. The customer shall be responsible for acquiring, installing, and maintaining any backflow prevention measures required by the water division to isolate the customer's system from the water distribution system. The return of used water to the city's water distribution system is not allowed under any circumstance. This includes but is not limited to cases of heat exchangers designed to return water to the distribution system.
A. Premises Isolation Required. With the possible exception of cases listed under subsection (D) of this section and cases where exceptions are granted under subsection (B) of this section,

premises isolation is required for all services where a cross-connection or a potential for a cross-connection exists, including but not limited to:

1. Premises where the cross-connection control specialist has determined that an actual or potential cross-connection exists.

2. Premises or systems specified as requiring mandatory premises isolation by Table 1 in this section or by WAC 246-290-490.

3. Where, in the opinion of the water system manager, there has been a history of repeating the same or similar backflow occurrences, cross-connections, or backflow conditions even if the cross-connection or condition has since been removed or disconnected.

4. Premises where entry is restricted so that inspections for cross-connections cannot be made with sufficient frequency or at sufficient short notice to ensure that cross-connections do not exist.

5. Premises where materials of a toxic or hazardous nature are handled such that if backflow should occur, a serious health or system hazard may result. This includes but is not limited to facilities in the following table:

Table 1 **Premises or systems requiring mandatory premises isolation by means of an approved air gap or reduced pressure backflow assembly**
Agricultural (farms and dairies)
Beverage bottling plants
Car washes
Chemical plants
Commercial laundries and dry cleaners
Premises where both reclaimed water and potable water are provided
Film processing facilities
Food processing plants
Hospitals, medical centers, nursing homes, veterinary, medical and dental clinics, blood plasma centers
Laboratories
Metal plating industries
Mortuaries
Petroleum processing or storage plants
Piers and docks
Premises having an auxiliary water supply which has not been approved by the Washington State Department of Health for public consumption and approved by the city of Walla Walla water division to be connected to the public water distribution system
Premises where complex plumbing arrangements may, in the judgment of the cross-connection control specialist, result in cross connections which are unreasonably difficult to identify
Premises with separate irrigation systems using the public water supply and with chemical addition*

Table 1 Premises or systems requiring mandatory premises isolation by means of an approved air gap or reduced pressure backflow assembly
Radioactive material processing plants or nuclear reactors**
Premises where access by water division personnel or backflow assembly testers is denied or restricted
Wastewater lift stations and pumping stations
Wastewater treatment plants**

Notes:

* For example, parks, playground, golf courses, cemeteries, estates, etc.

** RPBAs for connections serving these premises are acceptable only when used in combination with an in-plant approved air gap; otherwise, an approved air gap shall be required at the service connection.

B. Exceptions to Premises Isolation. In-premises isolation may be substituted for premises isolation requirements where mandatory premises isolation is not required by WAC 246-290-490 or Table 1 of this section, and only through written agreement with the water division and where the customer has demonstrated to the satisfaction of the water system manager that premises isolation would impose a hardship on the customer and that an acceptable alternative would substantially relieve that hardship, and only if all of the following conditions are met to the satisfaction of the water system manager. The alternative arrangement:

1. Must not pose a threat to public health;
2. Must provide at least the level of protection required by the cross-connection control specialist;
3. Must not place an undue burden on the city's cross-connection control program or set a precedent that, if applied evenly to all customers, would have the effect of placing an undue burden on the city;
4. Must not create a potential for bypasses or other potential risks associated with future changes to the plumbing or water use on the premises;
5. Must not compromise the legal or authoritative integrity of the cross-connection program;
6. Must comply with the rest of this chapter and all other guidelines set forth by the city of Walla Walla;
7. Must be consistent with rules and guidelines set forth by the Washington State Department of Health;
8. Must be approved by the cross-connection control specialist; and
9. Must include a written agreement providing the water division with reasonable access to conduct an initial hazard evaluation and subsequent periodic reevaluations to determine if the backflow prevention measures are adequate to protect the public water system from health or system hazards.

C. Type of Backflow Prevention Required. The type of backflow prevention required shall be commensurate with the degree of hazard that exists as follows:

1. Air Gap. An approved air gap separation, measured vertically above the overflow rim of the receiving vessel, shall be installed for cases in which very hazardous contaminants pose an immediate or potential risk for entering the distribution system. The substance(s) that

pose a risk to the water distribution system may include, but are not limited to, sewage, industrial waste of a toxic nature or other contaminants that would cause a health or system hazard. Air gaps may be required in addition to other backflow prevention measures for severe health risks including but not limited to, sewage facilities, radioactive material processing plants, and nuclear reactors. In such cases, the air gap shall be used to isolate the process(es) involving the severe health hazard, and a reduced pressure backflow assembly shall be used to isolate the facility.

2. Reduced Pressure Backflow Assembly or Reduced Pressure Detector Assembly. An approved reduced pressure backflow prevention assembly or reduced pressure detector assembly shall be installed where the substance that could backflow is a contaminant or is potentially hazardous to health. The substance(s) posing a risk to the water distribution system may include but are not limited to sewage, industrial waste of a toxic nature or other contaminants that could cause a health or system hazard.

3. Double Check Valve Assembly or Double Check Detector Assembly. An approved double check valve assembly or double check detector assembly shall be installed only where the substance that could backflow is not a contaminant. In situations involving secondary contaminants, or where a potential for backpressure exists, a double check valve assembly shall be required at a minimum.

4. Pressure Vacuum Breaker Assembly. An approved pressure vacuum breaker assembly shall be installed for in-premises isolation only for the purpose of preventing backflow through backsiphonage-only situations and only where all of the following conditions are true:

a. Where the substance that could backflow is not a contaminant and there is no high health hazard posed by the system;

b. Where there is no possibility of flooding of the assembly; and

c. Where there is no possibility of backpressure in the downstream piping.

5. Atmospheric Vacuum Breaker. An atmospheric vacuum breaker shall be installed for in-premises isolation only for the purpose of preventing backflow through backsiphonage-only situations and only where all of the following conditions are true:

a. The substance that could backflow is not a contaminant;

b. There is no possibility of flooding of the atmospheric vacuum breaker;

c. There is no possibility of backpressure in the downstream piping;

d. Where there are no shut-off valves located downstream of the atmospheric vacuum breaker; and

e. Where the atmospheric vacuum breaker is not subject to pressure for more than twelve hours in a twenty-four-hour period.

D. Requirements for Specific Types of Services. The following specific types of services must comply with the following requirements. The cross-connection control specialist shall determine the level of backflow prevention required and whether or not premises isolation shall be required.

1. Temporary Water Service. Temporary connections shall have backflow prevention in the form of a reduced pressure backflow assembly unless otherwise approved by the cross-connection control specialist. The required assembly may, at the customer's request, be provided by the city and a charge will then be assessed to the customer for the use of the assembly. In cases where the customer requires temporary service for a period of time exceeding six months, the customer shall provide the required backflow assembly, which shall be inspected and tested by the cross-connection control specialist at no additional charge. In all cases, water service shall be provided only after the following requirements are met:

a. Completion by the customer of an event application with **community** development ~~services~~ and/or the parks department as required (Note: Customers requesting temporary services for the sole purpose of construction may be exempt from this requirement);

b. Completion by the customer of a temporary water service application with the water division and approval by the water distribution system manager; and

c. The assembly is tested and installation approved by the cross-connection control specialist.

2. Fire Systems.

a. Fire systems that are not metered shall have backflow prevention in the form of an approved model of the detector type that includes a monitoring meter or detection system to detect unauthorized use or leakage within the system. The type of backflow preventer shall be appropriate to the degree of hazard as follows:

b. High Health Hazard. Systems that use or are designed to use unapproved auxiliary water supplies, chemical additives, or that contain any other cross-connection shall require a reduced pressure backflow assembly for metered services, or a reduced pressure detector assembly for nonmetered services.

c. Low Health Hazard. Systems that are designed for and use only potable water from the public distribution system, and that have been evaluated by the cross-connection control specialist as low health hazard, shall be required to have at a minimum backflow prevention in the form of a double check valve assembly for metered services, or a double check detector assembly for nonmetered services. Residential flow-through fire systems and combination fire systems using potable water do not require backflow prevention provided no cross-connections exist within the fire system or plumbing connected to the fire system, and the construction is of potable water piping and materials.

3. Water Trucks and Mobile Equipment. All trucks and mobile equipment that employ water reservoirs filled with water directly from the water distribution system shall have backflow prevention in the form of a reduced pressure backflow assembly or an approved air gap, unless otherwise approved by the cross-connection control specialist. The cross-connection control specialist shall determine the type and arrangement of the measures based on the degree of health or system hazard associated with existing or potential uses of the equipment. Additional consideration will be given to the potential for contamination through the inlet pipe as well as the possibility of the backflow prevention being circumvented or altered.

4. Heat Exchangers and Solar Potable Hot Water Systems. Any installation of a heat exchanger or solar potable hot water system shall require inspection and approval by the cross-connection control specialist before being placed into service. In no case shall any heat exchanger or solar potable hot water system return used water to the city's distribution system. All heat exchangers and solar potable hot water systems shall require backflow prevention in the form of a reduced pressure backflow assembly or approved air gap unless the device meets all of the following conditions (in which case a double check valve assembly shall be required at a minimum):

a. The heat exchanger or solar potable hot water heater is IAPMO-certified;

b. There is no nonpotable fluid or transfer medium used and the probability is very low in the opinion of the cross-connection control specialist that such substances will be added in the future; and

c. The heat exchanger type is double-walled with leak detection.

5. Irrigation. All irrigation and lawn irrigation systems that are supplied by city water shall have backflow prevention that is commensurate with the degree of hazard that exists as follows:

a. Atmospheric vacuum breakers shall be required as a minimum on all irrigation systems with meters of one inch or smaller.

b. A pressure vacuum breaker assembly or double check valve assembly shall be required as a minimum on irrigation systems with meters larger than one inch.

c. A double check valve assembly shall be required as a minimum for irrigation systems subjected to backpressure, elevated piping, or flooding, or where an unapproved auxiliary supply is available but not connected to city water, in which case the double check valve assembly shall be required as premises isolation.

d. A reduced pressure backflow assembly or approved air gap shall be required as premises isolation for any water service supplying an irrigation system where any of the following conditions exist:

i. Where an unapproved auxiliary supply is connected or likely to be connected to city water;

ii. Where the cross-connection control specialist determines there is a high health or system hazard or a possibility of changes being made to the irrigation system that could result in a high health or system hazard.

6. Tall Buildings. Buildings that contain plumbing that meets or exceeds thirty feet in elevation above the main where the service line taps the main shall be required to have at a minimum backflow prevention in the form of a double check valve assembly. Buildings with plumbing systems that employ booster pumps shall also be required to have at a minimum premises isolation in the form of a double check valve assembly.

E. Previously Installed Assemblies. Backflow prevention assemblies that were approved at the time they were installed, but are not on the current list of approved assemblies, shall be permitted to remain in service provided they meet the following conditions to the satisfaction of the cross-connection control specialist:

1. The assembly is properly maintained and tested annually;

2. The assembly is commensurate with the degree of hazard as determined by the cross-connection control specialist; and

3. The assembly performs satisfactorily as determined by the cross-connection control specialist.

When assemblies of this type are moved, or in the opinion of the cross-connection control specialist require more than minimum maintenance, they shall be replaced by assemblies that are on the list of approved assemblies by the Washington State Department of Health.

F. Installation Requirements for Backflow Preventers. All backflow preventers required under this chapter shall be of a type and model approved by the Washington State Department of Health. In addition, the installation of each backflow preventer is subject to inspection and approval by the cross-connection control specialist. All backflow preventers for premises isolation shall be installed on the customer's side of the meter, as close as possible to the meter, and before the first branch line or appurtenance with the following exception: a single lawn/ landscape irrigation line isolated with a separate backflow preventer may be allowed with the approval of the cross-connection control specialist. The distance between the meter and any backflow preventer installed for premises isolation must meet the approval of the cross-

connection control specialist. If the backflow preventer for premises isolation is installed inside the building, the backflow preventer shall be located no more than ten feet downstream of the point at which the line enters the building (as measured along the pipe from the inside surface of the outside wall where the pipe enters the building). Any alternative to the preceding requirement shall be at the discretion of the cross-connection control specialist. For all backflow preventers installed at or near the meter, a distance of at least five times the backflow preventer's pipe diameter shall be provided between the meter and the backflow assembly. The backflow assembly shall be placed before the first branch line or point of use and shall be easily accessible for inspecting, testing, repair, and replacement. Backflow preventers shall not be installed in city-owned enclosures, boxes, vaults, or other city facilities without the express written permission of the water system manager. Existing backflow prevention assemblies installed within city-owned enclosures, boxes, or vaults shall be moved outside upon replacement. In addition, every installation, including all enclosures, pits or vaults, shall be designed to provide adequate room and access for testing and repair of the backflow preventer. Parallel assemblies shall be separated by a minimum clearance of eighteen inches unless otherwise approved by the cross-connection control specialist. Additional specifications may be made by the cross-connection control specialist for ensuring adequate access and proper operation of all assemblies. Parallel assemblies or large assemblies may require specifications unique to each installation and the installer should contact the cross-connection control specialist for details before finalizing plans. All backflow preventers shall be installed no higher than five feet from the floor or ground to the top of the assembly to permit reasonable access by the inspector or repair person. As an alternative, the backflow preventer may be installed at a distance of five feet or less above a platform designed for access to the backflow preventer. Unless the backflow preventer installation is otherwise evaluated and approved by the cross-connection control specialist, it shall only be installed in the orientation for which it is designed. Any other orientation may interfere with the proper operation and testing of the backflow preventer.

1. Air Gap. Air gaps must be properly designed and operated such that there are no obstructions surrounding the gap and so that there is no possibility of any splashing from the receiving vessel to the supply pipe. For the required minimum specifications, refer to the City of Walla Walla Standard Plans.

2. Reduced Pressure Backflow Assembly and Reduced Pressure Detector Assembly. Reduced pressure backflow assemblies (RPBA) and reduced pressure detector assemblies (RPDA) shall be installed a minimum of twelve inches above grade. An approved air gap must be maintained directly below the differential pressure relief valve. No RPBA or RPDA may be installed in such a way that it may be exposed to gases or submersion by water or any other material. No RPBA or RPDA may be installed in a below-ground pit without prior approval by the cross-connection control specialist. Sufficient drainage must be provided to allow complete drainage in the event the differential pressure relief valve discharges at maximum capacity. For the required minimum specifications, refer to the City of Walla Walla Standard Plans.

3. Double Check Valve Assembly and Double Check Detector Assembly. A double check valve assembly (DCVA) or double check detector assembly (DCDA) may be installed in a pit below ground. In such cases, the installation must be designed to prevent flooding of the pit and a twelve-inch-deep gravel drain field must be provided below the assembly. In addition, plugs must be installed in the testcocks to reduce the risk of groundwater being siphoned through a leaking testcock. The assembly must be installed with testcocks facing up or to one side for testing. For the required minimum specifications, refer to the City of Walla Walla Standard Plans.

4. Pressure Vacuum Breaker Assemblies. Pressure vacuum breaker assemblies shall be used only where there is no possibility of backpressure, and may be used only as in-premises isolation. Pressure vacuum breaker assemblies shall only be installed in a vertical configuration a minimum of twelve inches above the highest fixture or point of downstream piping or water usage and in such a manner that drainage will preclude back pressure. The pressure vacuum breaker assembly shall be installed vertically with testcocks and control valves accessibly located for connection of test equipment. For the required minimum specifications, refer to the City of Walla Walla Standard Plans.

5. Atmospheric Vacuum Breaker. Atmospheric vacuum breakers shall be used only where there is no possibility of backpressure. Atmospheric vacuum breakers shall only be installed in a vertical configuration a minimum of six inches above the highest fixture or point of downstream piping or water usage and in such a manner that drainage will preclude back pressure. Downstream shut-off valves of any kind are not allowed. For the required minimum specifications, refer to the City of Walla Walla Standard Plans.

13.07.020 Cottonwood trunk system service area defined.

The Cottonwood trunk system service area consists of all properties which either directly or indirectly have water or sewage service available through the water or sewer mains extended from inside the city southerly along Cottonwood Road. This area is designated on an official map maintained in the offices of the city of Walla Walla **community** development ~~services~~ **department**~~division~~.

Title 15 Building and Construction

15.04.005 General Provisions

A. Conflict Between Codes. Whenever there is a conflict between a referenced code in Section 15.04.010 and these general provisions, these general provisions shall apply. In the event of conflict between the following identified codes, the code first listed shall have priority over those latter listed: the International Building Code, the International Residential Code, the International Mechanical Code, the International Fire Code, and, then, the Uniform Plumbing Code.
B. Design Requirements. The following design requirements apply:

Ground Snow Load*	Wind Speed	Seismic Design Category	Weathering	Frost Line Depth	Termites	Decay	Winter Design Temp	Ice Shield Underlay	Flood Hazard	Air Freeze Index	Mean Annual Temp
30 lbs./ft.^{2}	110 mph ultimate wind speed for Residential/Commercial	D	Severe	24"	Slight to Moderate	None to slight	10°	Yes	2003 1992 FIRM	1000	50.2°
Notes:											
* Minimum roof snow load to be thirty lbs./ft.^{2} in the city of Walla Walla.											

C. Flood Plain Development. All development within a designated flood plain located in the city of Walla Walla jurisdiction shall comply with Chapter 21.10 and the construction specifications detailed in Section R322 of the International Residential Code as incorporated by Section 15.04.013, as amended.
D. Professional Preparation of Plans. The city of Walla Walla shall require a Washington design professional, licensed under the provisions of Chapter 18.08 RCW, 308-12 WAC or 18.43 RCW, to prepare or oversee the preparation of plans for any building or structure containing five or more residential dwelling units or for any new construction, or the enlargement, alteration, repair

of a commercial building or structure which affects the structural integrity or life safety systems of the building or structure.
E. Construction Plans. All submitted construction documents must be of sufficient detail to show the entire project with emphasis on the following:
1. Building codes analysis: type of construction; occupancy type; exit path; occupant loads; number of required exits; et cetera.
2. Structural integrity.
3. Life safety.
4. Americans with Disabilities Act (ADA) requirements.
5. Compliance with all codes having jurisdiction.
6. Scope of work.
7. Special inspection requirements and protocols.
8. Deferred submittal schedule.
The amount of detail required will vary, depending on the nature and complexity of the project.
F. Permit Issuance. City of Walla Walla development permits shall be issued only to the property owner or the property owner's authorized agent.
G. Expiration of Permits. All permits shall expire by limitation and be declared void if:
1. Work is not started within one hundred eighty days of obtaining a permit,
2. Work is abandoned for one hundred eighty days or more after beginning work, or
3. After two years from the date of permit issuance, regardless of whether the work is finished.
If a permit is expired for time, a new permit shall be obtained for one-half the permit fee or based on the value of the remainder of the work to finish the original permit, whichever is less. When an applicant has been notified that their permit application has been approved and is ready to purchase, the applicant shall obtain the permit within thirty days of notification or said permit application shall become void.
H. Valuation Table. For purposes of calculating permit fees, the city of Walla Walla adopts by reference the most recent building valuation data (BVD) table published by the International Code Council, as amended. Any changes in the BVD table published by the International Code Council shall be deemed to be adopted by the city of Walla Walla without additional amendment to this subsection.
1. For purposes of calculation of permit fees for a carport, wood deck, covered patio, covered porch, unconditioned single-story self-service storage facility without interior corridor areas, or similar structures, as determined by the building official, the permit fees shall be calculated at fifty percent of the square foot construction cost rate as shown in the current BVD table rate for group U Utility, miscellaneous.
2. For the purposes of calculation of permit fees, a permit-ready accessory dwelling unit, PRADU, the permit fees shall be calculated at thirty-five percent of the square foot construction cost rate as shown in the current BVD table rate for Group R3 residential occupancy.
I. Reinspection Fees. A reinspection fee shall be assessed when an initial inspection cannot be approved due to required corrections and when a re-inspection, of the original corrections for whatever reason, still cannot be approved by the inspector. The fee shall be paid by the permit holder prior to any further inspections being scheduled.
J. Work Without a Permit.

1. Investigation. Whenever any work for which a permit is required by this code has been commenced without first obtaining said permit, a special investigation shall be made before a permit may be issued for such work.
2. Fee. An investigation fee, in addition to the permit fee, shall be collected whether or not a permit is then or subsequently issued. The investigation fee shall be equal to the amount of the permit fee required by this code. The minimum investigation fee shall be the same as the minimum fees set forth in Section 15.04.050. This fee is an additional penalty, and shall not apply to reduce any fee that may apply to any permit subsequently issued. Payment of the investigative fee does not vest the illegal work with any legitimacy, nor does it establish any right to a permit for continued development of that project. If the work done remains illegal for ninety days after service of the stop work order, it shall be considered hazardous.
3. The payment of such investigation fee shall not exempt any person from compliance with all other provisions of this code nor from any penalty prescribed by law.
K. Fee Refunds. The building official may authorize the refunding of:
1. One hundred percent of any fee erroneously paid or collected.
2. Up to eighty percent of the permit fee paid when no work has been done under a permit issued in accordance with this code.
3. Up to eighty percent of the plan review fee paid when an application for a permit for which a plan review fee has been paid is withdrawn or canceled before any plan reviewing is done.
The building official shall not authorize refunding of any fee paid except on written application filed by the original permittee not later than one hundred eighty days after the date of fee payment.
L. References to Boards of Appeal. All references to a board of appeal in the codes, regulations, and statutes adopted in this chapter, and any amendment or addition thereto, shall be deemed amended to refer to city of Walla Walla hearing examiner.
(Ord. 2004-08 § 2, 2004; Ord. 2006-45 § 2, 2006; Ord. 2008-37 § 2, 2008; Ord. 2010-39 § 1, 2010; Ord. 2014-07 § 1, 2014; Ord. 2016-17 § 1, 2016; Ord. 2021-02 § 1, 2021; Ord. 2024-01 § 1, 2024)

15.36.020 Moving permit ~~and development authorization~~ – Application – Contents required.

Each application for a moving permit ~~or development authorization~~ shall be made to the city **community** development **department** ~~services division~~ upon forms furnished by it and shall set forth such information as it may reasonably require in order to carry out the purpose of this chapter.

Title 19 Subdivisions

19.02.030 Purpose.

The purpose of the subdivision code is to enhance the quality of life, protect the health and safety, and enhance the general welfare of the citizens of the city. ~~The subdivision code intends to accomplish t~~**T**his purpose **is accomplished** by implementing the requirements of Chapter 58.17 RCW ~~and the goals and policies of the comprehensive plan~~. To this end, the subdivision code is intended to:

A. Accomplish the orderly development of land within the city through regulations and standards governing subdivisions, short plats, boundary adjustments, planned unit developments, and binding site plans. Condominium developments are processed as a binding site plan;
B. Coordinate development with public facilities and services and provide standards for **the** construction of new services;
C. Improve land records and boundary monumentation;
D. Safeguard the interests of the public, the applicant and future property owners.

19.02.050 Development permit ~~authorization~~.

A. Development **Permit** ~~Authorization~~ – Subdivision Application. All development covered by this code shall be undertaken by first applying for a development **permit** ~~authorization~~ pursuant to Chapter 20.14. No application for a permit required by this code shall be accepted for administration by the city until it is determined by the director to be complete, and until all appropriate administrative fees are paid. All administrative timelines listed in this code shall run from the date of acceptance by the director which shall be placed on the application and signed by the director or his/her designate.

B. Development **Permit** ~~**Authorization**~~ – Lot Development. Development **permits** ~~sauthorization~~ for lots approved under this code shall not be issued by the director until the required improvements have been satisfactorily completed or placed under surety and have been approved by the director and the city engineer.
C. Concurrency. No subdivision, short subdivision, boundary adjustment, planned unit development, binding site plan or other division of land shall be ~~authorized~~ **permitted** unless such action meets the requirements of this title, Titles 20 and 21, and concurrency requirements of the city.
D. Variance. Application for variance of the standards of the Subdivision Code shall be processed the same as under Chapter 20.220. All variance requests shall be processed under Level III review process, Chapter 20.26.

19.02.060 Administration – Interpretation.

The director of the city **community** development ~~services~~ department shall have the responsibility of administering and interpreting all terms and provisions of this code. Formal interpretation shall be requested in writing on forms provided by the director. Issuance of a formal interpretation shall be considered an administrative decision, with appeal as provided by Section 19.02.065 of this code.

19.06.020.C C Definitions.

" **Community** Development ~~services~~ department" (known and referred to alternatively herein as the "department," "staff," or "planning staff") means the department created by Section 2.17.010(F).

19.06.020.D D Definitions.

"Director" (known and referred to alternatively herein as the "**community** development **director** ~~services manager~~," "department head," "administrator," or "zoning administrator") means the official appointed by the city manager in accordance with Section 2.17.070, and such other staff granted authority to act on behalf of the director.
"Director of parks and recreation" means the head of the department of parks and recreation, appointed by and responsible to the city manager.
"Director of public works" means the head of the department of public works appointed by and responsible to the city manager.

19.06.020.S S Definitions.

"Site plan review committee" means the site plan review committee (SPRC) consisting of the **director of community** development ~~services manager~~, director of public works, city engineer, director of parks and recreation, fire chief, chief of police, or their designee.

19.14.030 Hearing examiner review.

A. If the director determines that the preliminary plat contains sufficient elements and data to furnish a basis for its approval or disapproval, he or she shall set a date for public hearing before the hearing examiner. The purpose of the public hearing is to gather information on the proposal's conformance to the relevant criteria and standards of this code.
B. Notice. The director shall give notice as provided in Chapter 20.14 of this code. The hearing examiner shall consider the application materials, the director's report of findings and recommendations, the recommendations of the SPRC, comments submitted, and information received at the public hearing to determine whether the proposal conforms to policies, standards and accepted design principles for the following:
1. Consistency with the ~~comprehensive plan and~~ municipal code;
2. Appropriate provisions for the factors enumerated in RCW 58.17.110 within and around the proposed subdivision;
3. Adequate means of ingress and egress to the proposed lots in accordance with the provisions of this code;
4. Appropriateness of the site, scale, and density of development;
5. Maximization of green space within a plat and minimization of the impact of development upon views;
6. Energy usage requirements and maximization of energy efficiency; and
7. Mitigation of probable adverse environmental impacts.
D. Subdivision Phasing. If a subdivision proposal is designed for phased development, the hearing examiner shall determine whether the design adequately accommodates continuity of public improvements. Each phase must be designed for full standard access, utilities and public facilities within itself, and shall provide for proper extension of these facilities to subsequent phases.
E. Land Acquisition. Any public agency with power to acquire land by condemnation or otherwise for public uses may, at any time prior to approval of a preliminary plat, notify the city and the developer of its intention to acquire some or all of the land in a proposed subdivision for public uses.

F. Reserved Land. In the event the land will not be dedicated for the uses requested, the public agency may request that the city require the reservation of such land for a stated period, not to exceed three years following the council's approval of the final plat, during which time the agency may acquire the land. If it is found that the public health, safety, or general welfare will be served thereby, the city may require, as a condition of the preliminary plat approval, that the reserved land, or such part of it as the council deems sufficient, not be developed as planned and included in the proposed development for uses other than the contemplated public use. A public agency may accelerate the expiration date of a reservation period by filing written notice with the county auditor and the city of its intention to abandon its right to acquire the reserved land.
G. Public Hearing and Decision. The hearing examiner shall conduct a public hearing and issue a decision on the preliminary plat in accordance with this section and Chapter 20.36 of this code. The decision of the hearing examiner shall be in writing and shall include findings and conclusions, based on the record, to support the decision. The decision of the hearing examiner on a subdivision preliminary plat shall be given the effect of a final decision of the city council. The decision of the hearing examiner on a planned unit development preliminary plat shall be given the effect of a recommendation to the city council.
(Ord. 94-11 § 1(part), 1994; Ord. 97-14 §§ 4 – 8, 1997; Ord. 98-42 § 1(part), 1998; Ord. 2008-06 § 8, 2008; Ord. 2012-09 § 12, 2012; Ord. 2026-01, 1/14/2026)

19.18.040. Final plat acceptance – Recording.

A. Review by Director. Prior to approval of the final plat, the director shall make a determination that:

1. The final plat meets all standards established by state law and this code;
2. The proposed final plat bears the certificates and statements of approval required by law (see Section 19.40.010, Table of required information);
3. A title insurance report furnished by the developer confirming that the title of the land in the proposed subdivision is vested in the name of the owners having a title interest and whose signatures appear on the plat's certificate;
4. The developer has provided any required surety in a form acceptable to the city attorney in an amount commensurate with improvements required to be completed as described in Section 19.18.010(D).

B. Filing for Final Approval. RCW 58.17.140 provides that the city shall act on the final plat within thirty days from the date of filing. For this purpose, the date of filing shall be construed to be the date the director has determined that all requirements of this code have been met.
C. Director Determination. The city council has delegated the approval authority of final plats to the **community** development ~~services~~ director. The director shall determine that the conditions imposed on the approved preliminary plat have been met and that any required surety is adequate to assure completion of the required improvements not already completed.
D. Certification and Recording. If approved, the director shall certify its acceptance by signing a statement to that effect on the face of the plat. The director shall then forward one mylar base or reproducible copy to the city engineer. The applicant is responsible for the recording fee and shall record the final plat with the county auditor.

19.26.015 Review requirements.

Planned unit development subdivisions are a Level IV review as specified in Chapter 20.27 of this code. Applications are processed according to the procedures prescribed in Chapter 19.14, Chapter 19.18, and Chapter 19.26 of this code. The application process shall specifically include the following steps:

A. A pre-application meeting with the **community** development ~~services~~ staff and site plan review committee (SPRC) shall be required. The applicant shall prepare concept-level plans to be reviewed by staff and the SPRC.

B. P.U.D. applications are subject to the provisions of Chapter 20.14, Application Review – General.

C. Each application shall comply with the minimum submittal requirements for site plan review set forth in Chapter 20.46 **of** this code. Applications for developments involving a subdivision shall also comply with the corresponding minimum submittal requirements set forth in this title. In addition to the minimum submittal requirements specified above, the application shall also contain: elevations of proposed buildings; proposed development standards including but not limited to land use, density, setbacks, site coverage, and building heights; and plans for development of common open space and amenity areas.

19.26.040 Residential density and density bonus.

A. Net Developable Area Calculation. The net developable area of a P.U.D. shall be the gross area of the subject property less twenty-five percent which would account for public right-of-way under a normal subdivision design (where normal subdivision design would require the creation of new street right-of-way). If sufficient public right-of-way is already provided, the twenty-five percent reduction does not apply.

B. Base Density. The minimum development density of a parcel is determined by the applicable zone of the subject property.

C. Density Bonus. A density bonus of up to twenty percent of the base density (development density allowed by the applicable zone) may be allowed if:

1. The developer makes substantive improvements to the common area(s) including but not limited to: facilities for active and passive recreation or community service facilities appropriate for the residents of the development, restoration or revegetation of critical areas in accordance with an approved restoration plan, or installation of extensive landscaping; or

2. The developer provides open space/common area in excess of the minimum required fifteen percent in order to protect critical areas, environmentally sensitive areas, or other significant natural site features. The additional area must represent at least five percent of the gross acreage in order to be eligible for the density bonus.

D. Dimensional Standards. Dimensional standards and street standards may vary in order to achieve clustering and common area design objectives. Such variations shall be justified based on consistency with the goals and policies of the comprehensive plan and the purpose and intent of this chapter. Variations shall be documented and become the applicable standards for the subject subdivision. Dimensional standards shall be reviewed by the city **community** development ~~services~~ department and documented in the approval.

19.30.010 General provisions.

Conformance to ~~Comprehensive Plan and~~ Zoning Code. The design of subdivisions, short plats, planned unit developments and binding site plans, including but not limited to layout of streets, lots and blocks, shall be consistent ~~with the Walla Walla comprehensive plan.~~ ~~D~~**d**imensional lot standards ~~shall be~~ as required by the Walla Walla zoning code.

19.40.020 Information to be shown on plat map.

A. All items in this section shall be shown on the map or plat of a development for both preliminary and final submittals.
1. Scale. All pertinent information shall be shown normally at a scale of one inch to one hundred feet; however, the scale may be increased or decreased to fit standard size sheets of eighteen inches by twenty-four inches. In all cases, the scale shall be a standard drafting scale, being ten, twenty, thirty, forty, fifty or sixty feet to the inch or multiples of ten for any one of these scales.
2. Appropriate identification of the drawing as a short plat, subdivision, preliminary, final, binding site plan and the name of the development. The name shall not duplicate or resemble the name of any other subdivision or short plat in the county unless the subject subdivision is contiguous to an existing subdivision under the same subdivision of the same last name filed.
3. The names and addresses of the owner(s) and surveyor or engineer.
4. The date, north point, and scale of the drawing.
5. A full legal description and location of the entire proposed development property.
6. The locations, widths and names of both improved and unimproved streets and alleys within or adjacent to the proposed development together with all existing easements and other important features such as section lines, section corners, city boundary lines and monuments.
7. The name and location of adjacent subdivisions and the location and layout of existing streets which are adjacent to or across contiguous right-of-way from the proposed development.
8. The location, approximate dimensions, and areas of lots, proposed lot and block numbers.
9. The lot area in square feet identified on each lot on the plat.
10. The location, approximate acreage, and dimensions of areas proposed for public use.
11. The location, approximate acreage, and dimensions of areas proposed for "open space" and/or common ownership.
12. The acreage of the development, acreage of rights-of-way or other dedications, and acreage of critical areas and buffers, and well locations within one hundred feet of project area.
13. Maximum residential density to be completed in the development.
~~14. Buildable area envelope for each lot (for residential developments).~~
1**4**~~5~~. Proposed housing type/form for each lot (for residential developments).
1**5**~~6~~. Existing contour lines at two-foot intervals based on NAVD '88 Vertical Datum.
1**6**~~7~~. The approximate curve radii of any existing public street or road within the proposed development. The approximate location, width, names, and curve radii for all proposed streets.
1**7**~~8~~. Existing uses of the property and locations of all existing buildings and designating which existing buildings are to remain after completion of the proposed development.
1**8**~~9~~. The location of areas subject to inundation, overflows from stormwater facilities, and/or within a designated one-hundred-year floodplain, all areas covered by water, and the location, width and direction of flow of all water courses.
19~~20~~. Locations of existing natural features such as rock outcroppings, which would affect the design of the development.

201. A vicinity map showing the location of the proposed development in relation to the rest of the city.
212. The locations and dimensions of proposed lots and the proposed lot and block numbers. Numbers shall be used to designate each block and lot. Where a plat is an addition to a plat previously recorded, numbers of blocks and lots or parcels shall be in consecutive continuation from a previous plat.
223. Locations and widths of streets and roads to be held for private use and all reservations or restrictions relating to such private roads.
234. Designation of any land the council may require held for public reserve and configuration of projected lots, blocks, streets and utility easements should the reserved land not be acquired.
245. All areas and the proposed uses thereof to be dedicated by the owner.
256. Tract, block and lot boundary lines with dimensions.
267. Street rights-of-way widths with centerline.
278. Radius, length, and central angle of all tangent curves; radius, length, centered angle, long chord distance and bearing of all nontangent curves.
289. Ties to boundary lines and section or 1/4 section corners immediately surrounding the development.
2930. The location and type of all permanent monuments within the development including initial point, boundary monuments and lot corners.
301. One of the following forms of horizontal control to supplement the plat's inclusion in the city/county GIS:
a. State plane coordinates on the NAD83/91 Datum for each lot corner and controlling monument (or a minimum of two adjacent controlling monuments) as established by survey with reference to Federal Geodetic Control Committee Guidelines for Third Order Class II Surveys; or
b. A tie showing the bearing or angles and distances to one of the city's control grid monuments. If there is a second control monument that is intervisible to the primary control monument, the bearing or angle between the two control monuments shall be shown. (Basis of bearings should be record bearing between control monuments.)
312. Reference points of existing surveys identified, related to the plat by distance and bearings, and referenced to a field book or map as follows:
a. Stakes, monuments, or other evidence found on the ground and used to determine the boundaries of the development;
b. Adjoining corners of adjoining subdivisions;
c. Monuments to be established marking all street intersections and the centerlines of all streets at every point of curvature and the point of tangent;
d. Other monuments found or established in making the survey required to be installed by provisions of this title and state law.
323. Designation of proposed portions of subdivisions to be developed in phases, if any, indicating proposed sequence of platting.
334. All flood control features and references to easements or deeds for drainage land.
345. Existing and proposed easements clearly identified and denoted by dashed lines and, if already of record, their recorded reference. The width of the easement, its length and bearing, and sufficient ties to locate the easement with respect to the development shall be shown.
356. Identification of any land or improvements to be dedicated or donated for any public purpose or private use in common.

367. The following certificates:
a. A certificate signed and acknowledged by all parties having any record title interest in the land, consenting to the preparation and recording of the plat;
b. A certificate signed and acknowledged as above, dedicating to the public all land intended for public use;
c. A certificate for execution by the director;
d. A certificate for execution by the city engineer;
e. A certificate of execution by the county auditor;
f. A certificate for execution by the county treasurer;
g. A surveyor's certificate certifying that he is registered as a professional land surveyor in the state of Washington and certifies that the plat is based on an actual survey of the land described and that all monuments have been set and lot corners staked on the ground as shown on the plat.
378. Such additional information pertaining to the subdivision, short plat or development site and the immediate vicinity as may be required by the director for the review of the proposal.
(Ord. 2019-38 § 6 (part), 2019; Ord. 2021-46 § 3, 2021)

Title 20 Zoning

Division I General Provisions and Definitions

Chapter 20.02 General Provisions

20.02.040 Purpose and intent.

The purpose of this code is to protect the health and safety, and enhance the general welfare and quality of life of the citizens of the City of Walla Walla. This Code intends to accomplish this purpose by defining and quantifying the uses of land designated by the Comprehensive Plan. ~~This Code is the principal means of implementing the Plan.~~ To this end, this code is intended to:
A. Designate Land Use Zones. Designate land use zones which contribute to organized development of the community by restricting the location and relationships of uses, and providing for location of compatible uses in ways which encourage efficiency and mutual benefit. (Refer to Chapter 20.50 for a description of the Land Use Zones established by this Chapter.)
B. Organize Development Process. Quantify the responsibilities of the private and public sectors involved in land development so that uncertainty and delay are kept to a minimum.
C. Provide for Utility Development. Provide a reliable basis for the provision of public services, utilities and facilities.
D. Provide for Citizen Involvement. Establish procedures by which citizens of the community may participate in the land use process, and effect the changes necessitated by new circumstances and needs.

20.02.050 Establishment of zone districts – Official zoning map.

To implement the Comprehensive Plan land use designations, and the Purpose and Intent Statements of this code, the following land use zoning districts are established by delineation on the Official Zoning Map as defined in Section 20.06.030.O.

A. General Zones.
Abbreviation | Zoning Name
RN | Neighborhood Residential
RM | Multi-Family Residential
MHC | Mobile/Manufactured Home Park Community
CC | Central Commercial
CH | Highway Commercial
IL/C | Light Industrial/Commercial
IH | Heavy Industrial
AD | Airport Development District
PR | Public Reserve
UPC | Urban Planned Community

20.02.080 Annexations.

A. Property may be annexed to the city as authorized by Chapter 35A.14 RCW, as amended. Annexation is a Level VI process, initiated as provided in Chapter 35A.14 RCW. Annexation proposals shall be initiated through forms approved by the department.
B. The city will accept annexation petitions twice per year. The first annexation petition submittal time will open January 1st and close January 31st of each calendar year. The second annexation petition submittal time will open July 1st and close July 31st of each calendar year.
C. Annexations are exempt from State Environmental Policy Act (SEPA) review pursuant to RCW 43.21C.222, as amended.
D~~. Annexation of property shall be consistent with the land use and annexation policies of the Comprehensive Plan's Land Use Element.~~ As soon as practicable upon initiation of annexation proceedings, the department shall determine whether ~~or not~~ the proposed annexation area has been prezoned, and whether ~~or not~~ such prezone designation(s) are consistent with and implement the Comprehensive Plan **Future Land Use Map**.
E. Notice of Initiation. The department shall give at least thirty days' advance notice of city council meetings which will consider resolutions calling for election under RCW 35A.14.015, meetings with initiating parties under RCW 35A.14.120 or 35A.14.420, resolutions for initiation of island annexations under RCW 35A.14.295, or resolutions to commence negotiations under RCW 35A.14.460, as those statutes may be amended. The notice shall identify the area proposed for annexation and provide the date and time of the meeting.
1. Initiator Notice. The department shall deliver or mail notice of application to the initiator(s), if any, or the person or entity designated by the applicant to receive notice.
2. Public Notice.
a. The department shall deliver or mail notice to parties that have filed a special notification request in accordance with Section 20.14.015.
b. The department shall deliver or mail notice to the record owner(s) of property, as shown by the records of the Walla Walla County assessor's office, which is included in the area to be annexed or adjacent to the area to be annexed.
3. Agency Notice. The department shall mail notice to the Walla Walla County commission, any fire protection district serving the area to be annexed, any water district serving the area to be

annexed, and any holder of any franchise or permit for operation of a public service business which will be cancelled pursuant to RCW 35A.14.900.

F. Notice of Hearing. The city council shall by resolution set public hearing(s) to the extent required by RCW 35A.14.130, 35A.14.295(2), 35A.14.430, and 35A.14.460(3), as those statutes may be amended, and notice of hearing shall be given as required by the applicable statute. Such notice shall include the proposed zoning for the property.

G. Property within the urban growth area which has been prezoned by a proposed zoning regulation pursuant to RCW 35A.14.330 and 35A.14.340, as those statutes may be amended, will automatically be zoned in conformance with the land use designation prescribed for that property by the city council through the prezone process unless the proposed zoning designation is changed as provided herein.

H. Where property is prezoned, and the prezone designation is inconsistent with the Comprehensive Plan, the council, upon consideration of the annexation proposal, may determine zoning requirements as follows:

1. The prezone designation for the property may be changed concurrently with annexation by a proposed zoning regulation pursuant to RCW 35A.14.330 and 35A.14.340, as those statutes may be amended; or

2. The prezone designation will be applied and the zoning designation for the property may be amended through the rezone process after annexation.

I. Where property has not been prezoned, the council upon consideration of the annexation proposal may determine the zoning requirements as follows:

1. The city may adopt a zoning designation for the property pursuant to RCW 35A.63.~~100 which is consistent with and~~ implements the ~~Comprehensive Plan~~ **Future Land Use Map**; or

2. The property shall be deemed to be included in the zoning map as follows:

a. Property zoned by the county as Agriculture Industrial Heavy or Heavy Industrial shall be deemed to be zoned by the city as Heavy Industrial (IH);

b. Property zoned by the county as Agriculture Industrial Light, Light Industrial, or Industrial/Business Park shall be deemed to be zoned by the city as Light Industrial/Commercial (IL/C);

c. Property zoned by the county as Airport Development District shall be deemed to be zoned by the city as Airport Development (AD);

d. Property zoned by the county as Public Reserve shall be deemed to be zoned by the city as Public Reserve (PR);

e. Property zoned by the county as Urban Planned Community shall be deemed to be zoned by the city as Urban Planned Community (UPC);

f. Property zoned by the county as Primary Agriculture, Exclusive Agriculture, General Agriculture, Agricultural Residential, Rural Remote, Rural Agriculture, Rural Flowing, Rural Residential, or Rural Transition shall be deemed to be zoned by the city as Neighborhood Residential; and

g. Property given a zoning designation by the county other than those identified in this subsection shall be deemed to be zoned by the city as Neighborhood Residential.

The deemed zoning designation may be amended through the rezone process after annexation, and the department is directed to process such amendment(s) that may be necessary to make the zoning designation(s) for annexed property consistent with the Comprehensive Plan as soon as practicable following the effective date of the annexation.

h. The deemed zoning designation may be amended through the rezone process after annexation, and the department is directed to process such amendment(s) that may be necessary to make the zoning designation(s) for annexed property consistent with the Future Land Use Map as soon as practicable following the effective date of the annexation. (Ord. 97-14 § 10, 1997; Ord. 2000-6 § 2(part), 2000; Ord. 2008-06 § 15, 2008; Ord. 2018-53 § 5(part), 2018; Ord. 2019-38 § 7, 2019; Ord. 2021-46 § 4, 2021; Ord. 2024-24 § 3, 2024)

20.02.130. Zoning Code review and evaluation.

Community development ~~services~~ staff and the planning commission will review this code periodically and prepare a report to the city council, detailing any particular problems, proposals, concerns or amendments.

The Zoning Code shall be thoroughly examined as part of the planning commission's normal program of work commensurate with the required review and updating of the Comprehensive Plan, in consultation with technical staff and other interested parties. The Zoning Code is required to be consistent with and implement the Comprehensive Plan.

Title 20 Zoning

Division II Administrative Provisions

Chapter 20.10 Administration

20.10.030. Community development ~~services~~ department.

A. The **community** development ~~services~~ department shall have the following authority and responsibilities:

1. Receive and process, according to the appropriate processing Level (I, II, III, IV, V, or VI), all applications for building, plumbing and mechanical permits, sign permits, site plan review, conditional use permits, special use permits, variances, rezones, annexations, utility extension agreements, subdivisions, short plats, right-of-way permits, street vacations, home occupations, business registration cards, moving permits, and all other applications required by this code;
2. Issue permits;
3. Provide staff support to the planning commission on all long range planning matters, proposed comprehensive plan and implementing code amendments, and all other proposals for which the planning commission is the reviewing body;
4. Provide staff support to the hearing examiner;
5. Provide staff support to the city council;
6. Receive and process complaints applicable to this code;
7. Immediately update the Official Zoning Map to accurately reflect any amendments made by official action of the city council;
8. Maintain the official index of all permits and approvals under this code;

9. Coordinate all development activity to ensure that an applicant receives all necessary input from this and all other city departments sharing an involvement with the proposal.

20.10.040. Director.

A. The director shall be the administrative official of the **community** development ~~services~~ department. The director shall have the following authority and responsibilities:

1. To oversee all duties and responsibilities of the **community** development ~~services~~ department and to determine the appropriate processing level of each application;
2. To act as chair of the site plan review committee, coordinating their review process;
3. To recommend to the planning commission and city council sound planning and development activities or policies;
4. To enforce the provisions of this title or to designate such employees, representatives or officers to act on his/her behalf in the enforcement of this title under such control and supervision as the director may specify;
5. To interpret this title;
6. To perform any other function or duty authorized or assigned to the director by the Walla Walla Municipal Code, council ordinance or resolution or the city manager.

B. Decisions of the director made under authority of this title may be appealed only as provided in this title.

20.10.080 City Council

The city council shall have the following authority and duties associated with this code:
A. Make the final legislative decision on amendments to the Zoning Code, Subdivision Code, Shoreline Master Program, Critical Areas Code, and the Comprehensive Plan.
B. Make the final legislative decision on street vacations, pre-zones, and annexations.
C. Make the final quasi-judicial decision on planned unit development **permits** ~~subdivision plans~~, shoreline permits processed through Level IV (Chapter 20.27 of this code), and site-specific amendments to the Official Zoning Map.
D. Perform any other act or duty authorized by law.

20.14.030. Permit assistance – Consolidated project permit review – Concurrent non-project review – Pre-application process.

A. The **community** development ~~services~~ department personnel are designated as general permit assistance staff. The director may designate special permit assistance staff upon an application.

B. Consolidated Permit Review Process. **Community** development ~~services~~ staff shall attempt to determine if more than one permit approval or action under this code is required for a proposal, and notify the applicant prior to issuance of a determination of completeness; provided, however, that the failure of staff to notify the applicant shall not extend the time to elect to consolidate review processes. An applicant may elect in writing to consolidate the review processes for project permits subject to the following:

1. A project permit review process shall not be consolidated with a non-project action approval process.

a. Director interpretations, Level I matters, Level II matters, Level III matters, and Level IV matters shall not be consolidated with Level V or Level VI processes;

2. The election to consolidate project permit review processes must be filed with the department prior to issuance of a determination of completeness or it is deemed waived; provided, however, that the director may consolidate project permit review processes in his or her discretion even if an election is not timely made;

3. In the event that project permit review processes are consolidated, the determination of completeness, notice of application, and notice of final decision must include all project permits being reviewed through the consolidated review process;

4. In the event that consolidated review processes involve open record hearings before the same hearing body, they will be consolidated into one joint hearing;

5. In the event that consolidated review processes involve open record hearings before more than one hearing body, they will be consolidated into one joint hearing; provided, however, that one hearing body may designate another to conduct the joint hearing on its behalf and without its presence. The hearing bodies shall separately consider the application as soon as practicable upon the record after the hearing has been conducted;

6. Consolidation shall not change the designation of the approving authority for any review process. The department shall determine the order of processing subject to the following unless otherwise ordered by the director after reviewing special processing considerations presented by a particular proposal:

a. If processes are consolidated which involve the same approving authority, they shall be scheduled in a manner which allows the approving authority to consider all matters contemporaneously, and the approving authority shall issue a consolidated final decision;

b. If processes requiring director or department decisions are consolidated with a Level III process, the director or department decisions shall be made first, and the administrative appeal, if any, of such decisions shall be consolidated and presented to the hearing examiner in a manner which allows the hearing examiner to consider the appeal and the Level III decision contemporaneously, and the hearing examiner shall issue a consolidated final decision on the appeal and the Level III matter;

c. If processes requiring director or department decisions are consolidated with a Level IV project permit process, the director or department decisions shall be made first; the appeal, if any, of such decisions shall be consolidated and decided by the hearing examiner prior to the Level IV public hearing; and the hearing examiner's appeal decision shall be made part of the record in the Level IV public hearing, but it is not subject to revision through the Level IV process. In such cases, the hearing examiner's appeal decision shall be deemed final for purposes of further appeal, if available, at the time of issuance of the final decision by the city council on the Level IV matter;

d. If processes requiring director or department decisions are consolidated with a Level III process and a Level IV project permit process, the director or department decisions shall be made first; the appeal, if any, of such decisions shall be consolidated and decided by the hearing examiner prior to the consolidated Level III and Level IV public hearing; the hearing examiner's appeal decision shall be made part of the record in

the consolidated Level III and Level IV public hearing, but it is not subject to revision through the Level III or Level IV processes; the hearing examiner decision on the Level III matters and, if applicable, any hearing examiner recommendation on Level IV matters shall be consolidated into a joint final decision on the Level III matter and recommendation on any Level IV matter; and all hearing examiner recommendations on Level IV matters shall be contemporaneously presented to the city council. In such cases, the hearing examiner's appeal decision and Level III decision shall be deemed final for purposes of further appeal, if available, at the time of issuance of the final decision by the city council on the Level IV matter;

e. If a Level III process is consolidated with a Level IV project permit process, the hearing examiner's decision on the Level III matters and, if applicable, any hearing examiner recommendation on Level IV matters shall be consolidated into a joint final decision on the Level III matter and recommendation on any Level IV matter; and all hearing examiner recommendations on Level IV matters shall be contemporaneously presented to the city council, but any hearing examiner final decision on the Level III matter is not subject to revision through the Level IV process. In such cases, the hearing examiner's Level III decision shall be deemed final for purposes of further appeal, if available, at the time of issuance of the final decision by the city council on the Level IV matter;

f. If Level IV project permit processes are consolidated, the recommendations of hearing examiner shall be contemporaneously presented to the city council.

C. Concurrent Non-Project Review.

1. Except as provided in RCW 36.70A.130 proposals to amend the Comprehensive Plan shall be considered no more frequently than once a year and all proposals shall be considered concurrently so the cumulative effect of the various proposals can be ascertained.

2. Non-project approvals may be processed concurrently with other non-project approvals at the discretion of the director, but they shall not be consolidated.

D. A preapplication conference may be required by the department prior to filing of an application, and a preapplication conference shall be required for subdivisions, short plats, planned unit developments, binding site plans, or if permit assistance staff determines prior to filing of the application that more than one permit approval or action under this code is required for a proposal. The applicant shall arrange such conference with the **community** development ~~services~~ department to review the proposed action, to become familiar with the policies, plans and development requirements of the city of Walla Walla and to coordinate all necessary permits and procedures. Any information or opinions expressed by the city shall not be binding or constitute approval of the project.

E. At any time prior to issuance of a determination of completeness, the applicant may request that the following be provided:

1. A form which lists the requirements for a completed application;

2. A general summary of the procedures to be used for processing the application;

3. The references to the relevant code provisions, development standards, and regulations which may apply to the approval of the application; and

4. The city's design guidelines.

F. It is not possible for permit assistance by staff or the conference to be an exhaustive review of all possible issues. Neither staff advice nor information provided by the city to the

applicant shall bind the city or prohibit the city's future application or enforcement of all applicable law and other requirements.

20.14.060. Initial application processing.

Upon receipt of an application for a Level 1 – Level IV review, the **community** development ~~services~~ department shall proceed as follows:

A. Determination of Completeness. A determination of completeness shall be made within twenty-eight days of receipt of the application. During the completeness review, the department shall attempt to identify other local, state, or federal departments and agencies which may have jurisdiction over some aspect of the application, and the department shall determine the lead agency for the proposal in accordance with Title 21. The department shall provide a written determination which states either: (1) that the application is complete; or (2) that the application is incomplete and what is necessary to make the application complete. The determination of completeness shall be made when the application is sufficient for continued processing even though additional information may be required or project modifications may be undertaken subsequently. An application is complete when it meets the submission requirements of Section 20.14.040 and other applicable code sections.

1. An application shall be deemed complete upon the expiration of the review period if the department does not provide the written determination that the application is incomplete within the time allowed. An application that has been deemed complete shall still be subject to all other applicable requirements and procedures.

2. The department's determination of completeness shall not preclude the city from requesting additional information or studies either at the time of the notice of completeness or at some later time, if new information is required or where there are substantial changes in the proposed action.

B. Incomplete Application Procedure.

1. If the applicant receives a determination that an application is not complete, the applicant shall have ninety days to submit the necessary information.

Within fourteen days after the applicant has submitted the requested information, the department shall make the determination as described in subsection A of this section, and notify the applicant in the same manner. An application shall be deemed complete upon the expiration of the extended review period if the department does not provide the written determination that the application remains incomplete within the time allowed. An application that has been deemed complete shall still be subject to all other applicable requirements and procedures.

2. If the applicant either refuses in writing to submit the additional information or does not submit the required information within the ninety-day period, the application shall lapse and be considered void ab initio; provided, however, the applicant shall not be entitled in such event to a refund for any fees or charges paid to the city.

C. Determination of Completeness – Contents. The determination shall be prepared in a manner to provide notice to the applicant and to integrate its use, when required, with the notice of application/proposal to the public and agencies with jurisdiction. Preliminary determinations and information contained in a determination of completeness shall not bind the city and are subject to continuing review and modification. The determination of completeness may incorporate by reference the application to the extent that it substantially provides the information required herein. In such case, the determination of completeness and copies thereof

shall attach a copy of the application and additionally provide the information required herein that is not provided by the application. Each determination of completeness shall include:

1. The date of the application and the date of the notice of completion;
2. A description of the proposed action;
3. The determination of the lead agency for the proposal under SEPA;
4. A preliminary determination whether the proposal is categorically exempt under SEPA or subject to threshold determination requirements; if subject to threshold determination requirements, the preliminary threshold determination that it expects will issue;
5. Preliminary identification of existing environmental documents that evaluate the proposal and the location where the application and studies can be reviewed;
6. A preliminary determination and reference to the relevant code provisions, development standards, and regulations which may apply to the approval of the application; a preliminary list of those regulations that will be used for project mitigation; and, if a mitigated DNS is expected to issue, a preliminary list of conditions being considered to mitigate environmental impacts;
7. A preliminary determination of consistency for project permit proposals;
8. A list of the project permits included in the application and, to the extent known to the department, a list of other permits not included in the application which are required for the proposal;
9. A preliminary determination indicating which municipal code review level(s) will be used to process the application;
10. A preliminary determination identifying additional information or studies requested from the applicant;
11. To the extent known by the department, a preliminary determination and identification of other departments and agencies with jurisdiction over the project permit application;
12. A preliminary determination and identification of parties entitled to notice of application; and
13. Other information that the department determines to be appropriate to include.

D. The department shall electronically deliver or mail notice of any determination made under this section to the applicant, or the person or entity designated by the applicant to receive determinations and notices. The department should document the date and manner by which notice is given.

20.14.065. Notice of application/proposal.

A. Notice of Application/Proposal – Contents. Notice of application/proposal shall be given no later than fourteen days after the application has been determined to be complete. Notice of application/proposal is not required for interpretation requests or Level I proposals that are categorically exempt under SEPA, unless a special notification request has previously been made in accordance with Section 20.14.015. If the proposal requires an open record hearing, notice of application shall be given at least fifteen days prior to the hearing.

1. Notice of application/proposal shall include:
    a. The identity of the applicant;
    b. The date of the notice of application/proposal;
    c. Project description;

d. Preliminary identification of existing environmental documents that evaluate the proposal and the location where the application and studies can be reviewed;

e. A preliminary determination and reference to the relevant code provisions, development standards, and regulations which may apply to the approval of the application; a preliminary list of those regulations that will be used for project mitigation; and, if a mitigated DNS is expected to issue, a preliminary list of conditions being considered to mitigate environmental impacts;

f. On the first page, notice that:

i. The city uses the optional threshold determination process authorized by WAC 197-11-355;

ii. The application comment period for nonexempt proposals may be the only opportunity to comment on the environmental impacts of the proposal;

iii. The proposal may include mitigation measures under applicable codes, and the project review process may incorporate or require mitigation measures regardless of whether an environmental impact statement is prepared; and

iv. A copy of the subsequent threshold determination on the proposal may be obtained upon request;

g. The information required by Section 20.14.060(C);

h. A statement identifying the public comment period, including:

i. The right to comment on the application,

ii. The opening and closing date of the public comment period,

iii. The last date and time that written comments may be submitted,

iv. The right to receive notice of and participate in hearings,

v. The right to request a copy of decision on the proposal once made, and any appeal rights;

i. To the extent applicable, the date, time, place, and type of hearing upon the application if such hearing has been scheduled at the time the notice of application/proposal is given; and

j. Other information that the department determines to be appropriate ~~to~~ include~~.~~ **but not limited to a designated permit responsible official and contact information such as a phone number and/ or email address.**

2. The notice of application/proposal may incorporate by reference the determination of completeness to the extent that it substantially provides the information required herein. In such case, the notice of application/proposal and copies thereof shall attach a copy of the determination of completeness and additionally provide the information required herein that is not provided by the determination of completeness. A notice of application/proposal and copies thereof which by reference incorporates a determination of completeness shall also attach any copies of documents incorporated through reference by the determination of completeness. The department shall prepare and provide a separate notice of application/proposal containing the information required by this section if either:

a. A determination of completeness was not required for the proposal;

b. A determination of completeness was not timely prepared for the proposal; or

c. The determination of completeness substantially omits the information required by Section 20.14.060(C).

B. Notice of Application – How Given.

1. Applicant Notice. The department shall electronically deliver or mail notice of application/proposal to the applicant, or the person or entity designated by the applicant to receive notice. The notice of application/proposal may be provided to the applicant or applicant's designee contemporaneously with the determination of completeness.

2. Agency Notice. The department shall electronically mail notice of all applications/proposals that are not categorically exempt under SEPA in accordance with Chapter 21.08 to departments and agencies with potential jurisdiction over the project permit application. The list of departments and agencies receiving notice shall be maintained by the **community** development ~~services~~ department.

3. Site Plan Review Committee Notice. The department shall electronically deliver notice of application/proposal to members of the site plan review committee if the proposal requires site plan review.

4. Sustainability Committee. The department shall electronically mail notice of applications/proposals that are not categorically exempt under SEPA to the city's sustainability committee.

5. Public Notice.

a. The department shall electronically deliver or mail notice of application/ proposal of interpretation requests and Level I proposals that are categorically exempt under SEPA to parties that have filed a special notification request in accordance with Section 20.14.015. Such notice shall explain that there is no comment period, and that the proposal is categorically exempt under SEPA.

b. Anyone who has filed a special notification request in accordance with Section 20.14.015 shall receive the notice of application.

c. The notice of application shall be provided as follows:

Review Level	**Notice Provided** (1)
Non-SEPA exempt Level I	• Mailed to adjacent property owners (2) • City's website
Level II	• Mailed to adjacent property owners (2), except for unit lot subdivisions. For unit lot subdivisions, the community and property owners within 250 feet shall be notified, consistent with RCW 36.70B.110 and notice posted on the closest public sidewalk or roadway. • City's website
Level III (3)	• Property owners within 400 feet of project site boundaries • City's website • Post the project site in a conspicuous location • Publish in the Union-Bulletin

Level IV	• Property owners within 400 feet of project site boundaries • City's website • Post the project site in a conspicuous location • Publish in the Union-Bulletin
Level V	• City's website • Publish in the Union-Bulletin
Level VI	• City's website • Publish in the Union-Bulletin
Annexation Proposals	• In accordance with Section 20.02.080 instead of this section
Prezone Proposals	• In accordance with the provisions of Chapter 35A.14 RCW instead of this section
Shoreline Permits (4)	• Property owners within 400 feet of project site boundaries • City's website • Post the project site in a conspicuous location • Publish in the Union-Bulletin two consecutive weeks on the same day of the week
Street Vacations	• In accordance with the provisions of Chapter 35.79 RCW instead of this section

Notes:

(1) Notice is provided to the record owner(s) of property, as shown by the records of the Walla Walla County assessor's office.

(2) If the owner of the proposal site owns another parcel or parcels of real property which lie adjacent to the proposal site, the notice of application/proposal shall be given to the record owner(s) of property, as shown by the records of the Walla Walla County assessor's office, which is adjacent to any portion of the boundaries of the proposal site or such other adjacently located parcels owned by the same owner as the proposal site.

(3) Notice of subdivision preliminary plat proposals shall be given to the Washington State Secretary of Transportation if a proposed subdivision preliminary plat is located adjacent to the right-of-way of a state highway or within two miles of the boundary of a state or municipal airport.

(4) Notices regarding shoreline proposals shall additionally include a statement that any person desiring to submit written comments concerning an application, or desiring to receive notification of the final decision concerning the proposal as expeditiously as possible after the issuance of decision, may submit the comments or requests for decisions to the department within applicable time periods which shall be stated in the notice.

C. Combined Notice. Notice of application/proposal may be combined with notice of hearing if the hearing date has been set at the time notice of application/proposal is given. Each combined notice shall contain the notice of application/proposal information required herein and the notice of hearing information required by Section 20.14.085.

D. The department should document the date and manner by which any notice is given.
E. The department may remove posted notice upon expiration of the comment period.
F. Publication costs and costs incurred to post and remove notice at the proposal site shall be borne by the applicant in addition to other costs and fees which apply.

20.14.095. Compliance with notice of decision.

A. Notice of Decision Compliance Required. Decisions issued on the basis of approved plans and applications and conditions of approval imposed by the approving authority authorize only the use, arrangement and construction set forth in the approved plans and application together with any associated conditions of approval and the final site plan. Any use, arrangement, or construction at variance with that authorized is a violation of this code and is punishable as provided in Chapter 20.42, Violations and Enforcement.
B. Site Inspection Authorized. The director, the building official, and other city officials having responsibilities under this code, or their designees, are authorized to perform interim and final inspections of all development and modifications to development to assure that it has been established and/or constructed in conformance with the final site plan and associated terms and conditions of approval. Such inspections may be coordinated with the inspections required by other applicable codes or ordinances.
C. Approval Extension. A valid decision for project permit action may be extended one time only for up to one additional year by action of the director. Requests for extensions shall be in writing to the department and shall be accompanied by the previously approved final site plan showing the location and size of any development or work already completed on the project. The director shall review the request without public notice or hearing and issue his or her decision within ten days from the receipt of the extension request. The director may (1) approve the extension, (2) approve the extension with conditions to assure the work will be timely completed, or (3) disapprove the extension. An extension shall be issued for good cause only and the burden of showing cause shall be upon the applicant. The director shall mail his or her decision to the applicant and shall specify his or her decision as final unless appealed under the provisions of Chapter 20.38, Closed Record Decisions and Appeals.
D. Decision Expiration. An approval for project permit action shall automatically expire and be terminated when:
1. A new or modified decision is issued for the parcel or parcels affected;
2. The work or action authorized in the decision has not begun within one hundred eighty days from the date of issuance thereof, unless a longer or shorter time is specified in the approval itself; or
3. The work or action authorized in the decision has not been completed within two years from the date of issuance, unless a longer or shorter time is specified in the approval itself.

Knowledge of expiration date and initiation of a request for extension of approval time are the responsibility of the applicant. The city shall not be held responsible for the notification of expiration, although it may notify the applicant of date of expiration. All requests for additional time must be submitted to the **community** development ~~services~~ office prior to expiration of the decision.

20.18.050 Approval.

The director shall issue a decision when determined that the proposal complies with the provisions of this code ~~and the Comprehensive Plan.~~

20.22.040. Review procedures, decision – Level II.

Upon acceptance of a completed application for a Level II review, the department shall determine whether the proposal is categorically exempt under SEPA or subject to threshold determination requirements.
A. Site Plan Review Committee. Proposals requiring site plan review will be sent to the site plan review committee by the department no later than fourteen days after the application has been determined to be complete. The site plan review process shall be as set forth in Chapter 20.46, Site Plan Review Committee.
B. The director may, but is not required to, solicit comments during any comment period from other resource persons or public agencies he or she may determine may be affected by the proposal.
C. SEPA Review. All applications will be reviewed by the department and if SEPA review is required, such review will be conducted by the responsible official in accordance with the provisions of Chapter 20.14 and Title 21 of this code and Chapter 197-11 WAC. No approval or permit shall be issued on the proposal until SEPA review is complete.
D. Director's Decision. After considering the proposal and all relevant materials and timely comments, if any, the director shall take one or more of the following actions:
1. Approve the proposal and issue a decision;
2. Establish conditions for approval, or require other changes in the proposed site plan;
3. Request additional or more detailed information including but not limited to a written program for development;
4. Determine a higher review level is needed and/or refer the proposal to the city council, planning commission or hearing examiner for review, public hearing and decision; or
5. Disapprove the proposal.
E. Conditional Approval.
The director may attach conditions to his or her approval in order to ensure the development is consistent with the applicable development standards of the Walla Walla Municipal Code ~~and the policies of the Comprehensive Plan.~~

20.26.040. Review Procedures, decision – Level III.

The following procedures will be followed for the review of Level III applications:
A. Approving Authority. Level III decisions are processed according to Chapter 20.14 with final decision made by the approving authority (hearing examiner) after public hearing.
B. Site Plan Review/Staff Report. Proposals requiring site plan review will be sent to the site plan review committee by the department no later than fourteen days after the application has been determined to be complete. The site plan review process shall be as set forth in Chapter 20.46, Site Plan Review Committee. The department shall coordinate and assemble the comments received. These comments shall be included in a staff report prepared by the department. The staff report shall summarize the proposal with the department's proposed findings, conclusions, and recommendations. The staff report is then submitted to the hearing examiner for consideration at a public hearing.

C. SEPA Review. All Level III applications will be reviewed by the department and if SEPA review is required, such review will be conducted by the responsible official in accordance with the provisions of Chapter 20.14 and Title 21 of this code and Chapter 197-11 WAC. No approval or permit shall be issued on the proposal until SEPA review is complete.
D. The hearing examiner shall approve, deny, or approve the application with such conditions as are necessary to bring the proposal into conformance with the standards of this code ~~and the policies of the Comprehensive Plan~~. Conditions of approval may include actions necessary to avoid imposition of undue public service obligations on the city, or mitigation of adverse impacts.
E. Decision. Following the public hearing and upon completion of its action, the hearing examiner shall issue a written decision.
F. Issuance of Building Permits. No use requiring a Level III decision shall be entitled to a building permit until and unless the hearing examiner approves the application. The Level III decision is not a building permit and does not by itself authorize the construction or occupancy of any use or structure.

20.28.020. When required.

Level V legislative review is required for:
A. Zoning Code text and Official Zoning Map amendments of general applicability;
B. Subdivision Code amendments;
C. Certain amendments to the Shoreline Master Program regulations and any other planning related regulation as determined by the director ~~to implement the Comprehensive Plan or subarea plan~~.

20.34.040 Approval procedure, recording.

A development agreement shall only be approved by the city council after a **recommendation by a hearing examiner and a** public hearing. ~~The director shall make a recommendation to the city council, who will determine the hearing body based on the nature of the proposed action necessitating a development agreement. A~~ **The** hearing **examiner** ~~body~~, if other than the city council, shall conduct a hearing and forward its recommendation to the city council for consideration and decision.
B. Upon approval, a development agreement shall be recorded with the Walla Walla County Auditor.
1. During the term of a development agreement, it is binding on the parties and their successors.
2. Unless amended or terminated, a development agreement is enforceable during its term by a party to the agreement.
3. Any permit or approval issued by the city after the execution of a development agreement must be consistent with the terms of the development agreement.
4. A development agreement and the development standards incorporated in the agreement govern during the term of the agreement, or for all or that part of the build-out period specified in the agreement, and may not be subject to an amendment to a zoning ordinance or development standard or regulation or a new zoning ordinance or development standard or regulation adopted after the effective date of the agreement.

20.36.020 Administrative responsibility.

The **community** development ~~services~~ director shall have the following responsibilities:
A. Schedule the application for review and public hearing.
B. Give notice as provided in Chapter 20.14 and Title 21.
C. Prepare the staff report on the application. The report shall be a single report stating all decisions made as of the date of the report, including recommendations on any project permits in the consolidated permit process that do not require an open record pre-decision hearing. The report shall state any mitigation required or proposed under the city's development regulations or authority under SEPA. If the threshold determination other than a determination of significance has not been issued previously by the city, the report shall include or append this determination.
D. Prepare the Notice of Decision, if required by the hearing body, and/or mail a copy of the notice to those required by this code to receive such decision.

20.36.090 Findings and notice of decision/action.

A. Following the public hearing procedure described in Section 20.36.080, the approving authority shall approve, conditionally approve, or deny the application based on findings that address or relate to the applicable standards and criteria of this code and other referenced chapters of the Walla Walla Municipal Code ~~and the Comprehensive Plan.~~
B. The approving authority's written decision or action shall be issued as soon as practicable following the hearing and within the time required by Section 20.14.090.
C. Notice of decision shall be given as provided in Section 20.14.090.

20.38.050. Appeals – Filing.

Administrative appeal of the approving authority's decision on a project permit application shall be governed by the following:
A. Standing. Only parties with standing may appeal a decision. Standing is limited to the following persons:
1. The applicant and the owner of property to which the decision is directed;
2. Another person aggrieved or adversely affected by the decision, or who would be aggrieved or adversely affected by a reversal or modification of the land use decision. A person is aggrieved or adversely affected within the meaning of this section only when all of the following conditions are present:
a. The decision has prejudiced or is likely to prejudice that person;
b. That person's asserted interests are among those that the approving authority was required to consider when it made the decision;
c. An administrative appeal decision in favor of that person would substantially eliminate or redress the prejudice to that person caused or likely to be caused by the decision of the approving authority; and
d. The person has participated orally or in writing before the approving authority regarding the matter upon which review is requested.
B. Time to File. An appeal of a decision must be filed within fourteen calendar days after service or publication of the notice of decision/action under Section 20.14.090 is deemed complete under Section 20.14.050 or 20.14.055. If Section 20.14.090 requires notice to be given

by more than one method, the appeal period shall commence on the earliest date that the appellant is deemed to have been given any of the methods of notice. Appeals must be filed with the **community** development ~~services~~ department before 5:00 p.m. on the last business day of the appeal period.

C. Computation of Time. For the purposes of computing the time for filing an appeal, the day the decision is rendered shall not be included. The last day of the appeal period shall be included unless it is a Saturday, Sunday, a day designated by RCW 1.16.050 or by the city's ordinances as a legal holiday, then it also is excluded and the filing must be completed on the next business day.

D. Content of Appeal. Appeals shall be in writing, be accompanied by an appeal fee as required in Chapter 2.94, and shall contain the following information:

1. Appellant's name, address, and phone number;
2. Appellant's statement describing his or her standing to appeal;
3. Identification of the application which is the subject of the appeal;
4. Appellant's statement of grounds for appeal and the facts upon which the appeal is based;
5. Appellant's statement that explains why the action is not consistent with the Walla Walla Comprehensive Plan, this code, or other provisions of law;
6. The relief sought, including the specific nature and extent, including an explanation of its consistency with the Comprehensive Plan and this code; and
7. A sworn statement that the appellant has read the appeal and believes the contents to be true, followed by the appellant's signature.

E. An answer need not be filed to an appeal. An appellant shall be confined to matters raised in the written appeal filed in accordance with subsection D of this section. A written appeal may be amended only upon the approval of the appellate body. Requests to amend an appeal must be filed with the **community** development ~~services~~ department and served by the appellant upon all parties entitled to notice of appeal at least seven calendar days prior to the appeal hearing. Requests to amend shall not be freely granted.

F. Effect of Appeal. The timely filing of an appeal shall stay the processing of a proposal and the effective date of the final decision until such time as the administrative appeal process is complete as provided in this chapter or withdrawn.

G. Notice of Appeal. The administrator shall provide notice of the appeal to:

1. The applicant, or the person or entity designated by the applicant to receive notice;
2. Parties that have filed a special notification request in accordance with Section 20.14.015 prior to rendering of the decision;
3. Agencies with jurisdiction; and
4. Identifiable parties who have provided addresses and submitted substantive written comments on the proposal prior to rendering of the decision.

H. The department should document the date and manner by which any notice is given.

20.42.020 Enforcement and administration.

The city of Walla Walla **community** development ~~services~~ director and the Walla Walla police chief are authorized to enforce and charged with the primary enforcement of the provisions of Titles 15 and 19, this title and Chapters 8.05 and 8.07. The **community** development ~~services~~

director, and designees of either the **community** development ~~services~~ director or the police chief, are recognized as limited authority Washington peace officers for purposes of enforcement of Titles 15 and 19, this title, and Chapters 8.05 and 8.07. The **community** development ~~services~~ director and police chief, and designees of either the **community** development ~~services~~ director or police chief, shall be authorized to order discontinuance of the unlawful use of buildings or structures, removal of buildings or structures, discontinuance of any illegal work being done, or shall take any other action authorized by Title 15 or 19, this title or Chapter 8.05 or 8.07 to insure compliance with or prevent violations of its provisions.

20.42.070 Complaints.

Whenever a violation of this code or Chapter 8.05 or Chapter 8.07 of the Walla Walla Municipal Code occurs, any person may file a complaint in regard thereto. All such complaints must be in writing and shall be filed with the **Community** Development **Department** ~~services Division~~ of the City of Walla Walla, which shall properly record such complaint, conduct a preliminary investigation, and take such other action as deemed necessary by the City of Walla Walla **Community** Development **Director** ~~Services Manager~~.

20.46.070 Review, decision.

A. Applications before the site plan review committee shall be reviewed and evaluated based upon city-adopted policies, programs, and ordinances, and shall be in keeping with the Walla Walla Comprehensive Plan. To accomplish this, SPRC recommendations and decisions made by the approving authority under this code may include, but not be limited to, conditions of approval for site improvements, public improvements (streets, sidewalks, landscaping, etc.) and for the dedication of right-of-way necessary for public facilities.

B. The SPRC shall have the prerogative of deferring its review if, in the opinion of the SPRC, the site plan is sufficiently complex that it should be reviewed by the planning commission or hearing examiner. All decisions to defer shall be made during the comment period for the proposal.

C. The SPRC shall within the comment period for the proposal approve, disapprove or approve with conditions any site plan submitted to it and accepted for review unless this time period is extended by mutual agreement, in writing, between the applicant and the site plan review committee. The action taken by the site plan review committee will be submitted to the **community** development ~~services~~ department for subsequent action on the ~~development authorization~~ application.

D. Any time required to review and approve, disapprove or approve with conditions any environmental checklist and make a threshold determination, and to develop and review an environmental impact statement as required under the provisions of SEPA shall not be included under the time constraints of this chapter.

E. The decision of the site plan review committee shall be given the effect of a recommendation to the approving authority.

F. The foundation for project review and decision making shall be the city's comprehensive plan and development regulations. The city's review of a project permit application will include determination as to whether the proposed project is consistent with applicable regulations or comprehensive plan and concurrency requirements. The determination of consistency shall be

based on review of the city's adopted service levels, the applicable development regulations, or in the absence of a relevant development regulation, upon the comprehensive plan. The city's review will emphasize existing requirements and adopted standards, with the use of supplemental authority as specified by Chapter 43.21C RCW to the extent that existing requirements do not adequately address a project's specific probable adverse environmental impacts.

20.46.080 Relationship of review to other permits.

The review and approval of site plans is considered a part of the city's development permit application approval process. Following approval of a site plan requiring review under the provisions of this code, a development permit may be issued by the **community** development ~~services~~ department provided all other requirements of development permit application and ordinances of the city have been complied with.

20.46.110 Duration of approval.

A. Approval of the site plan shall be effective for eighteen months from the date of approval by the approving authority unless otherwise stated. During this time, the terms and conditions upon which approval was given will not change. If application for a building permit is not made within the eighteen-month period, the approval shall automatically terminate.
However, upon the application of the owner or representative, the director may extend the approval period for up to six months unless substantive change has been made in the regulations, ordinances, requirements, policies, or standards which impact the site since the initial approval.
B. Knowledge of expiration date and initiation of a request for extension of approval time is the responsibility of the applicant. The city shall not be held responsible for notification of expirations, although it may notify the applicant of date of expiration. All requests for additional time must be submitted to the **community** development ~~services~~ office prior to expiration of site plan approval.

20.48.045 Review Criteria prezones, area wide rezones and text amendments.

The decision on a prezone, area wide rezone, or text amendment shall be based on a legislative finding upon whether or not the proposal is consistent with and implements the Walla Walla ~~**Urban Area**~~ Comprehensive Plan **Future Land Use Map.**

20.48.050 Record of amendments.

All amendments to the zone code will be recorded and indexed in the **community** development ~~services~~ department according to Section 20.14.100 of this code.

20.50.020 RN Neighborhood Residential.

The Neighborhood Residential Zone is intended to provide for a variety of housing dwelling unit types including but not limited to single-family residential, duplexes, triplexes, fourplexes, townhomes, cottage housing, tiny homes, stacked flats, and accessory dwelling units.

A. Level of Uses. The uses allowed by Level I, II, III, or IV procedures in this zone are designated by a 1, 2, 3, or 4 respectively on the Tables of Permitted Land Uses, Chapter 20.100.
B. The subdivision of an existing lot in the Neighborhood Residential Zone requires a minimum net density of four dwelling units per acre.
C. The Neighborhood Residential Zone allows for up to four dwelling units per lot.
1. For exceptions to these maximum standards, see Affordable Housing Development on Properties Owned by Religious Organizations in RCW 35.63.280, RCW 35A.63.300, RCW 36.70A.545.
D. Minimum Yard Requirements.
1. Front yard: twenty feet. Front setbacks for cottage housing: see Chapter 20.117. Corner lots have two front yards: primary and secondary. The primary front yard (generally off-street parking side) shall be full depth; the secondary front yard shall be one-half the required front yard depth. Front yard setback for garage or carport must be twenty feet; front yard setback for house may be reduced to fifteen feet.
2. Side yard: five feet; attached housing with a shared wall/property line can be zero feet except for end units that shall be five feet.
3. Rear yard: twenty feet. Rear yards for cottage housing: see Chapter 20.117. Rear yards for detached accessory structures: see Chapter 20.118. Corner lots are not considered to have rear yards. Rear yard setbacks subject to the setbacks in this subsection (D)(3) may be reduced to ten feet when the following conditions are met:
a. Two parking spaces are provided per dwelling unit; and
b. The rear yard abuts an alley; or
c. The rear yard does not abut an alley but the maximum building height is no greater than twenty-seven feet.
4. For exceptions to these minimum standards, see Section 20.102.020.
E. Lot Coverage. Buildings shall occupy a maximum of fifty percent of the lot.
F. Building Height. No building shall exceed thirty-five feet.
G. Off-Street Parking. See Chapter 20.127 for residential parking requirements.
(Ord. 2018-53 § 12(part), 2018; Ord. 2020-51 § 10, 2020; Ord. 2021-46 § 10, 2021; Ord. 2023-33 § 3, 2023; Ord. 2025-07 § 5, 5/14/2025)

20.50.105 Landfill Vicinity Development Standards
A. Any enclosed structure or paving requiring a building or grading and clearing permit that is located within one thousand feet of an active or former sanitary landfill shall incorporate measures to protect the structure, and neighboring structures, from potential landfill gas migration. The distance shall be calculated from the location of the proposed structure to the nearest property line of the active or former landfill site.
B. The method for ensuring a structure's, and neighboring structure's, protection from landfill gas shall be addressed in a landfill gas mitigation report prepared and stamped by a licensed professional engineer to the city for review and approval prior to construction. The cost of preparing this report shall be borne by the developer.
C. The report shall contain a description of the investigation conducted, identify any landfill gas hazards, and provide specific recommendations for preventing the accumulation of explosive concentrations of landfill gas within or under enclosed portions of the proposed building or structure.

D. The city shall review the landfill gas mitigation report for compliance with applicable standards as part of the building/grading permit review process. No building/grading permit shall be issued until the report and proposed mitigation measures are approved by the city.
E. Design and Installation Requirements.
1. A licensed professional engineer shall design all landfill gas mitigation systems, including but not limited to barriers, ventilation systems, subslab depressurization systems, and monitoring components.
2. All approved landfill gas mitigation measures shall be installed by qualified contractors.
3. Installation of landfill gas mitigation systems shall be subject to inspection by the city to verify compliance with the approved design prior to final inspection or issuance of a certificate of occupancy.
F. At the time of the final inspection, the engineer of record shall furnish a signed statement attesting that, to the best of the engineer's knowledge, the building or structure has been constructed in accordance with their recommendations for addressing methane gas migration. Any changes to the design shall be submitted in writing and stamped by the engineer of record, and the developer shall provide as-built drawings to the city documenting the changes.

20.50.130 Application.
An application for development of a UPC site shall be on forms prepared by the **community** development ~~services~~ department and a draft development agreement. The information required on the application forms shall take into account that detailed information may not be available at the time of the application and may be developed through the environmental review process.

20.50.170 Urban planned community modifications.
A. Site elements or conditions of approval may be amended or modified **upon** ~~at the~~ written request **by** ~~of~~ the applicant or the applicant's successor ~~in interest~~ **who has been formally** designated in writing by the applicant.
B. Minor modifications of the urban planned community may be authorized by the **community** development ~~services~~ director and shall be established in the development agreement.
C. Major modifications require city council approval following a public hearing. A decrease of more than five percent in the minimum amount of total required recreation and open space shall be deemed a major modification. Any decrease in the minimum number of residential dwelling units or increase in the maximum number of residential dwelling units shall be deemed a major modification. Any increase in the maximum amount of nonresidential uses shall be deemed a major modification. The development agreement may specify additional criteria for determining whether proposed modifications are minor or major.

20.100.040 C Community Services.

Land Uses	RN	RM	MHC	PR	CC	CH	I/LC	IH	AD
Addressing, Mailing and Stenographic Services	x	x	x	x	1	1	1	x	x

Cemetery	x	x	x	1	x	x	x	x	x
Churches, Synagogues, Temples	3	3	3	1	1	1	3	3	3
Colleges (other than state education facilities)	3	3	x	1	1	1	2	x	3
Community Animal Shelters	x	x	x	x	x	3	1	1	3
Community Center, Services Clubs, Fraternal Lodges	3	2	2	1	1	1	2	x	2
Day Care Centers: Mini (1 – 12 children) (*)	1	1	1	1	1	1	1	x	1
Day Care Centers: Family (13 or more children) (*)	~~3~~**1**	~~3~~**1**	~~3~~**1**	1	1	1	1	~~X~~**3**	1
Essential Public Facilities (•)	3	3	3	3	3	3	3	3	3
Fire Stations, Police Stations and Ambulance Service	3	3	3	1	1	1	1	1	1
Funeral Homes, Crematories, Mausoleums and Columbaria	x	3	x	1	1	1	3	x	x
Government Offices, Quasi-Government Offices, Community Services Agencies Offices	x	3	x	1	1	1	1	1	1
Hospitals	3	3	x	1	x	3	3	x	x
Emergency Housing/Shelter	3	1	3	1	1	1	~~1~~**x**	~~1~~**x**	~~x~~**1**
Libraries	3	3	x	1	1	1	3	x	x
Museums, Art Galleries	3	3	x	1	1	1	3	x	x
Schools,	3	3	x	1	2	2	x	x	x

Public/Private Schools									
Schools, Vocational Schools	3	3	x	2	2	2	2	x	2
Storage of Gravel and Equipment for Street Construction (Permanent)	x	x	x	1	x	x	3	1	3
Designated Camping Area (¤)	x	x	x	1	x	x	x	1	x
Zoo	x	x	x	1	x	x	x	x	x

NOTES:

1. (•) The facility must be sited in accordance with Chapter 20.176, or, in the case of preemption, such other applicable process established by law, before proceeding with Level III conditional use review.
2. (¤) Refers to an area designated in accordance with Chapter 9.18.

20.100.040 F Residential.

Land Uses	**RN**	**RM**	**MHC**	**PR**	**CC**	**CH**	**I/LC**	**IH**	**AD**
Accessory Dwelling Unit, Attached (*)	1	1	1	x	x	x	x	x	x
Accessory Dwelling Unit, Detached (*)	1	1	1	x	x	x	x	x	x
Adult Family Home	1	1	1	1	x	x	x	x	x
Animals	See Chapter **20.130**								
Boarding House (*)	2	1	1	x	x	x	x	x	x
Congregate Care Facility (*)	3	3	3	3	1	1	x	x	x
Conversion of Historic Structures to Nonresidential Use	See Chapter **20.146**								
Cottage	1	1	1	x	x	2	x	x	x

Housing (*) – See Chapter **20.117**									
Detached Single-Family Dwelling	1	1	See Chapter **20.184**	x	x	x	x	x	x
Dwelling Unit, Security Personnel	x	x	1	x	x	1	1	1	1
Duplex, Triplex and Fourplex (*)	1	1	x	x	x	See Chapter **20.169**	x	x	x
Garage Sales (*)(1)	1	1	1	1	1	1	x	x	x
Group Housing for Persons with a Disability (6 or fewer clients) (*)	1	1	1	1	x	x	x	x	x
Group Housing for Persons with a Disability (More than 6 clients) (*)	3	1	3	1	x	x	x	x	x
Home Occupations (*)	See Chapter **20.122**								
Manufactured Home Parks (*)	3	2	1	x	x	1	x	x	x
Mobile Home (*) or Manufactured Homes (*) (2)	1	1	1	x	x	x	x	x	x
Multifamily Dwelling (*)	See Section **20.50.020**	1	x	2	2	See Chapter **20.169**	x	x	x
Nursing Care Home (9 or fewer	3	2	2	2	2	2	x	x	x

clients) (*)									
Nursing Care Facility (10 or more clients) (*)	3	3	3	3	3	3	x	x	x
Permanent Supportive Housing (*)	3	3	3	x	3	3	x	x	x
Manufactured Home Parks (*)	3	2	1	x	x	1	x	x	x
Planned Residential Development (Level 4 Review)	See Title 19, Subdivisions Code								
Residential Use, Commercial Districts (3)	x	x	x	x	1	1	1	x	x
Small Satellite Dish Antennas	See Chapter **20.170**								
Short-Term Rental Type 1 (Principal Residence)	1	1	1	x	1	1	x	x	x
Short-Term Rental Type 2 (Not Owner-Occupied)	x	x	x	x	1	1	x	x	x
Stacked Flat (*)	1	1	x	x	x	See Chapter **20.169**	x	x	x
Tiny Home (*)	1	1	1	x	x	2	x	x	x
Townhouse (*)	1	1	x	2	x	See Chapter **20.169**	x	x	x
Transitional Housing (*)	3	3	3	x	~~3~~ **1**	~~3~~ **1**	~~3~~ **1**	x	x

NOTES:

1. No residential premises shall have more than four per year for a total of twelve days a year. See Section 20.118.060.
2. Subject to specific development standards. See Division V.
3. Second story and above, except**:** ~~that all floors of~~
   a. ~~h~~**H**otels and motels located in the Central Commercial Zone ~~can be~~ converted to residential use~~.~~**, and**
   b. Existing buildings in the Central Commercial Zone, when a reduction or waiver based on the merits of the project is issued. Commercial uses along the street facing public frontage, with residential in the rear of the building, will be prioritized by staff when reviewing requests.

20.106.010 Purpose and intent.

The purpose of this chapter is to ~~carry out the objectives and policies of the comprehensive plan with respect to "critical areas and the natural environment" and "preservation and enhancement of trees";~~ to maintain and enhance the urban forest as an important asset to the community ~~as expressed in the comprehensive plan~~; to provide landscaping and screening regulations which will promote a well balanced, healthy, aesthetically pleasing environment for city residents and visitors. Specifically, the regulations contained in this chapter are intended to accomplish the following:

A. Maintain and enhance property values;
B. Enhance air quality by preserving tree quality and planting new trees;
C. Provide adequate buffers between differing land uses;
D. Mitigate the effects of noise, light, glare, heat, wind and other adverse impacts;
E. Improve the character and appearance of the city;
F. Reduce erosion and stormwater runoff;
G. Increase opportunities to provide a balanced habitat for wildlife which can be maintained in an urban setting;
H. Promote public health, safety and comfort through the retention and planting of trees;
I. Work in harmony with the Shoreline Master Program and Critical Areas Ordinance;
J. Soften the visual impacts of paved surfaces; and
K. Improve safety by helping to separate pedestrians from vehicular traffic.
(Ord. 2012-09 § 45, 2012)

Chapter 20.110 Fences and Retaining Walls.

20.110.030 Permit, required when.

All fences anywhere on a lot are subject to **the** provisions of this chapter and require a fence permit prior to construction. Fence permits are to be processed under Level I procedures. **Retaining walls over 48" anywhere on a lot are subject to the provisions of this chapter and require a building permit.**

20.110.040 General standards.

A. Fences **and retaining walls** shall not conflict with requirements for clearview triangle in Chapter 20.114. For public safety reasons, no variances from these provisions shall be applied for or permitted.
B. Fences **and retaining walls** shall always be required to be built on private property and never on public right-of- way. Private property lines may be a considerable distance from street surfaces or curb lines.
C. It shall be the property owner's responsibility and obligation to identify the property line when proposing to construct a fence **or retaining wall** on said property line. A property survey may be required.
D. All fences **and retaining walls** shall be constructed and maintained in a structurally sound manner. Fences which are structurally unsound and/or hazardous are subject to abatement.
E. **Fences and retaining walls shall be constructed and maintained of materials commonly used in standard construction.** Fences may ~~be constructed of~~ **include** wood, masonry, **and** wire ~~or similar materials employed by standard building practice:~~**. Retaining walls may include masonry, stone or concrete.** ~~Fences~~ **Neither** shall ~~not~~ be **constructed** ~~made~~ of ~~tires or similar~~ salvage materials not originally designed **for use** as structural components of fences**, retaining walls,** or buildings.
F. All fences seven feet and taller shall require a building permit, as well as a fence permit.

20.127.007 Exemptions.
The provisions of this code, as it pertains to the required number of parking spaces, shall not apply to the following:
A. A building undergoing a change of use from nonresidential to a residential use or a change of use for a commercial use.
B. Child care center, as defined in RCW 43.216.010.
C. Commercial spaces under three thousand square feet.
D. Ground level nonresidential space in a mixed-use building.
E. Residences under one thousand two hundred square feet.
F. The following land uses:
1. Affordable housing,
2. Senior housing/congregate care facility,
3. Transitional housing.
G. Tree retention, when such compliance would make the development infeasible. This section does not apply to requirements for parking spaces permanently marked for the exclusive use of individuals with disabilities in compliance with the Americans with Disabilities Act.
H. Downtown, as defined by the boundaries in the Walla Walla Comprehensive Plan Land Use Map.

20.134.130 Inadvertent discovery of archaeological and cultural resources.

When an unanticipated discovery of protected cultural material (e.g., bones, shell, stone tools, beads, ceramics, old bottles, hearths, etc.) or human remains are discovered, the permittee(s) for any building or grading permit secured in accordance with this title shall immediately stop all work, completely secure the location, and contact the Washington State Department of Archaeology and Historic Preservation and other contacts as identified in the inadvertent

discovery plan and procedures made available by the city of Walla Walla **community** development ~~services~~ department. The individual or representative whom the permit was issued to must send written notification of the inadvertent discovery to the city of Walla Walla **community** development ~~services~~ department.

20.139.040 Application requirements.

In addition to the general application requirements of the designated review level, applicants for a short-term rental permit and license and yearly renewals must pay the fees stated herein and provide the following additional information as required on the forms provided by the city. Applications which do not include all required information shall be deemed incomplete within twenty-eight days from application submittal. After applicant's notice of incomplete application is deemed received, application must be complete within thirty days or nonconforming uses will be deemed abandoned as outlined in Section 20.139.100(E).

A. Verification that lodging and business taxes through the previous quarter from the expiration date have been remitted to the Washington State Department of Revenue for an existing short-term rental. If applying for a new short-term rental, then verification of lodging taxes will be done at the annual renewal of the license.

B. The application fee for a short-term rental permit is one hundred fifty dollars. There shall also be an additional license fee.

C. The annual renewal fee for a short-term rental permit is one hundred fifty dollars. There shall also be an additional license fee.

D. Statement that required parking spaces are available on the subject property. A parking layout shall be shown on the submitted site plan of the subject property.

E. Acknowledgment of receipt and review of a copy of the good neighbor guidelines. In addition, evidence that the good neighbor guidelines have been effectively relayed to short-term rental tenants through the rental contract or posting online or providing in a conspicuous place in the dwelling unit, or other similar method. This will be verified at the inspection.

F. Provide information identifying all websites and other locations where availability of the short-term rental is posted (such as VRBO/Air BNB/etc.) or advertised and any listing number(s). (The city issued permit and license number(s) must be part of any posting or advertisement of the short-term rental.)

G. Such other information the **community** development ~~services~~ director or designee deems reasonably necessary to administer this chapter.

20.139.070 Violation and repeat offenses.

A. It is unlawful to rent, offer for rent, or advertise for rent a dwelling unit located on any property within the city as a short-term rental without a permit and license authorizing such use that has been approved and issued in the manner required by this chapter.

B. Failure of the owner or the authorized agent or local contact of a short-term rental to respond to a nuisance complaint to the Walla Walla police department arising out of the occupancy and use of the short-term rental by a tenant, or the tenant's visitors or guests, is a violation and will be fined as follows:

1. First call and violation received no charge;
2. Second call and violation received seven hundred fifty dollars;

3. Third call and violation received one thousand dollars; and

4. Fourth call and violation received permit and license revoked.

C. In addition to any other remedy provided by this chapter, a short-term rental permit and license issued pursuant to this chapter may be suspended, modified, or revoked for violations of this chapter, for violation of any other law on the premises of the short-term rental, or for the maintenance of such other conditions as may be shown to be injurious to the public health and safety.

D. A violation of Chapter 10.13, Stopping, Standing and Parking, as well as Title 8, Health and Safety.

E. Violation of this chapter shall be processed as outlined in Chapter 20.42.

1. The **community** development ~~services~~ director shall determine whether a short-term rental permit and license should be suspended, modified, or revoked, and notify the applicant of that determination in writing.

2. The **community** development ~~services~~ director's determination under subsection (E)(1) of this section shall be appealable to the Walla Walla hearing examiner as provided in Chapter 20.38.

F. Violation of this chapter is additionally declared to be a nuisance.

20.139.100 Elimination of type 2 short-term rentals.

A. Short-term rental type 2 is not a permitted use in the city of Walla Walla.

B. Only those type 2 short-term rentals that were lawfully established and existing as of November 9, 2017, will be allowed as nonconforming uses. Such uses may not be significantly changed, altered, extended, or enlarged and must cease as provided herein. A use shall not be considered lawfully established and existing unless the owner proves all of the following:

1. That a location was used for short-term rental use during 2017 prior to November 9th;

2. That the use was continuing as of November 9, 2017, and not merely intermittent or occasional;

3. That the owner registered the short-term rental use and obtained a business registration card from the city of Walla Walla in accordance with Chapter 20.142 before November 9, 2017; and

4. That all applicable taxes were fully and timely paid for all short-term rental use that occurred prior to November 9, 2017.

C. Type 2 short-term rentals established and existing as of November 9, 2017, must obtain a short-term rental permit and license, and must apply for such permit and license by no later than February 1, 2018. In addition to the information required by Chapter 20.14 and Section 20.139.040, the applicant must provide proof of a lawfully established and existing short-term type 2 rental use predating November 9, 2017, as provided in subsection B of this section and the scope and extent of such use. Failure to timely apply for a short-term rental permit and license or to provide proof of lawful use shall be conclusive evidence that such use was not lawfully established or existing as of November 9, 2017, and neither a permit nor a license shall be issued for such locations.

1. The **community** development ~~services~~ director shall determine whether a type 2 short-term rental use was lawfully established and existing as of November 9, 2017, and notify the applicant of that determination in writing.

2. The **community** development ~~services~~ director's determination under subsection (C)(1) of this section shall be appealable to the Walla Walla hearing examiner as provided in Chapter 20.38.

D. Type 2 short-term rentals must meet the requirements of Sections 20.139.040 and 20.139.050(B) through (J). Failure to satisfy such requirements shall be grounds for imposition of penalties and suspension, modification or revocation of permits and licenses as provided in Section 20.139.070. Revocation of a short-term rental permit or license for noncompliance shall terminate any right to continue type 2 short-term rental use; such use must immediately cease upon permit or license revocation, and type 2 short-term rental uses may not be reestablished at such locations.

E. Permits and licenses for short-term rentals must be timely renewed each year. Renewal applications must provide proof that type 2 short-term rental use continued throughout the preceding year. Type 2 short-term rental use must cease if such use has been discontinued or abandoned. Intent to discontinue and abandon a type 2 short-term rental use shall be presumed if a location was not rented at least a total of twenty-nine days during the preceding year. An owner may rebut such presumption by presenting proof that the failure to sufficiently rent a location was due to conditions over which the owner had no control. Discontinued and abandoned uses may not be reestablished, and no permit or license for a discontinued or abandoned type 2 short-term rental use shall be renewed.

1. The **community** development ~~services~~ director shall determine whether a type 2 short-term rental use has been discontinued or abandoned, and notify the applicant of that determination in writing.

2. The **community** development ~~services~~ director's determination under subsection (E)(1) of this section shall be appealable to the Walla Walla hearing examiner as provided in Chapter 20.38.

F. Type 2 short-term rental use must cease if a location is not rented for short-term use for six consecutive months or more. When a location is not rented for type 2 short-term use for six consecutive months or more, the use shall be deemed vacated even if the use has been unintentionally vacated.

1. The **community** development ~~services~~ shall determine whether a type 2 short-term rental use has been vacated, and notify the applicant of that determination in writing.

2. The **community** development ~~services~~ director's determination under subsection (F)(1) of this section shall be appealable to the Walla Walla hearing examiner as provided in Chapter 20.38.

G. Taxes and fees for type 2 short-term rental uses must be timely and fully paid. Failure to timely and fully pay any applicable taxes or fees shall be deemed discontinuance of type 2 short-term rental use, and such use must immediately cease. Type 2 short-term rental uses may not be reestablished at such locations until delinquent taxes and fees are fully paid.

20.170.032 Permit applications.

Any wireless communication service provider wishing to receive authorizations and permits to develop and operate a wireless communication facility or a person wishing to receive authorizations and permits to develop and operate an amateur radio tower in the city of Walla Walla shall submit an application package to city **community** development ~~services~~ that contains the following information:

A. A permit application signed by the property owner.
B. Name, address, contact person, and contact information for the entity seeking authorization and permits, including copies of all current licenses and authorizations required to provide wireless communications services in the city of Walla Walla.
C. Complete description, including technical diagrams and specifications, photos, depictions, and plans of the proposed wireless communications facility or facilities, and a complete description of the services to be provided by such facilities.
D. A site map depicting the location of the proposed facility and drawings or renderings depicting the antenna support structure or alternative antenna support structure and its appearance from street level from north, south, east, and west perspectives. The drawings should be produced with the purpose of showing the proposed facility from adjacent and nearby properties as it will appear when completed, including any proposed features to conceal, camouflage, or visually blend the proposed facility into its surroundings.
E. A complete discussion of the following:
1. Why the applicant selected the proposed site, including technical analysis, which explains why other sites are not satisfactory for the proposed facility;
2. If the applicant is proposing a site with no other wireless communications facilities present, explain why co-location is not technically feasible, unavailable, or is otherwise unsuitable;
3. A comparison of the service to be provided by the proposed facility services provided by the applicant's other facilities in the city, including service features, coverage or capacity needs, plans for new or added services, potential interference with radio transmissions for emergency services, and related service issues; and
4. A description of stealth design and technology and their availability to conceal, camouflage, or visually blend the proposed facility into its surroundings, and an explanation why certain stealth design technology were selected or not selected as part of the proposed facility.
F. The application fees required in Section 20.170.035.
G. Such other information and materials that may be required.

20.171.070 New poles in the rights-of-way for small wireless facilities and installations in a design zone.

A. New poles within the rights-of-way are only permitted if the applicant can establish that:
1. The proposed small wireless facility cannot be located on an existing utility pole or light pole, electrical transmission tower or on a site outside of the public rights-of-way such as a public park, public property, building, transmission tower or in or on a nonresidential use in a residential zone whether by roof or panel-mount or separate structure;
2. The proposed small wireless facility receives approval for a concealment element design, as described in subsection C of this section;
3. The proposed small wireless facility also complies with the Shoreline Management Act, and SEPA, if applicable; and
4. No new poles shall be located in a critical area or associated buffer required by the city's critical areas code, Chapter 21.04, except when determined to be exempt pursuant to said chapter.
B. An application for a new pole is subject to a Level I review.

C. The concealment element design shall include the design of the screening, fencing or other concealment technology for a tower, pole, or equipment structure, and all related transmission equipment or facilities associated with the proposed small wireless facility, including but not limited to fiber and power connections.

1. The concealment element design should seek to minimize the visual obtrusiveness of the small wireless facility. The proposed pole or structure should have similar designs to existing neighboring poles in the rights-of-way, including similar height to the extent technically feasible. If the proposed small wireless facility is placed on a replacement pole in a design zone, then the replacement pole shall be of the same general design as the pole it is replacing, unless the **community** development ~~services~~ department otherwise approves a variation due to aesthetic or safety concerns. Any concealment element design for a small wireless facility on a decorative pole should attempt to mimic the design of such pole and integrate the small wireless facility into the design of the decorative pole. Other concealment methods include, but are not limited to, integrating the installation with architectural features or building design components, utilization of coverings or concealment devices of similar material, color, and texture, or the appearance thereof, as the surface against which the installation will be seen or on which it will be installed, landscape design, or other camouflage strategies appropriate for the type of installation.

Applicants are required to utilize designs in which all conduit and wirelines are installed internally in the structure. Further, applicant designs should, to the extent technically possible, comply with the generally applicable design standards adopted pursuant to Section 20.171.060.

2. If the director has already approved a concealment element design either for the applicant or another small wireless facility along the same public right-of-way or for the same pole type, then the applicant shall utilize a substantially similar concealment element design, unless it can show that such concealment element design is not physically or technologically feasible, or that such deployment would undermine the generally applicable design standards.

D. Even if an alternative location is established pursuant to subsections (A)(1) and (2) of this section, the director may determine that a new pole in the right-of-way is in fact a superior alternative based on the impact to the city, the concealment element design, the city's Comprehensive Plan and the added benefits to the community.

E. Prior to the issuance of a permit to construct a new pole or ground-mounted equipment in the right-of-way, the applicant must obtain a site-specific agreement from the city to locate such new pole or ground-mounted equipment. This requirement also applies to replacement poles that are higher than the replaced pole, and the overall height of the replacement pole and the proposed small wireless facility is more than sixty feet.

F. These design standards are intended to be used solely for the purpose of concealment and siting. Nothing herein shall be interpreted or applied in a manner which dictates the use of a particular technology. When strict application of these requirements would unreasonably impair the function of the technology chosen by the applicant, alternative forms of concealment or deployment may be permitted which provide similar or greater protections of the streetscape.

20.178.050 Building height.

1. All structures in the downtown area that front Rose **Street**, Main **Street**, ~~and~~ Alder Street~~s~~ and Second Avenue shall be at least two full stories above sidewalk level~~, and~~**.** ~~m~~**M**ultiple stories are encouraged. The main level of a structure shall generally be at sidewalk level, and no split-level

structures or split-entry malls are permitted. Balconies and cantilevers are permitted subject to applicable permits to occupy **the** right-of-way.

2. Buildings fronting on other streets not identified in (1) above may be ~~S~~**s**ingle-story buildings **but** must be designed and built to be structurally capable of supporting at least one additional level.

20.184.060 Final manufactured home park plan approval.

Following hearing examiner approval, the developer shall submit the final manufactured home park plan. The final manufactured home park plan shall consist of an official survey of the exterior boundaries, roads, manufactured home spaces and common areas. Utility systems shall be stamped by a certified engineer.

A. The plan shall also include all items required in Section 20.184.040.

B. The plan shall provide certification of approval of the **community** development ~~services~~ director and the city engineer after review by the SPRC.

Title 21 Environment

Chapter 21.08 State Environmental Policy Act

21.08.120 Preparation of EIS – Additional considerations.

A. Preparation of draft and final EIS's and supplemental environmental impact statements (SEIS's) is the responsibility of the **community** development ~~services~~ department under the direction of the responsible official. Before the city issues an EIS, the responsible official shall be satisfied that it complies with this chapter and Chapter 197-11 WAC.

B. The responsible official shall determine whether the draft and final EIS or SEIS shall be prepared by either the applicant or by a consultant. If the responsible official requires an EIS for a proposal and determines that someone other than the applicant will prepare the EIS, the responsible official shall notify the applicant immediately after completion of the threshold determination. When the responsible official determines that an EIS, draft and final or supplemental, is to be prepared by a consultant, then the applicant will be requested to submit the names of two or more consultants whom he or she wishes to prepare the EIS to the responsible official. The responsible official shall have the authority to select the consultant who will prepare the EIS. The responsible official shall also notify the applicant of the city's procedure for EIS preparation, including approval of the draft and final EIS prior to distribution.

C. The city may require an applicant to provide information the city does not possess, including specific investigations. However, the applicant is not required to supply information that is not required under this chapter or that is being requested from another agency.

21.08.140 Designation of department to perform consulted agency responsibilities for the city.

A. The **community** development ~~services~~ department shall be responsible for preparation of written comments for the city in response to a consultation request prior to a threshold determination, participation in scoping, or reviewing a DEIS.
B. The **community** development ~~services~~ department shall be responsible for the city's compliance with WAC 197-11-550 whenever the city is a consulted agency and is authorized to develop operating procedures that will ensure that responses to consultation requests are prepared in a timely fashion and include data from all appropriate departments of the city.

21.08.170 Appeals.

A. The city establishes the following administrative appeal procedures under RCW 43.21C.075 and WAC 197-11-680:

1. Pursuant to RCW 43.21C.060, the city of Walla Walla formally eliminates appeals to the city council.

2. No administrative SEPA appeal is allowed for Level III, Level IV, Level V, or Level VI proposals except as provided in subsection (A)(4) of this section.

3. An administrative appeal of SEPA determinations on Level I and Level II proposals may be made to the Walla Walla hearing examiner as provided herein.

   a. Appeal of intermediate steps under SEPA (e.g., lead agency determination, scoping, draft EIS adequacy) shall not be allowed.

   b. Appeals on SEPA procedures shall be limited to review of a final threshold determination and/or final EIS. Only one administrative appeal is allowed, and successive administrative appeals on these issues are not allowed; provided, however, that this limitation does not apply to administrative appeals before another agency.

   c. Appeals must be consolidated with an appeal of the development ~~authorization~~ decision and proceed as provided in Chapter 20.38 of this code. SEPA determinations shall be appealable only upon issuance of the final development ~~authorization~~ decision.

   d. Procedural determinations by the responsible official shall be entitled to substantial weight.

   e. A record for an appeal shall be prepared by the **community** development ~~services~~ department and made available for public review and copying at least seven calendar days prior to the appeal hearing.

   f. An appeal of a SEPA determination under this subsection must be filed within fourteen calendar days after service of the notice of decision/action for the proposal under Section 20.14.090 is deemed complete under Section 20.14.050 or Section 20.14.055. If Section 20.14.090 requires notice to be given by more than one method, the appeal period shall commence on the earliest date that the appellant is deemed to receive any of the methods of notice. Appeals must be filed with the **community** development ~~services~~ department before 5:00 p.m. on the last business day of the appeal period.

4. An administrative SEPA appeal is allowed for Level III, Level IV, Level V, or Level VI proposals as provided herein.

   a. The following SEPA determinations on Level III, Level IV, Level V, or Level VI proposals may be appealed to the Walla Walla hearing examiner:

      i. A determination of significance;

ii. A procedural determination made by the city responsible official when the city is a project proponent on a Level III or Level IV proposal, or is funding a Level III or Level IV project proposal, and chooses to conduct its review under SEPA, including any appeals of its procedural determinations, prior to submitting an application for a project permit. Subsequent appeals of substantive determinations by an agency with jurisdiction over the proposal shall be allowed under the SEPA appeal procedures of the agency with jurisdiction; and

iii. A procedural determination made by the responsible official on a nonproject action.

b. Appeal of intermediate steps under SEPA (e.g., lead agency determination, scoping, draft EIS adequacy) shall not be allowed.

c. Appeals of determinations of significance and appeals of procedural determinations on nonproject actions shall be decided prior to the public hearing upon the proposal for which the determination(s) were made and shall not be consolidated with the open record hearing on the proposal. Such appeals shall proceed as provided in Chapter 20.38 of this code. A copy of the administrative appeal decision shall be provided to the approving authority by no later than the time of hearing on the proposal.

d. Hearings upon appeals under subsection (A)(4)(a)(ii) of this section must be consolidated with the open record hearing on the proposal as provided in Section 20.14.030. Such appeals shall proceed as provided in Chapter 20.38 of this code.

e. Procedural determinations by the responsible official shall be entitled to substantial weight.

f. A record for an appeal shall be prepared as provided in RCW 43.21C.075(3).

g. An appeal of a SEPA determination under this subsection must be filed within fourteen calendar days after the determination is made without regard to the date of service of notice of the determination. Appeals must be filed with the **community** development ~~services~~ department before 5:00 p.m. on the last business day of the appeal period.

B. The administrative appeal procedures provided herein must be used before anyone may initiate judicial review of any SEPA issue that could have been reviewed hereunder.

21.08.173 Notice – Statute of limitations.

A. The city, applicant for, or proponent of, any action may publish a notice of action pursuant to RCW 43.21C.080 for any action.

B. The form of the notice shall be substantially in the form provided in WAC 197-11-990. The notice shall be published by the **community** development ~~services~~ department, applicant or proponent pursuant to RCW 43.21C.080.

21.10.010 Authorization.

RCW 35A.63.100 authorizes the Walla Walla city council, by ordinance or other action ~~to the extent the Walla Walla city council~~ deem**ed**~~s~~ necessary or appropriate, to ~~implement or give effect to the comprehensive plan or parts thereof in developing the city of Walla Walla and in regulateing the use of~~ land **within the city.**

21.10.050 Definitions.

Unless specifically defined in this section, words or phrases used in this chapter shall be interpreted so as to give them the meaning they have in common usage and to give this chapter its most reasonable application:

"Administrator" (known and referred to alternatively herein as the " **community** development ~~services~~ director," ~~"development services manager,"~~ "director," or "zoning administrator") means the director of the **community** development ~~services~~ department or such other person to whom the city manager assigns the primary responsibility of administering and enforcing this code, and such other staff granted authority to act on behalf of director.

"Appeal" means a request for a review of the administrator's interpretation of any provision of this chapter or a request for a variance.

"Area of shallow flooding" means a designated AO or AH zone on the flood insurance rate map (FIRM). The base flood depths range from one to three feet; a clearly defined channel does not exist; the path of flooding is unpredictable and indeterminate; and velocity flow may be evident. AO is characterized as sheet flow and AH indicates ponding.

"Base flood" means the flood having one percent chance of being equaled or exceeded in any given year.

"Basement" means any area of the building having its floor sub-grade (below ground level) on all sides.

"Development" for the purposes of administering this code means any manmade change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations, or the storage of equipment or materials, located within the area of special flood hazard.

"Elevated building" means, for insurance purposes, a nonbasement building that has its lowest elevated floor raised above ground level by foundation walls, shear walls, post, piers, pilings, or columns.

"Existing manufactured home park or subdivision" means a manufactured home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including, at a minimum, the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads) is completed before the effective date of the adopted floodplain management regulations.

"Expansion to an existing manufactured home park or subdivision" means the preparation of additional sites by the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads).

"Flood" or "flooding" means a general and temporary condition of partial or complete inundation of normally dry land areas from the unusual and rapid accumulation of runoff of surface waters from any source.

"Flood insurance rate map (FIRM)" means the official map on which the Federal Insurance Administration has delineated both the areas of special flood hazards and the risk premium zones applicable to the community.

"Flood insurance study (FIS)" means the official report provided by the Federal Insurance Administration that includes flood profiles, the Flood Insurance Rate Maps, and the water surface elevation of the base flood.

"Floodway" means the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot.
"Lowest floor" means the lowest floor of the lowest enclosed area (including basement). An unfinished or flood resistant enclosure, usable solely for parking of vehicles, building access or storage, in an area other than a basement area, is not considered a building's lowest floor; provided, that such enclosure is not built so as to render that structure in violation of the applicable nonelevation design requirements of this code.
"Manufactured home" means a structure, transportable in one or more sections, which is built on a permanent chassis and is designed for use with or without a permanent foundation when connected to the required utilities. For floodplain management purposes "manufactured home" also includes park trailers, travel-trailers and other similar vehicles placed on a site for greater than one hundred eighty consecutive days. For insurance purposes, "manufactured home" does not include park trailers, travel trailers and other similar vehicles.
"Manufactured home park or subdivision" means a parcel (or contiguous parcels) of land divided into two or more manufactured home lots for rent or sale.
"New construction" means structures for which the "start of construction" commenced on or after the effective date of the ordinance codified in this chapter.
"New manufactured home park or subdivision" means a manufactured home park or subdivision for which the construction of facilities for servicing the lots on which the manufactured homes are to be affixed (including, at a minimum, the installation of utilities, the construction of streets, and either final site grading or the pouring of concrete pads) is completed on or after the effective date of adopted floodplain management regulations.
"Obstruction" means any dam, wall, wharf, embankment, levee, dike, pile, abutment, projection, excavation, channel rectification, bridge conduit, culvert, building, wire, fence, rock travel, refuse, fill, structure or matter in, along, across, or projecting into any channel, watercourse, or regulatory flood hazard area which may impede, retard or change the direction of flow of water, either in itself or by catching or collecting debris carried by such water, or that is placed where the flow of water might carry the same downstream to damage of life or property.
"Recreational vehicle" means a vehicle (1) built on a single chassis; (2) four hundred square feet or less when measured at the largest horizontal projection; (3) designed to be self-propelled or permanently towable by a light duty truck; and (4) designed primarily not for use as a permanent dwelling but as temporary living quarters for recreational, camping, travel, or seasonal use.
"Special flood hazard area" means the land in the floodplain within a community subject to a one percent or greater chance of flooding in any given year.
"Start of construction" includes substantial improvement, and means the date the building permit was issued, provided the actual start of construction, repair, reconstruction, placement or other improvement was within one hundred eighty days of the permit date. The actual start means either the first placement of permanent construction of a structure on a site, such as the pouring of slab or footings, the installation of piles, the construction of columns, or any work beyond the stage of excavation; or the placement of a manufactured home on a foundation. Permanent construction does not include land preparation, such as clearing, grading and filling; nor does it include the installation of streets and/or walkways; nor does it include excavation for a basement, footings, piers, or foundations or the erection of temporary forms. For a substantial improvement, the actual start of construction means the first alteration of any wall, ceiling, floor,

or other structural part of a building, whether or not that alteration affects the external dimensions of the building.
"Structure" means a walled and roofed building, including a gas or liquid storage tank that is principally above ground. Manufactured homes are considered structures.
"Substantial damage" means damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed fifty percent of the market value of the structure before the damage occurred.
"Substantial improvement" means any repair, reconstruction or improvement of a structure, the cost of which equals or exceeds fifty percent of the market value of the structure either:

1. Before the improvement or repair is started; or
2. If the structure has been damaged and is being restored, before the damage occurred. For the purposes of this definition "substantial improvement" is considered to occur when the first alteration of any wall, ceiling, floor, or other structural part of the building commences, whether or not that alteration affects the external dimensions of the structure.

The term does not, however, include either:

1. Any project for improvement of a structure to comply with existing state or local health, sanitary, or safety code specifications which have been previously identified by the local code enforcement official and which are solely necessary to assure safe living conditions; or
2. Any alteration of a structure listed on the National Register of Historic Places or a State Inventory of Historic Places.

"Water-dependent" means a structure for commerce or industry that cannot exist in any other location and is dependent on the water by reason of the intrinsic nature of its operations.

21.10.070 Special flood hazard area – Established.

The areas of special flood hazard, as may be annexed to the city of Walla Walla, identified by the Federal Insurance Administration in a scientific and engineering report entitled, "The Flood Insurance Study for the Unincorporated Areas in Walla Walla County," dated January 18, 2002, or as amended, with accompanying flood insurance rate maps (FIRM) is adopted by reference and declared to be a part of this chapter. The flood insurance study and FIRM are on file at the **community** development ~~services~~ department.

Section 2: Legislative Findings:

1. The Walla Walla City Council finds that the municipal code amendments adopted by this Ordinance and the Comprehensive Plan as adopted by Ordinance No. 2026-XX conform to the requirements of Chapter 36.70A RCW and are consistent with and implement the Walla Walla Comprehensive Plan Update 2046.
2. The Walla Walla City Council finds that the amendments adopted herein advance state interests which are stated in RCW 36.70A.010 and in the policies, goals, and other provisions of the City of Walla Walla's comprehensive plan, as amended. The specific policies supporting the amendments are as follows:

Goal or Policy	

Community Character 4.1	Carefully protect and enhance Downtown's visual character, the most important single aspect of the city's identity, through historic preservation activities, complementary infill development, and sensitively designed public works.
Land Use Policy 1.1	Accommodate new residential and commercial development in areas with available infrastructure and services.
Land Use Policy 1.4	The City will coordinate with Walla Walla County to plan for the delivery of urban services within unincorporated UGAs prior to annexation.
Land Use Policy 1.5	The City supports Walla Walla County's goal that, where feasible, all land within unincorporated Urban Growth Areas will be annexed to the City or incorporated within the 20-year planning horizon.
Land Use Policy 1.6	Encourage infill development that provides additional housing in the city.
Land Use Policy 2.2	Coordinate planning in the Urban Growth Area with Walla Walla County to ensure orderly, sustainable development consistent with City standards, and discourage development of subdivisions using septic systems and private water systems.
Land Use Policy 3.7	Support a variety of housing types such as tiny homes, duplexes, multi-family development, cottage housing, and single-family residential.
Housing Policy 1.1	Provide an array of housing choices such as apartments, small lot single-family housing, accessory dwelling units, townhomes, manufactured homes, and cottages to meet the needs of people of all incomes throughout their lifespan.
Economic Development Policy 5.1	Regularly review development regulations, evaluate the impact of regulations, and the needs of local businesses.

3. The Walla Walla City Council finds that this matter was duly scheduled for the City Council's regular meeting for October 14, 2026, in accordance with section 2.05.040 of the Walla Walla Municipal Code, and notice regarding the Council agenda was made publicly available in advance of the meeting. The City Council further finds that proper notice was given and an opportunity for appropriate public participation was provided prior to adoption of this ordinance.

4. The notice given by the City of Walla Walla for the Planning Commission public hearing conducted on September 14, 2026, review by the City Council at their work session on September 21, 2026, and the duly noticed public meeting before the City Council on October 14, 2026, constitutes the City's public participation procedures for this ordinance, which are adopted pursuant to RCW 36.70A.035.

Section 3: Transmittal. Pursuant to RCW 36.70A.106(2) and WAC 365-196-630(4)(a), the City of Walla Walla Development Services Department is hereby directed to transmit a complete and accurate copy of the adopted ordinance or amendment to the Washington State Department of Commerce within ten (10) days of final adoption.

Section 4: Severability. If any part of this ordinance is for any reason declared or held to be invalid or unconstitutional by any court or tribunal of competent jurisdiction, such part shall be deemed a separate and distinct and independent provision, and such holding shall not affect the validity of the remaining parts hereof.

Section 5: Effective Date. This ordinance shall take effect and be in force five days from and after its passage, approval, and publication as provided by law.

Section 6: Publishing. The Walla Walla City Clerk is directed to publish a copy of a summary and notice of adoption of this ordinance as permitted by section 36A.12.160 of the Revised Code of Washington.

Section 7: Correction of Scrivener's Errors. The Walla Walla City Clerk and the codifiers of this ordinance are authorized to make necessary clerical corrections to this ordinance including, but not limited to, the correction of scrivener's/clerical errors, references, ordinance numbering, section/subsection numbers, and any references thereto.

Section 8: Appeals. Notice is hereby given that any petition for review of the City of Walla Walla's comprehensive plan or comprehensive plan map amendment must be filed with the Eastern Washington Growth Management Hearings Board within sixty (60) days following publication of the ordinance, or summary of the ordinance, adopting the amendment, in accordance with Chapter 36.70A RCW.

PASSED by the City Council of the City of Walla Walla, Washington, this 28th day of October 2026.

_____

Mayor

Attest:

_____

City Clerk

Approved as to form:

_____

City Attorney

City of Walla Walla Planning Commission
Development Services
55 E. Moore Street
Walla Walla, WA 99362

CITY OF WALLA WALLA PLANNING COMMISSION
MEETING AGENDA
Monday, September 14, 2026 – 6:30 P.M.
City Hall, Second Floor, Council Chambers
15 N Third Avenue, Walla Walla

Members of the public may also attend and participate in the meeting virtually by using this Zoom meeting link https://bit.ly/4pbogQ1 or may listen to the meeting by calling (253) 215-8782 and entering meeting ID 840 6250 3220.

1. **CALL TO ORDER**

2. **ROLL CALL**

3. **Public Comment**
   Public comments on items not on the agenda.

4. **APPROVAL OF MINUTES**

5. **NEW BUSINESS**
   - **A. Public Hearing-** Draft Implementing Code Amendments for the 2046 Comprehensive Plan and Draft Critical Area Ordinance Code Amendments

6. **STAFF UPDATES**
   - **A.** Vote to cancel the October 5, 2026, meeting and continue with the scheduled meeting on Monday, November 2, 2026.

7. **ADJOURNMENT**

The City of Walla Walla complies with Title VI, ADA, and other applicable Federal civil rights laws and does not discriminate on the basis of race, color, national origin, age, disability, religion, veteran status, sexual orientation, gender identity, or sex. Persons who need auxiliary aids for effective communication are encouraged to make their needs and preferences known to the City of Walla Walla Development Services Department three business days prior to the meeting date so arrangements can be made.

The City of Walla Walla Planning Commission is a seven-member advisory body that provides recommendations to the Walla Walla City Council on the preparation of and amendments to land use plans and related codes such as zoning. Planning Commissioners are appointed by City Council. Actions taken by the Planning Commission are not final decisions; they are in the form of recommendations to the City Council who must ultimately make the final decision.

City of Walla Walla Planning Commission
Development Services
55 E. Moore Street
Walla Walla, WA 99362

CITY OF WALLA WALLA PLANNING COMMISSION
DRAFT MEETING MINUTES
Monday, August 3, 2026 – 6:30 P.M.
Hybrid Meeting – In Person and via *Zoom*
Council Chambers, 15 N 3rd Avenue, Walla Walla

1. CALL TO ORDER

Chair Williams called the meeting to order at 6:30 p.m.

2. ROLL CALL

Members Present: Jim Williams, Chair
Arlene Alen, Member
Kristin Jensen, Member
Liz Jessee, Member
Jeff Strickler, Member
Jennifer Walden, Vice-Chair

Members Excused: John Gahbauer, Member

Staff Present: Emily Arteche, Deputy Director
Jon Maland, Sr. Planner
Pam Ransier, Administrative Permit Coordinator
Monte Willis, Council Liaison

Quorum was established.

3. PUBLIC COMMENT

No members of the public provided comment.

4. APPROVAL OF MINUTES

A. Regular Meeting – July 6, 2026

MOTION: **Commissioner Jenson** moved, and **Commissioner Alen** seconded to approve the regular meeting minutes for July 6, 2026 as presented.
Motion carried 6- 0

5. OLD BUSINESS

A. Comprehensive Plan Update — Commission Action

Chair Williams introduced the Comprehensive Plan Update and outlined the next steps to move the draft plan forward in the approval process, including a recommendation by the Planning Commission to City Council.

MOTION: **Commissioner Strickler** moved, and **Commissioner Walden** seconded to recommend approval of the draft 2046 Comprehensive Plan to the City Council.
Discussion: **Commissioner Jessee** noted that a county document related to extreme

weather is in the process of being revised and the document link from the county's website will be available to include in the final version of the 2046 Comprehensive Plan.

Motion carried 6- 0

B. Emily Arteche, Deputy Director, presented a minor change to the list of upcoming code amendments. This change is related to when the city will accept annexation petitions. The requested amendment was received in Development Services after the July workshop. No action is needed at this time.

6. NEW BUSINESS

A. Critical Area Ordinance Amendments **Workshop**

Ms. Arteche, introduced **Nell Lund,** Senior Ecologist with Facet, the city's consultant for the 10-year Critical Areas Ordinance (CAO) update. Using a PowerPoint presentation, Ms. Lund gave an overview of the CAO and what the ordinance governs. Primarily wetlands, aquifer recharge areas, fish and wildlife conservation areas, frequently flooded areas, and geologically hazardous areas. She stressed the importance of using Best Available Science (BAS) during the update process. **Ms. Arteche** explained that Mill Creek was not included in this work as it is a waterway of the state and is included in the Shoreline Master Program, not the CAO.

Commissioners asked clarifying questions and staff and Ms. Lund responded.

Chair Williams asked staff to provide to the commission as soon as possible any public comments on the amendments received prior to the next meeting.

The final draft of the proposed code amendments will be presented to the Planning Commission September 14, 2026, for recommendation to City Council. The City Council will hold a workshop on the code amendments on September 21, 2026, with action at a future date.

7. STAFF UPDATES

- MC Gateway, a planned community near the airport, is working with the city on a development agreement outlining all aspects of the future development.
- A proposed 14-lot residential development on Fern Avenue will go before the Hearing Examiner on August 13, 2026.
- A variance request for a subdivision on E Sumach Street will also go before the Hearing Examiner on August 13. The variance is related to access to a 15-lot subdivision with geographical constraints that prevent a second access point. This variance was originally approved in 2023 but expired before the development could move forward.
- Staff are finalizing a binding site plan for the WinCo property that will create eight building pads.
- Shoreline review is underway for bridge replacement projects at 4th Avenue and 6th Avenue.
- Staff are working on the environmental review for a planned community located near Highway 125, south Myra Road and Village Way.

8. ADJOURNMENT

MOTION: **Commissioner Jessee** moved, and **Commissioner Jessen** seconded to adjourn.

Motion carried 6- 0

Meeting adjourned at 7:15 p.m.

2026 Draft Comprehensive Plan Implementing Code Amendments
Level V Review Staff Report
File# PLN5-26-0001

I. GENERAL INFORMATION:

Application Date: June 29, 2026

Public Hearing Date: September 14, 2026

Applicant: City of Walla Walla Development Services
55 E Moore Street, Walla Walla, WA 99362

Amendment Description:
Walla Walla Municipal Code (WWMC) Text Amendments to implement the Walla Walla Comprehensive Plan 2046. The proposed code amendments would apply citywide. Amendments are proposed to the following Municipal Code sections:

Title 2: Administration

Code Section	Amendment Summary	Category
Chapter 2.17 City Departments		
2.17.010 Created 2.17.070 City Departments	Renames the "development services" department to the "community development" department.	Outdated
Chapter 2.27 Historic Preservation Commission		
2.27.040(G) Historic Preservation Commission	Renames the "development services" department to the "community development" department.	Outdated
Chapter 2.28 Multifamily Housing Tax Incentives		
2.28.050(A) Application Procedure 2.28.060 Application review and issuance of conditional twelve-year certificate.	Renames the "development services" department to the "community development" department.	Outdated

Title 3: Revenue and Finance

Code Section	Amendment Summary	Category
Chapter 3.23 Trust Funds		
3.23.130(A) Code enforcement revolving fund	Renames the "development services" department to the "community development" department.	Outdated

Title 5: Business Licenses and Regulations

Code Section	Amendment Summary	Category
Chapter 5.02 Telecommunications – Small Wireless Facilities		
5.02.450 (A-B) Application process 5.02.470(B and G) Review process 5.02.500(A) Consolidated permit	Renames the "development services" department to the "community development" department.	Outdated
Chapter 5.04 Mobile Vendors		
5.04.020 Mobile and street vendor – License required	Renames the "development services" department to the "community development" department.	Outdated
Chapter 5.05 General Business License		
5.05.050(A) Business license application, renewal, delinquency, and cancellation 5.05.120 Rules and regulations	Renames the "development services" department to the "community development" department.	Outdated
Chapter 5.09 Pawnbrokers and Secondhand Dealers		
5.09.015 Fixed place of business required – Development permit	Renames the "development services" department to the "community development" department.	Outdated

Title 10: Vehicles and Traffic

Code Section	Amendment Summary	Category
Chapter 10.17 Construction Parking Permits		
10.17.010 (A-B) Issuance of construction vehicle parking permits	Renames the "development services" department to the "community development" department.	Outdated

10.17.040 Penalties		
Chapter 10.27 Special Event Permits		
10.27.040 (F) Definitions	Renames the “development services” department to the “community development” department.	Outdated

Title 12: Streets and Sidewalks

Code Section	Amendment Summary	Category
Chapter 12.14 Downtown Development and Care Standards		
12.14.040(B) Public fixtures and street furniture, standardized design and location	Renames the “development services” department to the “community development” department.	Outdated
Chapter 12.64 Street Addressing		
12.64.020 Official Map	Clarifies the name of the comprehensive plan Future Land Use Map.	Clarification

Title 13: Water and Sewers

Code Section	Amendment Summary	Category
Chapter 13.03 Sewer Utility – Regulations and Rates		
13.03.601 (A-C) Service – Provided Where	Clarifies that single-family residences and other approved uses in the UGA may be connected to city sewer, with City Manager approval.	Clarification
Chapter 13.04 Water Utility – Regulations and Rates		
13.04.040 (A-C) Service – Provided Where	Clarifies that single-family residences and other approved uses in the UGA may be connected to city water, with City Manager approval.	Clarification
13.04.150 (A-B) Service – Extension outside city limits – Furnished when	Clarifies when water service may be provided to properties outside city limits and the associated requirements.	Clarification
Chapter 13.05 Water System Cross-Connection Control		
13.05.060 (D)(1)(a) Backflow prevention requirements	Renames the “development services” department to the “community development” department.	Outdated

Chapter 13.07 Cottonwood Trunk System Special Charge		
13.07.020 Cottonwood trunk system service area defined	Renames the “development services” department to the “community development” department.	Outdated

Title 15: Building and Construction

Code Section	Amendment Summary	Category
Chapter 15.04 Technical Building Codes		
15.04.005 (H)(2) General provisions	Adds clarification relating to the permit fees for permit-ready accessory dwelling units, or PRADU’s.	State Mandated HB 1337 and codified under: RCW 36.70A.680, 681, and 696
Chapter 15.36 House and Structure Relocation		
15.36.020 Moving permit and development authorization – Application – Contents required	Renames the “development services” department to the “community development” department.	Outdated

Title 19: Subdivisions

Code Section	Amendment Summary	Category
Chapter 19.02 General Provisions		
19.02.030 Purpose	Clarifies the purpose of the subdivision code per case law.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
19.02.050 Development authorization	Changes “development authorization” to “permit authorization”.	Clarification
19.02.060 Administration – Interpretation	Renames the “development services” department to the “community development” department.	Outdated
Chapter 19.06 Construction and Definitions		
19.06.020 (C-D) C and D Definitions	Renames the “development services” department to the “community development” department.	Outdated

Code Section	Amendment Summary	Category
19.06.020.S S Definitions	Renames the “development services manager” to the “community development director”.	Outdated
Chapter 19.14 Preliminary Subdivision Procedures		
19.14.030(C)(1) Hearing examiner review	Clarifies that the hearing examiner’s review is consistent with the municipal code, per case law.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
Chapter 19.18 Final Plat Procedures		
19.18.040 Final plat acceptance – recording	Renames the “development services director” to the “community development director”.	Outdated
Chapter 19.26 Planned unit developments		
19.26.015 (A) and (C) Review requirements	Renames the “development services staff” to the “community development staff”.	Outdated
19.26.040 (D) Residential density and density bonus	Renames the “development services department” to the “community development department” and clarifies the review of the dimensional standards.	Outdated
Chapter 19.30 Subdivision Design		
19.30.010 General provisions	Clarifies that subdivision design shall be consistent with the Walla Walla zoning code rather than the comprehensive plan, per case law.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
Chapter 19.40 Required Information		
19.40.020(A)(14) Information to be shown on a plat map	Removes the requirement that buildable area envelopes be shown on plat maps.	Clarification

Title 20: Zoning

Code Section	Amendment Summary	Category
Chapter 20.02 General Provisions		
20.02.040 Purpose and intent	Clarification relating to the Comprehensive Plan, per case law.	Clarification
20.02.050 Establishment of zone districts – Official zoning map.	Adds the "MHC – Mobile/ Manufactured Home Park Community" zoning district to the list of zones shown on the Official Zoning Map.	Clarification
20.02.080 (B), (D), (I)(1) and (I)(2)(h) Annexations	Clarifies that annexation petitions shall be accepted anytime throughout the calendar year and updates terminology relating to the Comprehensive Plan Future Land Use Map.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
20.02.130 Zoning code review and evaluation	Renames "development services staff" to "community development staff" and clarifies the Planning Commission's and staff's regular work program of reviewing the zoning code.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
Chapter 20.10 Administration		
20.10.030 Title and (A) Development services department 20.10.040(A) and (A)(1) Director	Renames "development services department" to "community development department".	Outdated
20.10.080(C) City council	Clarifies language relating to planned unit development permits.	Clarification
Chapter 20.14 Application Review – General		
20.14.030(A); (B); and (D) Permit assistance – Consolidated project permit review – Concurrent non-project review – Pre-application process	Renames "development services department" and "development services staff" to "community development department" and "community development staff".	Outdated
20.14.065(A)(1)(J) Notice of application/ proposal	Adds clarification relating to contact information for a designated permit responsible official.	State Mandate HB 2418
20.14.065(B)(2) Initial application processing	Renames "development services department" to "community development department".	Outdated
20.14.095(D)(3) Compliance with notice of decision	Renames the "development services office" to the "community development office".	Outdated

Code Section	Amendment Summary	Category
Chapter 20.18 Level I Review		
20.18.050 Approval	Clarification relating to the Comprehensive Plan, per case law.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
Chapter 20.22 Level II Review		
20.22.040(E) Review procedures, decision – Level II	Clarification relating to the Comprehensive Plan, per case law.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
Chapter 20.26 Level III Review		
20.26.040(D) Review procedures, decision – Level III	Clarification relating to the Comprehensive Plan, per case law.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
Chapter 20.28 Level V Review		
20.28.020(C) When required	Clarification relating to the Comprehensive Plan, per case law.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
Chapter 20.34 Development Agreements		
20.34.040(A) Approval procedure, recording	Clarifies the approval procedure for development agreements, specifically adding that the Hearing Examiner shall conduct a public hearing and forward their recommendation to the City Council.	Clarification
Chapter 20.36 Public Hearings		
20.36.020 Administrative responsibility	Renames the “development services director” to the “community development director”.	Outdated
20.36.090(A) Findings and notice of decision/ action	Clarification relating to the Comprehensive Plan, per case law.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*

Code Section	Amendment Summary	Category
Chapter 20.38 Closed Record Decisions and Appeals		
20.38.050(B and E) Appeals – Filing	Renames the “development services department” to the “community development department”.	Outdated
Chapter 20.42 Violations and Enforcement		
20.42.020 Enforcement and administration	Renames the “development services director” to the “community development director”.	Outdated
20.42.070 Complaints	Renames the “development services department” to the “community development department” and the “development services director” to the “community development director”.	Outdated
Chapter 20.46 Site Plan Review Committee		
20.46.070(A); (C); and (F) Review, decision	Clarification relating to the Comprehensive Plan, per case law, and renames the “development services department” to the “community development department”.	Outdated/ Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
20.46.080 Relationship of review to other permits	Renames the “development services department” to the “community development department”.	Outdated
20.46.110(B) Duration of approval	Renames the “development services office” to the “community development office”.	Outdated
Chapter 20.48 Amendments		
20.48.045 Review criteria prezones, area wide rezones and text amendments	Clarification relating to Comprehensive Plan Future Land Use Map terminology.	Clarification
20.48.050 Record of amendments	Renames the “development services department” to the “community development department”.	Outdated
Chapter 20.50 Land Use Zones		
20.50.020(C)(1) RN Neighborhood Residential	Adds exceptions relating to residential density and property owned by religious organizations.	State Mandated HB 1859
20.50.105(A-F) Landfill Vicinity Development Standards	New section that clarifies requirements for development occurring within 1,000 feet of an active or former sanitary landfill.	Clarification Moved from Title 21

Code Section	Amendment Summary	Category
20.50.130 Application	Renames the “development services department” to the “community development department”.	Outdated
20.50.170(A-B) Urban planned community modifications	Clarifies outdated language and renames “development services director” to “community development director”.	Outdated
Chapter 20.127 Table of Off-Street Parking Standards		
20.127.007(H) Exemptions	Clarifies the parking exemptions relating to Downtown.	Clarification
Chapter 20.100 Table of Permitted Land Uses		
20.100.040.C Community Services	Changes family day care centers (13 or more children) to a Level 1 permitted use in all residential zones and allowed uses in the Heavy Industrial and Airport District zones.	State Mandate SB 5509
20.100.040.C Community Uses	Changes for emergency housing/ shelters to be non-allowed uses in the industrial zones and a Level 1 permitted use in the Airport District zone.	State Mandate HB 2266
20.100.040.F Residential	Clarifies ground floor residential uses in commercial districts to allow them in hotels and motels and existing buildings in the Central Commercial zone, under certain circumstances.	State Mandate SB 6026
Chapter 20.106 Landscaping and Screening		
20.106.010 Purpose and Intent	Clarification relating to the Comprehensive Plan, per case law.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
Chapter 20.110 Fences		
20.100.030 Permit, required when	Clarifies the requirements for retaining walls over 48 inches tall.	Clarification
20.100.040(A-E) General standards	Adds that retaining walls are subject to the general standards for fences.	Clarification
Chapter 20.134 Environmental Performance		
20.134.130 Inadvertent discovery of archaeological and cultural resources	Renames the “development services department” to the “community development department”.	Outdated
Chapter 20.139 Short Term Rentals		
20.139.040 Application requirements	Renames the “development services director” to the “community development director”.	Outdated

Code Section	Amendment Summary	Category
20.139.070 Violation and repeat offenses 20.139.100 Elimination of type 2 short term rentals		
Chapter 20.170 Wireless Communication Facilities		
20.170.032 Permit applications	Renames “development services” to “community development”.	Outdated
Chapter 20.171 Small Wireless Communication Facilities		
20.171.070 New poles in the rights-of-way for small wireless facilities and installations in a design zone	Renames “development services department” to “community development department” and adds clarification relating to the comprehensive plan.	Outdated/ Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
Chapter 20.178 Design Standards for Downtown Walla Walla		
20.178.050 Building height	Clarifies the requirements for building heights of new buildings in the downtown area.	Clarification
Chapter 20.184 Manufactured Home Parks		
20.184.060 Final manufactured home park plan approval	Renames “development services director” to “community development director”.	Outdated

Title 21: Environment

Code Section	Amendment Summary	Category
Chapter 21.04 Environment		
21.04.010 Authority	Renames “development services director” to “community development director”.	Outdated
21.04.020 Definitions 21.04.035 Critical area maps 21.04.055 Administrative rules	Renames “development services department” to “community development department”.	Outdated
21.04.075 Relationship to other regulations	Renames “development services director” to “community development director”.	Outdated
21.04.700 Landfill vicinity development standards	Moves this section, which discusses the requirements for development within 1,000 feet of a landfill, to Title 20 Zoning.	Clarification Moved to Title 20 Zoning
Chapter 21.08 State Environmental Policy Act		

21.08.120 Preparation of EIS – Additional considerations 21.08.140 Designation of department to perform consulted agency responsibilities for the city 21.08.170 Appeals 21.08.173 Notice – Statute of limitations	Renames "development services department" to "community development department".	Outdated
Chapter 21.10 Floodplain Management		
21.10.010 Authorization	Clarification relating to the comprehensive plan.	Clarification Case law: *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
21.10.050 Definitions	Renames "development services department" to "community development department" and the "development services director" to the "community development director".	Outdated
21.10.070 Special flood hazard area – Established	Renames "development services department" to "community development department".	Outdated

II. SEPA STATUS:

The Notice of Application and Washington State Environmental Policy Act (SEPA) checklist was circulated to the SEPA distribution list and the Washington State Department of Ecology SEPA register on August 18, 2026.

The City of Walla Walla Development Services has determined that this proposal is unlikely to have a significant adverse impact on the environment. An environmental impact statement (EIS) is not required under RCW 43.21C.030(2)(c). Staff reviewed the following: the submitted SEPA Checklist, dated June 29, 2026, and the existing environmental documents: Walla Walla Comprehensive Plan Final Environmental Impact Statement (FEIS), issued May 22, 2018, and Walla Walla Comprehensive Plan - Walla Walla 2040, Ordinance 2018-15, adopted June 13, 2018.

Pursuant to WAC 197-11-600(4)(c) and the addendum procedures in WAC 197-11-625, the City is issuing an Addendum to the 2018 FEIS. The Addendum provides additional information and analysis based on the June 29, 2026, Environmental Checklist. The information presented does not substantially change the analysis of probable significant adverse impacts or the range of alternatives considered in the 2018 FEIS. The original FEIS remains valid and is not modified or replaced by this Addendum.

III. FINDINGS OF FACT:

1. In accordance with Walla Walla Municipal Code (WWMC) Section 20.02.130, the Development Services staff and the Planning Commission review the WWMC throughout the year to ensure consistency with newly passed Washington State legislation, to clarify confusing sections that Development Services staff have observed to be difficult to administer, or to amend and remove outdated language or land uses. The Zoning Code is thoroughly examined as part of the Planning Commission's regular work program, in coordination with the required periodic update of the Comprehensive Plan.

2. The Development Services staff began initial discussions and review of the draft code amendments in spring 2026. Draft proposed code amendments were presented to the Planning Commission at the regularly scheduled workshops on July 6, 2026, and August 3, 2026.

3. The formal municipal code amendments were initiated (application submitted) on June 29, 2026. The 60-day notice was submitted to the Washington State Department of Commerce on August 4, 2026, and the submittal receipt was received on August 4, 2026.

4. Zoning code text amendments are a Level V review under Walla Walla Municipal Code (WWMC) Chapter 20.28, which requires the Planning Commission to hold a public hearing and make a recommendation to the City Council. The City Council is the decision authority.

5. A Notice of Application/ Notice of Public Hearing was published in the Union Bulletin newspaper on August 18, 2026, and posted on the City of Walla Walla website on August 18, 2026, as required by WWMC 20.14.065.

6. **Public Comments:** No public comments have been received, as of the preparation of this staff report.

7. WWMC Chapter 20.48, Amendments, outlines the requirements for processing amendments as follows:

   20.48.020 Who may initiate.
   A. Amendments may be initiated by:
   1. The City Council;
   2. The City Manager;
   3. The Planning Commission;
   4. The Zoning Administrator;
   5. Any person requesting an amendment to the text of this Code;
   6. Any property owner or contract purchaser or authorized agent requesting a rezone of his property; or
   7. Any property owner(s) requesting annexation to the City.

   20.48.030 Procedure.
   C. The City Council is responsible for the approval or denial of a rezone or text amendment. When considering a rezone request or a text amendment, the City Council will act on the request at a public meeting upon the hearing record of the initial reviewing body.

   20.48.045 Review criteria for prezones, area-wide rezones and text amendments.
   The decision on a prezone, area-wide rezone, or text amendment shall be based on a legislative finding upon whether or not the proposal is consistent with and implements the Walla Walla Comprehensive Plan.

20.48.050 Record of amendments.
All amendments to the zone code will be recorded and indexed in the Development Services Department according to Section 20.14.100 of this code.

8. The proposed code amendments are supported by the City of Walla Walla Comprehensive Plan as identified in the conclusions of law section of this staff report as required by RCW 36.70A.130(1)(d), which reads in part: "Any amendment of or revision to development regulations shall be consistent with and implement the comprehensive plan."

9. The Planning Commission is scheduled to conduct a Public Hearing on September 14, 2026.

IV. CONCLUSIONS OF LAW:

1. Pursuant to Walla Walla Municipal Code Chapter 20.48 Amendments, the following applies:

20.48.020 Who may initiate.
A. Amendments may be initiated by:
1. The City Council;
2. The City Manager;
3. The Planning Commission;
4. The Zoning Administrator;
5. Any person requesting an amendment to the text of this Code;
6. Any property owner or contract purchaser or authorized agent requesting a rezone of his property; or
7. Any property owner(s) requesting annexation to the City.

20.48.030 Procedure.
C. The City Council is responsible for the approval or denial of a rezone or text amendment. When considering a rezone request or a text amendment, the City Council will act on the request at a public meeting upon the hearing record of the initial reviewing body.

20.48.045 Review criteria for prezones, area-wide rezones, and text amendments.
The decision on a prezone, area-wide rezone, or text amendment shall be based on a legislative finding upon whether or not the proposal is consistent with and implements the Walla Walla Comprehensive Plan.

20.48.050 Record of amendments.
All amendments to the zone code will be recorded and indexed in the Development Services Department according to Section 20.14.100 of the Walla Walla Municipal Code.

Staff analysis of how the proposed code amendments meet the requirements of WWMC Chapter 20.48 Amendments:

1. **Procedural Elements-**
The proposed code amendments were initiated by the Development Services Department (Zoning Administrator) to revise and update sections of the code to improve clarity and usability, to align with recently passed State legislation, and to remove and update outdated language.

The review by the Planning Commission was conducted at regularly scheduled workshops on July 6, 2026, and August 3, 2026.

A notice of application and notice of public hearing for the Planning Commission Public Hearing on September 14, 2026, was published in the Union Bulletin on August 18, 2026, and posted on the City's website on August 18, 2026. The public comment period concluded on September 4, 2026, and no public comments were received. The Planning Commission shall conduct a Public Hearing and make a recommendation to the City Council.

The review criterion for municipal code text amendments is that the amendments are consistent with and implement the Walla Walla Comprehensive Plan – Walla Walla 2046. Staff will outline how the proposed code amendments are consistent with the Comprehensive Plan in the next conclusion analysis below.

Staff finds that the proposed code amendments meet the requirements of WWMC Chapter 20.48 Amendments based on the above staff analysis.

2. **Walla Walla Comprehensive Plan -**
The proposed code amendments are supported by the Walla Walla Comprehensive Plan – Walla Walla 2046 Goals and Policies, as follows:

Community Character (CC) 4.1: Carefully protect and enhance Downtown's visual character, the most important single aspect of the city's identity, through historic preservation activities, complementary infill development, and sensitively designed public works.

Land Use (LU) Policy 1.1: Accommodate new residential and commercial development in areas with available infrastructure and services.

LU Policy 1.4: The City will coordinate with Walla Walla County to plan for the delivery of urban services within unincorporated UGAs prior to annexation.

LU Policy 1.5: The City supports Walla Walla County's goal that, where feasible, all land within unincorporated Urban Growth Areas will be annexed to the City or incorporated within the 20-year planning horizon.

Land Use Policy 1.6: Encourage infill development that provides additional housing in the city.

LU Policy 2.2: Coordinate planning in the Urban Growth Area with Walla Walla County to ensure orderly, sustainable development consistent with City standards, and discourage development of subdivisions using septic systems and private water systems.

LU Policy 3.7: Support a variety of housing types such as tiny homes, duplexes, multi-family development, cottage housing, and single-family residential.

Housing (H) Policy 1.1: Provide an array of housing choices such as apartments, small lot single-family housing, accessory dwelling units, townhomes, manufactured homes, and cottages to meet the needs of people of all incomes throughout their lifespan.

Economic Development Policy 5.1: Regularly review development regulations, evaluate the impact of regulations, and the needs of local businesses.

Staff analysis of how the proposed code amendments align with the Comprehensive Plan:

The proposed 2026 implementing code amendments fall into the categories of outdated, clarification, and state-mandated. Many of the proposed amendments are related to the renaming of the Development Services Department to the Community Development Department, as well as state laws that passed over the recent legislative sessions. Additionally, there are several code amendments related to the *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)* case law, which held that specific zoning or land use regulations take precedence over comprehensive plans, which serve as a general guide rather than rigid regulations.

The new legislation includes HB 1337, which reduces barriers to the construction and use of accessory dwelling units; HB 2418, which relates to residential permit review processes; HB 1859, which expands opportunities to build affordable housing on properties owned by religious organizations; SB 5509, which relates to the siting of childcare centers; HB 2266, which pertains to the siting and permitting of transitional housing, permanent supportive housing, emergency housing, and shelters; and SB 6026, which addresses residential development in commercial and mixed-use zones. Many of the state laws noted above are aimed at reducing barriers to constructing housing and expanding housing types, which align with and are supported by Comprehensive Plan Housing Policy 1.1, Land Use Policy 1.1, and Land Use Policy 1.6.

There are proposed code amendments that would clarify where and under what conditions the City is permitted to provide water and sewer services. The draft amendment establishes that the City may provide water and sewer service to properties located outside city limits but within the Urban Growth Area (UGA), subject to specific conditions. These include approval by the City Manager and a commitment from the property owner not to further subdivide the property until it is annexed into the City. These draft code amendments are in alignment with and supported by Land Use Policies 1.4 and 2.2.

Additional code amendments are proposed regarding annexations and when annexation petitions are accepted by the City. The code previously allowed petitions twice a year, once in January and once in July. This code amendment proposes allowing annexation petitions to be submitted at any point during the calendar year, consistent with and supported by Land Use Policy 1.5.

Another proposed code change relates to the approval procedure for development agreements, clarifying that the hearing examiner is the body that conducts the public hearing and forwards their recommendation to the city council for consideration and decision. This proposal supports Economic Development Policy 5.1.

Other code amendments include minor clarifications and relocations. Specifically, relocating landfill vicinity development standards from Title 21 Environment to a more appropriate location, Title 20 Zoning; adding retaining walls to the fence code so that the same general standards apply to both fences and retaining walls; and clarifying the Downtown parking exempt area.

Staff reviewed the existing Municipal Code for inconsistencies, lack of clarity and usability, and places where the existing code was out of alignment with recently passed state legislation.

3. **Growth Management Act -**

The Growth Management Act (GMA) RCW 36.70A.020 goals that apply to the proposed Municipal Code Text Amendments are as follows:

Goal 1 Urban Growth. Encourage development in urban areas where adequate public facilities and services exist or can be provided in an efficient manner.

Goal 4 Housing. Plan for and accommodate housing affordable to all economic segments of the population of this state, promote a variety of residential densities and housing types, and encourage preservation of existing housing stock.

Goal 5 Economic Development. Encourage economic development throughout the state that is consistent with adopted comprehensive plans, promote economic opportunity for all citizens of this state, especially for unemployed and for disadvantaged persons, promote the retention and expansion of existing businesses and recruitment of new businesses, recognize regional differences impacting economic development opportunities, and encourage growth in areas experiencing insufficient economic growth, all within the capacities of the state's natural resources, public services, and public facilities.

Goal 7 Permits. Applications for both state and local government permits should be processed in a timely and fair manner to ensure predictability.

Goal 11 Citizen Participation and Coordination. Encourage the involvement of citizens in the planning process and ensure coordination between communities and jurisdictions to reconcile conflicts.

The public hearing notice was posted on August 18, 2026, and published on August 18, 2026, advertising the Planning Commission's public hearing on September 14, 2026, and soliciting comments from the public.

The intent is to take public input and feedback and bring forth the proposed amendments in this legislative process. Staff conclude that the proposed text amendments will implement the goals and policies of the proposed City of Walla Walla Comprehensive Plan 2046 and of the Growth Management Act.

V. STAFF RECOMMENDATION

Staff recommends that the Planning Commission recommend approval to the Walla Walla City Council for the proposed Walla Walla Municipal Code text amendments to Titles 2, 3, 5, 10, 12, 13, 15, 19, 20, and 21.

Prepared by Lisa Wasson-Seilo, Planner: Lisa Wasson-Seilo

VI. EXHIBITS

1.	Draft 2026 Implementing Code Amendments Table for Application and Public Comment	September 14, 2026
2.	SEPA Checklist	June 29, 2026
3.	SEPA Addendum to the 2018 FEIS	August 17, 2026
4.	Planning Commission Workshop Draft Minutes	July 6, 2026
5.	Planning Commission Workshop Draft Minutes	August 3, 2026
6.	WA Department of Commerce Submittal Receipt	August 4, 2026
7.	Notice of Application/ Notice of Public Hearing	August 18, 2026

2026 Draft Implementing Code Amendments 2026 Comprehensive Plan

Planning Commission Public Hearing – September 14, 2026

KEY:
BOLD (NEW)
STRIKEOUT (PROPOSED DELETION)
CATEGORIES: OUTDATED, CLARIFICATION, STATE MANDATED

WWMC	Section	Proposed Amendment	Category and Notes
Title 2: Administration			
Chapter 2.17(F) City Departments	Created	There are created the following departments: A. Support services; B. Fire; C. Police; D. Parks and recreation; E. Public works; F. **Community** ~~Dd~~development ~~services~~; G. Public library; H. Human resources; I. Finance; and J. Technology services	Outdated
2.17.070 City Departments	Director of development services – Appointment – Duties	Title Director of Community development ~~services~~ – Appointment – Duties The director of **community** development ~~services~~ shall be appointed by the city manager. The director of **community** development ~~services~~ shall be responsible for supervising all employees of the divisions of planning**, permitting,** ~~and~~	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		building inspection**, code compliance, and community development**. It shall be the duty of the director of **community** development ~~services~~ to promote, develop and supervise all planning, **permitting,** ~~development and~~ building inspection**, code compliance, and community development** services in the city in compliance with all applicable laws, ordinances, resolutions, rules and regulations, and to perform such additional duties as are determined by the city manager.	
2.27.040(G) Historic Preservation Commission	Walla Walla historic preservation commission	G. Commission Staff. Commission and professional staff assistance shall be provided by the **community** development ~~services~~ department with additional assistance and information to be provided by other city departments as may be necessary to aid the commission in carrying out its duties and responsibilities under this chapter.	Outdated
2.28.050(A) Multifamily Housing Tax Incentives	Application procedure	A property owner who wishes to propose a project for a tax exemption shall complete the following procedures: A. File with the Walla Walla **community** development ~~**services**~~ department the required application along with the required fees. The application fee shall be five hundred dollars. An additional one hundred dollar fee to cover the Walla Walla County assessor's administrative costs shall also be paid to the city. If the application shall result in a denial by the city, the city will retain that portion of the fee attributable to its own administrative costs and refund the balance to the applicant.	Outdated
2.28.060	Application review and issuance of	The director of the city of Walla Walla's **community** development ~~services~~ department or designee will review an	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Multifamily Housing Tax Incentives	conditional twelve-year certificate	application for a twelve-year certificate for completeness and fulfillment of eligibility requirements and approval criteria, return incomplete applications for correction or supplementation, and may approve eligible applications.	
Title 3: Revenue and Finance			
3.23.130(A) Trust Funds	Code enforcement revolving fund	A. The **community** development ~~services~~ director and police chief are directed to coordinate and make a recommendation to the city manager and council concerning the amount of such code enforcement revolving fund and the source of the funds, and are further directed to provide that a primary source of such funds shall be recovery of costs from the owners of unsafe structures and unkempt properties as provided by the above-referenced code provisions.	Outdated
Title 5: Business Licenses and Regulations			
5.02.450 (A-B) Telecommunications – Small Wireless Facilities	Application process	A. Overview. In order to manage its rights-of-way in a thoughtful manner which balances the need to accommodate new and evolving technologies with the preservation of the natural and aesthetic environment of the city, the city of Walla Walla has adopted this administrative process for the deployment of small wireless facilities. The city and applicant for a franchise and other permits associated with the deployment of small wireless facilities face challenges in coordinating applicable legislative and administrative processes under the Federal Communications Commission (FCC) regulations. A franchise for the use of the city's right-of-	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		way is a contract which requires approval by the city council. The small wireless permits are issued by the director of the **community** development ~~services~~ department or his/her designee. Applicants are encouraged and expected to provide all related applications in one submittal, unless they have already obtained a franchise. B. Application Process. The director of the **community** development ~~services~~ department or his/ her designee is authorized to establish franchise and other application forms to gather the information required by this chapter from applicants and to determine the completeness of the application process as provided herein. The application shall include Parts A, B, and C as described below.	
5.02.470(B and G) Telecommunications – Small Wireless Facilities	Review process	B. **Community** Development ~~services~~ Department. Small wireless deployment in areas designated as design zones pursuant to Section 20.171.050, as well as new non-city-owned poles, or replacement poles deviating from the pole design standards adopted pursuant to Section 20.171.060, are subject to review pursuant to Chapter 20.171. G. Withdrawal. Any applicant may withdraw an application submitted pursuant to Section 5.02.460 at any time, provided the withdrawal is in writing and signed by all persons who signed the original application or their successors in interest. When a withdrawal is received, the application shall be deemed null and void. If such withdrawal occurs prior to the director of **community** development**'s** ~~services'~~ or his/her designee's decision, then reimbursement of fees submitted in	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		association with said application shall be prorated to withhold the amount of city costs incurred in processing the application prior to time of withdrawal. If such withdrawal is not accomplished prior to the director of **community** development**'s** ~~services'~~ or his/her designee's decision, there shall be no refund of all or any portion of such fee.	
5.02.500(A) Telecommunications – Small Wireless Facilities	Consolidated permit	A. The issuance of a small wireless permit grants authority to construct small wireless facilities in the rights-of-way in a consolidated manner to allow the applicant, in most situations, to avoid the need to seek duplicative approval by both the public works and the **community** development ~~services~~ departments. If the applicant requires a new franchise to utilize the right-of-way, the franchise approval may be consolidated with the small wireless facility permit review if requested by the applicant. As an exercise of police powers pursuant to RCW 35.99.040(2), the small wireless facility permit is not a right-of-way use permit, but instead a consolidated public works and land use permit and the issuance of a small wireless facility permit shall be governed by the time limits established by federal law for small wireless facilities. B. The general standards applicable to the use of the rights-of-way described in Title 12 shall apply to all small wireless facility permits.	Outdated
5.04.020 Mobile Vendors	Mobile and street vendor – License required	No person, firm or corporation shall engage in the business of a mobile vendor without having first obtained a license therefor from the licensing agent issued by the department of	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		community development ~~services~~. This chapter shall not apply to vendors operating in conjunction with events holding a valid city of Walla Walla special event permit or the farmers' market. Mobile or street vendors shall also obtain a city endorsement on a state issued business license as required by Chapter 5.05, General Business License.	
5.05.050(A) General Business License	Business license application, renewal, delinquency, and cancellation	A. A person must register a business with the city program by submitting a business license application to the BLS in coordination with the **community** development ~~services~~ department, giving such information as is deemed reasonably necessary to enable the enforcement of this chapter and to complete the application process through BLS.	Outdated
5.05.120 General Business License	Rules and regulations	The **community** development ~~services~~ department may adopt and promulgate rules and regulations for administration and enforcement of this chapter which are not inconsistent herewith or with superior law. The purpose of such rules and regulations is to carry out the provisions of this chapter, and it shall be unlawful to fail to comply with any such rule or regulation.	Outdated
5.09.015 Pawnbrokers And Secondhand Dealers	Fixed place of business required – Development permit	No person may operate as a pawnbroker unless the person maintains a fixed place of business within the city, and has further obtained a development permit issued by the department of **community** development ~~services~~.	Outdated
Title 10: Vehicles and Traffic			

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
10.17.010 (A-B) Vehicles and Traffic	Issuance of construction vehicle parking permits	A. The **community** development ~~services~~ department may issue a construction vehicle parking permit to any licensed contractor, with a city business license, who is engaged in the construction, alteration, or repair of a building or property, or the installation or repair of equipment in such building or on such property, which requires vehicle parking in a parking zone for time periods longer than regularly permitted under this code. B. Anyone who desires a construction vehicle parking permit must apply in writing to the **community** development ~~services~~ department on such form that the department may require and provide such information and verifications that the department may demand. Applicants must submit evidence of a work contract, job order, or other documentation required by the department. Verification of need may be demonstrated by the issuance of an approved building permit issued by the **community** development ~~services~~ department. Each permit issued by the department shall bear the license number and other identifying data of the vehicle for which it is issued. The permit shall not be transferable between vehicles. C. The **community** development ~~services~~ department may renew or extend a permit beyond its initial term upon a showing of need.	Outdated
10.17.040 Vehicles and Traffic	Penalties	Anyone who violates or fails to comply with any of the provisions of this chapter shall be guilty of an infraction punishable in accordance with Section 1.24.010. Anyone who violates or fails to comply with any of the provisions of this chapter may have any permits revoked by the **community**	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		development ~~services~~ department and may also be prohibited by the department from purchasing future permits.	
10.27.040(F) Special Event Permits	Definitions	F. "Exempt closures or uses" means exempt from the provisions of this chapter, and includes: 1. Public or private street uses or closures related to construction activity or right-of-way improvements or maintenance, as authorized by the public works department; 2. Long-term uses of the public right-of-way between the curb and property line approved by permit issued by the **community** development ~~services~~ department, such as, but not limited to, sidewalk restaurants; and 3. Short-term or long-term uses of the public right-of-way as approved by the **community** development ~~services~~ department to support activities occurring primarily on adjacent private property, such as, but not limited to, furniture moving and building repairs.	Outdated
Title 12: Streets and Sidewalks			
12.14.040(B) Downtown Development and Care Standards	Public fixtures and street furniture, standardized design and location	B. Where the fixture being proposed is not represented on the current adopted City Standard Plans for Downtown as provided in Section 12.01.040, is not included in the downtown master plan, or is a variation on existing designs, the city engineer shall determine acceptability of design and proposed location after consultation with **community** development ~~services~~ and organizations concerned with development of downtown. The site plan review committee may be engaged if the city engineer or the **community** development ~~services~~ director feels that additional formal input is necessary.	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
12.64.020 Street Addressing	Official Map	The official map of the city of Walla Walla shall be the Walla Walla ~~urban area~~ comprehensive plan **Future Land Use** ~~m~~**M**ap adopted by resolution of the Walla Walla city council. The Walla Walla city manager may adopt, maintain, and modify a building number axis map which is consistent with the Walla Walla ~~urban area~~ comprehensive plan **Future Land Use** ~~m~~**M**ap. The official map ~~and the building numbering axis map~~ shall be available for public inspection.	Clarification
Title 13: Water and Sewers			
13.03.601(A-C) Sewer Utility – Regulations And Rates	Article II Sewer Service Service – Provided where	A. The council will provide sanitary sewer service to all ~~that~~ area**s** within the boundaries of the city where facilities are available and to such other areas as, in its sole discretion, may be in the best interest of the city to serve. B. **Unless otherwise approved by the City Manager, pursuant to (C) below** ~~P~~**p**roperty within the UGA shall annex prior to connection to the city sewer system. It must also be developed in compliance with city development standards, and its utilities must be constructed in compliance with city standards. C. The city retains discretion, on a case-by-case basis, to review connection to single-family residences or other approved uses in the UGA. ~~Consideration~~ **Subject to City Manager approval,** ~~C~~ **c**onsideration **may be given to** ~~in the event the~~ property **that** experiences a failed septic system, and ~~when~~ **a** connection to the city sanitary sewer system is necessary to maintain the existing use. **Other connection considerations may include property proximity to existing**	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		sewer and pollution potential, especially for properties near waterways. In such cases, **a** connection may not be made to the city's system unless the property owner has first executed and recorded an irrevocable agreement in a form acceptable to the city, consenting to annex the property to the city of Walla Walla**, and agreeing not to further subdivide the property until such annexation occurs. Agreements are binding upon successors and assignees**.	
13.04.040(A-C) Water Utility – Regulations And Rates	Service – Provided where	A. The council will furnish service to all ~~that~~ area**s** within the boundaries of the city where facilities are available and to such other areas as, in its sole discretion, may be in the best interest of the city to serve. **B. Unless otherwise approved by the City Manager,** ~~P~~ **p**roperty within the UGA shall annex prior to connection to the city water system. **It must also be developed in compliance with city development standards, and its utilities must be constructed in compliance with city standards.** C. The city retains discretion, on a case-by-case basis, to review **new** connection**s** to single-family residences or other approved uses in the UGA. **Consideration may be given** ~~in the event that~~ **to** property **that** experience**s** a failed well, and **a** connection to the city water system is necessary to maintain the existing use. ~~New connections will not be allowed in support of further subdivision.~~	Clarification
13.04.150(A-B) Water Utility – Regulations And Rates	Service – Extension outside city limits – Furnished when	A. Upon the application of any person to be furnished water outside the city limits, the city shall, at its discretion, determine whether the water applied for is available and whether it is in the best interests of the city	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		to furnish the water. Water from the city's system shall not be furnished to any property unless such property has been annexed, except as determined by **the City Manager** ~~council~~ per Section 13.04.040(C), and it is developed in compliance with city development standards and its utilities are constructed in compliance with city standards. B. If service is approved per Section 13.04.040(C), water from the city's system shall not be furnished to any property unless the property owner has first executed and recorded an irrevocable agreement in a form acceptable to the city consenting to annex the property to the city of Walla Walla, **and agreeing not to further subdivide the property until such annexation occurs. This agreement shall be** ~~which is~~ binding upon successors and assigns.	
13.05.060(D)(1)(a) Water System Cross-Connection Control	Backflow prevention requirements	D. Requirements for Specific Types of Services. The following specific types of services must comply with the following requirements. The cross-connection control specialist shall determine the level of backflow prevention required and whether or not premises isolation shall be required. 1. Temporary Water Service. Temporary connections shall have backflow prevention in the form of a reduced pressure backflow assembly unless otherwise approved by the cross-connection control specialist. The required assembly may, at the customer's request, be provided by the city and a charge will then be assessed to the customer for the use of the assembly. In cases where the customer requires temporary service for a period of time exceeding six months, the customer shall provide the required backflow assembly, which	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		shall be inspected and tested by the cross-connection control specialist at no additional charge. In all cases, water service shall be provided only after the following requirements are met: a. Completion by the customer of an event application with **community** development ~~services~~ and/or the parks department as required (Note: Customers requesting temporary services for the sole purpose of construction may be exempt from this requirement)	
13.07.020 Cottonwood Trunk System Special Charge	Cottonwood trunk system service area defined	The Cottonwood trunk system service area consists of all properties which either directly or indirectly have water or sewage service available through the water or sewer mains extended from inside the city southerly along Cottonwood Road. This area is designated on an official map maintained in the offices of the city of Walla Walla **community** development ~~services~~ **department** ~~division~~.	Outdated
Title 15: Building and Construction			
15.04.005 (H)(2)	General Provisions	H. Valuation Table. For purposes of calculating permit fees, the city of Walla Walla adopts by reference the most recent building valuation data (BVD) table published by the International Code Council, as amended. Any changes in the BVD table published by the International Code Council shall be deemed to be adopted by the city of Walla Walla without additional amendment to this subsection.	State Mandated HB 1337 and codified under: RCW 36.70A.680, 681, and 696

WWMC	Section	Proposed Amendment	Category and Notes
		1. For purposes of calculation of permit fees for a carport, wood deck, covered patio, covered porch, unconditioned single-story self-service storage facility without interior corridor areas, or similar structures, as determined by the building official, the permit fees shall be calculated at fifty percent of the square foot construction cost rate as shown in the current BVD table rate for group U Utility, miscellaneous. **2. For the purposes of calculation of permit fees, a permit-ready accessory dwelling unit, PRADU, the permit fees shall be calculated at thirty-five percent of the square foot construction cost rate as shown in the current BVD table rate for Group R3 residential occupancy.**	
15.36.020 House And Structure Relocation	Moving permit and development authorization – Application – Contents required	15.36.020 Moving permit ~~and development authorization~~ – Application – Contents required. Each application for a moving permit ~~or development authorization~~ shall be made to the city **community** development **department** ~~services division~~ upon forms furnished by it and shall set forth such information as it may reasonably require in order to carry out the purpose of this chapter.	Outdated
Title 19: Subdivisions			

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
19.02.030 General Provisions	Purpose	The purpose of the subdivision code is to enhance the quality of life, protect the health and safety, and enhance the general welfare of the citizens of the city. ~~The subdivision code intends to accomplish t~~ **T**his purpose **is accomplished** by implementing the requirements of Chapter 58.17 RCW ~~and the goals and policies of the comprehensive plan~~. To this end, the subdivision code is intended to: A. Accomplish the orderly development of land within the city through regulations and standards governing subdivisions, short plats, boundary adjustments, planned unit developments**,** and binding site plans. Condominium developments are processed as a binding site plan; B. Coordinate development with public facilities and services and provide standards for **the** construction of new services; C. Improve land records and boundary monumentation; D. Safeguard the interests of the public, the applicant and future property owners.	Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
19.02.050 Division I General Provisions And Definitions General Provisions	Development authorization	A. Development **Permit** ~~Authorization~~ – Subdivision Application. All development covered by this code shall be undertaken by first applying for **a** development **permit** ~~authorization~~ pursuant to Chapter 20.14. No application for a permit required by this code shall be accepted for administration by the city until it is determined by the director to be complete, and until all appropriate administrative fees are paid. All administrative timelines listed in this code shall run from the date of acceptance by the director which shall be placed on the application and signed by the director or his/her designate.	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		B. Development **Permit** ~~Authorization~~ – Lot Development. Development **permits** ~~sauthorization~~ for lots approved under this code shall not be issued by the director until the required improvements have been satisfactorily completed or placed under surety and have been approved by the director and the city engineer. C. Concurrency. No subdivision, short subdivision, boundary adjustment, planned unit development, binding site plan or other division of land shall be ~~authorized~~ **permitted** unless such action meets the requirements of this title, Titles 20 and 21, and concurrency requirements of the city. D. Variance. Application for variance of the standards of the Subdivision Code shall be processed the same as under Chapter 20.220. All variance requests shall be processed under Level III review process, Chapter 20.26.	
19.02.060 General Provisions	Administration – Interpretation	The director of the city **community** development ~~services~~ department shall have the responsibility of administering and interpreting all terms and provisions of this code. Formal interpretation shall be requested in writing on forms provided by the director. Issuance of a formal interpretation shall be considered an administrative decision, with appeal as provided by Section 19.02.065 of this code.	Outdated
19.06.020(C-D) Construction And Definitions	C and D Definitions	"**Community** Development ~~services~~ department" (known and referred to alternatively herein as the "department," "staff," or "planning staff") means the department created by Section 2.17.010(F). "Director" (known and referred to alternatively herein as the	Outdated

WWMC	Section	Proposed Amendment	Category and Notes
		"**community** development **director** ~~services manager~~," "department head," "administrator," or "zoning administrator") means the official appointed by the city manager in accordance with Section 2.17.070, and such other staff granted authority to act on behalf of the director.	
19.06.020.S Construction And Definitions	S Definitions	"Site plan review committee" means the site plan review committee (SPRC) consisting of the **director of community** development ~~services manager~~, director of public works, city engineer, director of parks and recreation, fire chief, chief of police, or their designee.	Outdated
19.14.030(C)(1) Preliminary Subdivision Procedures	Hearing examiner review.	The hearing examiner shall consider the application materials, the director's report of findings and recommendations, the recommendations of the SPRC, comments submitted, and information received at the public hearing to determine whether the proposal conforms to policies, standards and accepted design principles for the following: 1. Consistency with the ~~comprehensive plan and~~ municipal code;	Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
19.18.040 Final Plat Procedures	Final plat acceptance – Recording	C. Director Determination. The city council has delegated the approval authority of final plats to the **community** development ~~services~~ director. The director shall determine that the conditions imposed on the approved preliminary plat have been met and that any required surety is adequate to assure completion of the required improvements not already completed	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
19.26.015(A and C) Planned Unit Development Subdivision	Review requirements	A. A pre-application meeting with the **community** development ~~services~~ staff and site plan review committee (SPRC) shall be required. The applicant shall prepare concept-level plans to be reviewed by staff and the SPRC. B. P.U.D. applications are subject to the provisions of Chapter 20.14, Application Review – General. C. Each application shall comply with the minimum submittal requirements for site plan review set forth in Chapter 20.46 **of** this code. Applications for developments involving a subdivision shall also comply with the corresponding minimum submittal requirements set forth in this title. In addition to the minimum submittal requirements specified above, the application shall also contain: elevations of proposed buildings; proposed development standards including but not limited to land use, density, setbacks, site coverage, and building heights; and plans for development of common open space and amenity areas.	Outdated
19.26.040 (D) Planned Unit Development Subdivision	Residential density and density bonus	D. Dimensional Standards. Dimensional standards and street standards may vary in order to achieve clustering and common area design objectives. Such variations shall be justified based on ~~consistency with the goals and policies of the comprehensive plan and~~ on the purpose and intent of this chapter. Variations shall be documented and become the applicable standards for the subject subdivision. Dimensional standards shall be reviewed by the city **community** development ~~services~~ department and documented in the approval.	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
19.30.010 Subdivision Design	General Provisions	Conformance to ~~Comprehensive Plan and~~ Zoning Code. The design of subdivisions, short plats, planned unit developments and binding site plans, including but not limited to layout of streets, lots and blocks, shall be consistent ~~with the Walla Walla comprehensive plan. D~~ **d**imensional lot standards ~~shall be~~ as required by the Walla Walla zoning code.	Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
19.40.020(A)(14) Required Information	Information to be shown on a plat map	A~~14. Buildable area envelope for each lot (for residential developments).~~	Clarification
Title 20: Zoning			
20.02.040 General Provisions	Purpose and intent	The purpose of this code is to protect the health and safety, and enhance the general welfare and quality of life of the citizens of the City of Walla Walla. This Code intends to accomplish this purpose by defining and quantifying the uses of land designated by the Comprehensive Plan. ~~This Code is the principal means of implementing the Plan.~~ To this end, this code is intended to:	Clarification
20.02.050 Zoning Division I. General Provisions And Definitions	Establishment of zone districts – Official zoning map.	To implement the Comprehensive Plan land use designations, and the Purpose and Intent Statements of this code, the following land use zoning districts are established by delineation on the Official Zoning Map as defined in Section 20.06.030.O. A. General Zones. Abbreviation | Zoning Name	Clarification

WWMC	Section	Proposed Amendment	Category and Notes
		RN | Neighborhood Residential RM | Multi-Family Residential **MHC | Mobile/Manufactured Home Park Community** CC | Central Commercial CH | Highway Commercial IL/C | Light Industrial/Commercial IH | Heavy Industrial AD | Airport Development District PR | Public Reserve UPC | Urban Planned Community	
20.02.080(B),(D), (I)(1) and (I)(2)(h) General Provisions	Annexations	B. The city will accept annexation petitions **at any time throughout the calendar** ~~twice per~~ year~~. The first annexation petition submittal time will open January 1st and close January 31st of each calendar year. The second annexation petition submittal time will open July 1st and close July 31st of each calendar year.~~ D. ~~Annexation of property shall be consistent with the land use and annexation policies of the Comprehensive Plan's Land Use Element~~. As soon as practicable upon initiation of annexation proceedings, the department shall determine whether ~~or not~~ the proposed annexation area WWMC has been prezoned, and whether ~~or not~~ such prezone designation(s) are consistent with and implement the Comprehensive Plan **Future Land Use Map**. (I)(1) The city may adopt a zoning designation for the property pursuant to RCW 35A.63.100 ~~which is consistent with, and~~	Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		that implements the ~~Comprehensive Plan~~ **Future Land Use Map**; or (I)(2)**(h)** The deemed zoning designation may be amended through the rezone process after annexation, and the department is directed to process such amendment(s) that may be necessary to make the zoning designation(s) for annexed property consistent with the ~~Comprehensive Plan~~ **Future Land Use Map** as soon as practicable following the effective date of the annexation.	
20.02.130 General Provisions	Zoning Code review and evaluation	**Community** Development ~~service~~s staff and the planning commission will review this code periodically and prepare a report to the city council, detailing any particular problems, proposals, concerns**,** or amendments. The Zoning Code shall be thoroughly examined as part of the planning commission's ~~normal~~ **regular work** program ~~of work commensurate with the required review and updating of the Comprehensive Plan~~, in ~~consultation~~ **coordination with the required periodic update of the Comprehensive Plan and in consultation** with technical staff and other interested parties. ~~The Zoning Code is required to be consistent with and implement the Comprehensive Plan.~~	Clarification Caselaw-*Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
20.10.030 Title and (A) Administration	Development services department	**Community** ~~D~~**d**evelopment ~~services~~ department A. The **community** development ~~services~~ department shall have the following authority and responsibilities:	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
20.10.040(A) and (A)(1) Administration	Director	A. The director shall be the administrative official of the **community** development ~~services~~ department. The director shall have the following authority and responsibilities: 1. To oversee all duties and responsibilities of the **community** development ~~services~~ department and to determine the appropriate processing level of each application;	Outdated
20.10.080 (C) Administration	City council	C. Make the final quasi-judicial decision on planned unit development **permits** ~~subdivision plans~~, shoreline permits processed through Level IV (Chapter 20.27 of this code), and site-specific amendments to the Official Zoning Map.	Clarification
20.14.030(A and B) and (D) Application Review – General	Permit assistance – Consolidated project permit review – Concurrent non-project review – Pre-application process	A. The **community** development ~~services~~ department personnel are designated as general permit assistance staff. The director may designate special permit assistance staff upon an application. B. Consolidated Permit Review Process. **Community** development ~~services~~ staff shall attempt to determine if more than one permit approval or action under this code is required for a proposal, and notify the applicant prior to issuance of a determination of completeness; provided, however, that the failure of staff to notify the applicant shall not extend the time to elect to consolidate review processes. An applicant may elect in writing to consolidate the review processes for project permits subject to the following: D. A preapplication conference may be required by the department prior to filing of an application, and a preapplication conference shall be required for subdivisions, short plats, planned unit developments, binding site plans, or if	Outdated

WWMC	Section	Proposed Amendment	Category and Notes
		permit assistance staff determines prior to filing of the application that more than one permit approval or action under this code is required for a proposal. The applicant shall arrange such conference with the **community** development ~~services~~ department to review the proposed action, to become familiar with the policies, plans and development requirements of the city of Walla Walla and to coordinate all necessary permits and procedures. Any information or opinions expressed by the city shall not be binding or constitute approval of the project.	
20.14.030(D) Application Review – General	Initial application processing	D. A preapplication conference may be required by the department prior to filing of an application, and a preapplication conference shall be required for subdivisions, short plats, planned unit developments, binding site plans, or if permit assistance staff determines prior to filing of the application that more than one permit approval or action under this code is required for a proposal. The applicant shall arrange such conference with the **community** development ~~services~~ department to review the proposed action, ~~to become familiar with the policies, plans~~ and development requirements of the city of Walla Walla and to coordinate all necessary permits and procedures. Any information or opinions expressed by the city shall not be binding or constitute approval of the project.	Outdated
20.14.065(A)(1)(J)	Notice of application/proposal	Notice of application/proposal shall include: J. Other information that the department determines to be appropriate ~~to~~ include~~e~~**ing.** **but not limited to a designated permit responsible official and contact information such as a phone number and/or email address.**	State Mandate HB 2418

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
20.14.065(B)(2) Application Review – General	Initial application processing	B. Notice of Application – How Given. 1. Applicant Notice. The department shall electronically deliver or mail notice of application/proposal to the applicant, or the person or entity designated by the applicant to receive notice. The notice of application/proposal may be provided to the applicant or applicant's designee contemporaneously with the determination of completeness. 2. Agency Notice. The department shall electronically mail notice of all applications/proposals that are not categorically exempt under SEPA in accordance with Chapter 21.08 to departments and agencies with potential jurisdiction over the project permit application. The list of departments and agencies receiving notice shall be maintained by the **community** development ~~services~~ department.	Outdated
20.14.095(D)(3)	Compliance with notice of decision	D. Decision Expiration. An approval for project permit action shall automatically expire and be terminated when: 1. A new or modified decision is issued for the parcel or parcels affected; 2. The work or action authorized in the decision has not begun within one hundred eighty days from the date of issuance thereof, unless a longer or shorter time is specified in the approval itself; or 3. The work or action authorized in the decision has not been completed within two years from the date of issuance, unless a longer or shorter time is specified in the approval itself. Knowledge of **the** expiration date and initiation of a request for extension of approval time are the responsibility of the applicant. The city shall not be held responsible for the	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		notification of expiration, although it may notify the applicant of date of expiration. All requests for additional time must be submitted to the **community** development ~~services~~ office prior to expiration of the decision.	
20.18.050 Level 1 Review	Approval	The director shall issue a decision when determined that the proposal complies with the provisions of this code ~~and the Comprehensive Plan~~.	Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
20.22.040(E) Level II Review	Review procedures, decision – Level II	E. Conditional Approval The director may attach conditions to his or her approval in order to ensure the development is consistent with the applicable development standards of the Walla Walla Municipal Code a~~nd the policies of the Comprehensive Plan~~.	Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
20.26.040(D) Level III Review	Review procedures, decision – Level III	D. The hearing examiner shall approve, deny, or approve the application with such conditions as are necessary to bring the proposal into conformance with the standards of this code ~~and the policies of the Comprehensive Plan~~. Conditions of approval may include actions necessary to avoid imposition of undue	Clarification Caselaw- *Citizens v. Mount*

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		public service obligations on the city, or mitigation of adverse impacts.	*Vernon, 133 Wash.2d 861, 873-74 (1997)*
20.28.020(C) Level V Review	When required	C. Certain amendments to the Shoreline Master Program regulations and any other planning related regulation as determined by the director ~~to implement the Comprehensive Plan or subarea plan~~.	Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
20.34.040(A) Development Agreements	Approval procedure, recording	A. A development agreement shall only be approved by the city council after a **recommendation by the hearing examiner and** a public hearing. ~~The director shall make a recommendation to the city council, who will determine the hearing body based on the nature of the proposed action necessitating a development agreement~~. ~~A~~ **The** hearing **examiner** ~~body, if other than the city council,~~ shall conduct a hearing and forward its recommendation to the city council for consideration and decision.	Clarification
20.36.020 Public Hearings	Administrative responsibility	The **community** development ~~services~~ director shall have the following responsibilities:	Outdated
20.36.090(A) Public Hearings	Findings and notice of decision/action.	Following the public hearing procedure described in Section 20.36.080, the approving authority shall approve,	Clarification

WWMC	Section	Proposed Amendment	Category and Notes
		conditionally approve, or deny the application based on findings that address or relate to the applicable standards and criteria of this code and other referenced chapters of the Walla Walla Municipal Code ~~and the Comprehensive Plan~~.	Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
20.38.050(B and E) Closed Record Decisions And Appeals	Appeals – Filing	B. Time to File. An appeal of a decision must be filed within fourteen calendar days after service or publication of the notice of decision/action under Section 20.14.090 is deemed complete under Section 20.14.050 or 20.14.055. If Section 20.14.090 requires notice to be given by more than one method, the appeal period shall commence on the earliest date that the appellant is deemed to have been given any of the methods of notice. Appeals must be filed with the **community** development ~~services~~ department before 5:00 p.m. on the last business day of the appeal period. E. An answer need not be filed to an appeal. An appellant shall be confined to matters raised in the written appeal filed in accordance with subsection D of this section. A written appeal may be amended only upon the approval of the appellate body. Requests to amend an appeal must be filed with the **community** development ~~services~~ department and served by the appellant upon all parties entitled to notice of appeal at least seven calendar days prior to the appeal hearing. Requests to amend shall not be freely granted.	Outdated
20.42.020	Enforcement and administration	The city of Walla Walla **community** development ~~services~~ director and the Walla Walla police chief are authorized to	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Violations And Enforcement		enforce and charged with the primary enforcement of the provisions of Titles 15 and 19, this title and Chapters 8.05 and 8.07. The **community** development ~~services~~ director, and designees of either the **community** development ~~services~~ director or the police chief, are recognized as limited authority Washington peace officers for purposes of enforcement of Titles 15 and 19, this title, and Chapters 8.05 and 8.07. The **community** development ~~services~~ director and police chief, and designees of either the **community** development ~~services~~ director or police chief, shall be authorized to order discontinuance of the unlawful use of buildings or structures, removal of buildings or structures, discontinuance of any illegal work being done, or shall take any other action authorized by Title 15 or 19, this title or Chapter 8.05 or 8.07 to insure compliance with or prevent violations of its provisions.	
20.42.070 Violations And Enforcement	Complaints	Whenever a violation of this code or Chapter 8.05 or Chapter 8.07 of the Walla Walla Municipal Code occurs, any person may file a complaint in regard thereto. All such complaints must be in writing and shall be filed with the **Community** Development **Department** ~~services Division~~ of the city of Walla Walla, which shall properly record such complaint, conduct a preliminary investigation, and take such other action as deemed necessary by the city of Walla Walla **Community** Development **Director** ~~Services Manager~~.	Outdated
20.46.070(A), (C) and (F)	Review, decision	A. Applications before the site plan review committee shall be reviewed and evaluated based upon city-adopted policies, programs, and ordinances~~, and shall be in keeping with the~~	Outdated/ Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Site Plan Review Committee		~~Walla Walla Comprehensive Plan~~. To accomplish this, SPRC recommendations and decisions made by the approving authority under this code may include, but not be limited to, conditions of approval for site improvements, public improvements (streets, sidewalks, landscaping, etc.) and for the dedication of right-of-way necessary for public facilities. C. The SPRC shall within the comment period for the proposal approve, disapprove or approve with conditions any site plan submitted to it and accepted for review unless this time period is extended by mutual agreement, in writing, between the applicant and the site plan review committee. The action taken by the site plan review committee will be submitted to the **community** development ~~services~~ department for subsequent action on the **permit**~~development authorization~~ application. F. The foundation for project review and decision making shall be the city's ~~comprehensive plan and~~ development regulations. The city's review of a project permit application will include determination as to whether the proposed project is consistent with applicable regulations or comprehensive plan and concurrency requirements. The determination of consistency shall be based on review of the city's adopted service levels, the applicable development regulations, or in the absence of a relevant development regulation, upon the comprehensive plan. The city's review will emphasize existing requirements and adopted standards, with the use of supplemental authority as specified by Chapter 43.21C RCW to the extent that existing requirements do not adequately address a project's specific probable adverse environmental impacts.	Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*

WWMC	Section	Proposed Amendment	Category and Notes
20.46.080 Site Plan Review Committee	Relationship of review to other permits	The review and approval of site plans is considered a part of the city's development permit application approval process. Following approval of a site plan requiring review under the provisions of this code, a development permit may be issued by the **community** development ~~services~~ department provided all other requirements of development permit application and ordinances of the city have been complied with.	Outdated
20.46.110(B) Site Plan Review Committee	Duration of approval	B. Knowledge of expiration date and initiation of a request for extension of approval time is the responsibility of the applicant. The city shall not be held responsible for notification of expirations, although it may notify the applicant of date of expiration. All requests for additional time must be submitted to the **community** development ~~services~~ office prior to expiration of site plan approval.	Outdated
20.48.045 Division II Administrative Provisions Amendments	Review criteria prezones, area wide rezones and text amendments	The decision on a prezone, area wide rezone, or text amendment shall be based on a legislative finding upon whether or not the proposal is consistent with and implements the Walla Walla ~~Urban Area~~ Comprehensive **Plan Future Land Use Map**.	Clarification
20.48.050 Division II Administrative Provisions Amendments	Record of amendments	All amendments to the zone code will be recorded and indexed in the **community** development ~~services~~ department according to Section 20.14.100 of this code.	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
20.50.020(C)(1) Land Use Zones	RN Neighborhood Residential	C. The Neighborhood Residential Zone allows for up to four dwelling units per lot. 1. **For exceptions to these maximum standards, see Affordable Housing Development on Properties Owned by Religious Organizations in RCW 35.63.280, RCW 35A.63.300, RCW 36.70A.545.**	State Mandated HB 1859
20.50.105 Chapter (A-F) Land Use Zones	Landfill Vicinity Development Standards	**A. Any enclosed structure or paving requiring a building or grading and clearing permit that is located within one thousand feet of an active or former sanitary landfill shall incorporate measures to protect the structure and neighboring structures from potential landfill gas migration. The distance shall be calculated from the location of the proposed structure to the nearest property line of the active or former landfill site.** **B. The method for ensuring a structure's, and neighboring structure's, protection from landfill gas shall be addressed in a landfill gas mitigation report prepared and stamped by a licensed professional engineer to the city for review and approval prior to construction. The cost of preparing this report shall be borne by the developer.** **C. The report shall contain a description of the investigation conducted, identify any landfill gas hazards, and provide specific recommendations for preventing the accumulation of explosive concentrations of landfill gas within or under enclosed portions of the proposed building or structure.** **D. The city shall review the landfill gas mitigation report for compliance with applicable standards as part of the**	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		building/grading permit review process. No building/grading permit shall be issued until the report and proposed mitigation measures are approved by the city. **E. Design and Installation Requirements.** **1. A licensed professional engineer shall design all landfill gas mitigation systems, including but not limited to barriers, ventilation systems, subslab depressurization systems, and monitoring components.** **2. All approved landfill gas mitigation measures shall be installed by qualified contractors.** **3. Installation of landfill gas mitigation systems shall be subject to inspection by the city to verify compliance with the approved design prior to final inspection or issuance of a certificate of occupancy.** **F. At the time of the final inspection, the engineer of record shall furnish a signed statement attesting that, to the best of the engineer's knowledge, the building or structure has been constructed in accordance with their recommendations for addressing methane gas migration. Any changes to the design shall be submitted in writing and stamped by the engineer of record, and the developer shall provide as-built drawings to the city documenting the changes.**	
20.50.130 Land Use Zones	Application	An application for development of a UPC site shall be on forms prepared by the **community** development ~~services~~ department and a draft development agreement. The information required on the application forms shall take into account that detailed information may not be available at the	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		time of the application and may be developed through the environmental review process.	
20.50.170 (A-B) Land Use Zones	Urban planned community modifications	A. Site elements or conditions of approval may be amended or modified upon ~~at the~~ written request ~~of~~ by the applicant or the applicant's successor ~~in interest~~ **who has been formally** designated in writing by the applicant. B. Minor modifications of the urban planned community may be authorized by the **community** development ~~services~~ director and shall be established in the development agreement.	Outdated
20.127.007(H) Division IV Supplementary Use Regulations Table of Off-Street Parking Standards	Exemptions	The provisions of this code, as it pertains to the required number of parking spaces, shall not apply to the following: A. A building undergoing a change of use from nonresidential to a residential use or a change of use for a commercial use. B. Child care center, as defined in RCW 43.216.010. C. Commercial spaces under three thousand square feet. D. Ground level nonresidential space in a mixed-use building. E. Residences under one thousand two hundred square feet. F. The following land uses: 1. Affordable housing, 2. Senior housing/congregate care facility, 3. Transitional housing. G. Tree retention, when such compliance would make the development infeasible. This section does not apply to requirements for parking spaces permanently marked for the exclusive use of individuals with disabilities in compliance with the Americans with Disabilities Act.	Clarification

DRAFT

<table>
<tr><th>WWMC</th><th>Section</th><th>Proposed Amendment</th><th>Category and Notes</th></tr>
<tr><td></td><td></td><td>H. Downtown, as defined by the boundaries in the Walla Walla Comprehensive Plan Land Use Map.</td><td></td></tr>
<tr><td>20.100.040(C)
Table of Permitted Land Uses</td><td>Community Services</td><td>
<table>
<tr><td colspan="10">Zoning Districts</td></tr>
<tr><td>Land Uses</td><td>RN</td><td>RM</td><td>MHC</td><td>PR</td><td>CC</td><td>CH</td><td>IL/C</td><td>IH</td><td>AD</td></tr>
<tr><td>Day Care Centers: Family</td><td><s>3</s> 1</td><td><s>3</s> 1</td><td><s>3</s> 1</td><td>1</td><td>1</td><td>1</td><td>1</td><td><s>x</s>3</td><td><s>X</s>
1</td></tr>
</table>
</td><td>State Mandate
SB 5509</td></tr>
<tr><td>20.100.040(C)
Table of Permitted Land Uses</td><td>Community Services</td><td>
<table>
<tr><td colspan="10">Zoning Districts</td></tr>
<tr><td>Land Uses</td><td>RN</td><td>RM</td><td>MHC</td><td>PR</td><td>CC</td><td>CH</td><td>IL/C</td><td>IH</td><td>AD</td></tr>
<tr><td>Emergency Housing/ Shelter</td><td>3</td><td>1</td><td>3</td><td>1</td><td>1</td><td>1</td><td><s>1</s>x</td><td><s>1</s>
x</td><td><s>X</s>
1</td></tr>
</table>
</td><td>State Mandate
HB 2266</td></tr>
<tr><td>20.100.040(F)
Table of Permitted Land Uses and Footnote 3
Table of Permitted Land Uses</td><td>Residential</td><td>
<table>
<tr><td colspan="10">Zoning Districts</td></tr>
<tr><td>Land Uses</td><td>RN</td><td>RM</td><td>MHC</td><td>PR</td><td>CC</td><td>CH</td><td>IL/C</td><td>IH</td><td>AD</td></tr>
<tr><td>Transitional Housing</td><td>3</td><td>3</td><td>3</td><td>x</td><td><s>3</s> 1</td><td><s>3</s> 1</td><td><s>3</s> 1</td><td>X</td><td>X</td></tr>
</table>
Notes:
3. Second story and above, except:
a. <s>that all floors of h</s> Hotels and motels <s>located</s> in the Central Commercial Zone <s>can be</s> converted to residential use<s>.</s>, and
</td><td>State Mandate
SB 6026</td></tr>
</table>

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		b. Existing buildings in the Central Commercial Zone, when a reduction or waiver based on the merits of the project is issued. Commercial uses along the street facing public frontage, with residential in the rear of the building, will be prioritized by staff when reviewing requests.	
20.106.010 Landscaping and Screening	Purpose and intent	The purpose of this chapter is to ~~carry out the objectives and policies of the comprehensive plan with respect to "critical areas and the natural environment" and "preservation and enhancement of trees";~~ to maintain and enhance the urban forest as an important asset to the community ~~as expressed in the comprehensive plan~~; to provide landscaping and screening regulations which will promote a well balanced, healthy, aesthetically pleasing environment for city residents and visitors. Specifically, the regulations contained in this chapter are intended to accomplish the following:	Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
20.110 Fences	Title	Chapter 20.110 Fences **and Retaining Walls**	
20.110.030 Fences	Permit, required when	All fences anywhere on a lot are subject to **the** provisions of this chapter and require a fence permit prior to construction. Fence permits are to be processed under Level I procedures. **Retaining walls over 48" anywhere on a lot are subject to the provisions of this chapter and require a building permit.**	Clarification
20.110.040(A) Fences	General standards	A. Fences **and retaining walls** shall not conflict with requirements for clearview triangle in Chapter 20.114. For public safety reasons, no variances from these provisions shall be applied for or permitted.	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
20.110.040(B) Fences	General standards	B. Fences **and retaining walls** shall always be required to be built on private property and never on public right-of- way. Private property lines may be a considerable distance from street surfaces or curb lines.	Clarification
20.110.040(C) Fences	General standards	C. It shall be the property owner's responsibility and obligation to identify the property line when proposing to construct a fence **or retaining wall** on said property line. A property survey may be required.	Clarification
20.110.040(D) Fences	General standards	D. All fences **and retaining walls** shall be constructed and maintained in a structurally sound manner. Fences **and retaining walls** which are structurally unsound and/or hazardous are subject to abatement.	Clarification
20.110.040(E) Fences	General standards	E. **Fences and retaining walls shall be constructed and maintained of materials commonly used in standard construction.** Fences may ~~be constructed of~~ include wood, masonry, wire ~~or similar materials employed by standard building practice.~~**: retaining walls may include masonry, stone, or concrete.** ~~Fences~~ **Neither** shall ~~not~~ **be constructed** of ~~tires or similar~~ salvage materials not originally designed **for use** as structural components of fences**, retaining walls** or buildings.	Clarification
20.134.130 Environmental Performance	Inadvertent discovery of archaeological and cultural resources	When an unanticipated discovery of protected cultural material (e.g., bones, shell, stone tools, beads, ceramics, old bottles, hearths, etc.) or human remains are discovered, the permittee(s) for any building or grading permit secured in	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		accordance with this title shall immediately stop all work, completely secure the location, and contact the Washington State Department of Archaeology and Historic Preservation and other contacts as identified in the inadvertent discovery plan and procedures made available by the city of Walla Walla **community** development ~~services~~ department. The individual or representative whom the permit was issued to must send written notification of the inadvertent discovery to the city of Walla Walla **community** development ~~services~~ department.	
20.139.040(G) Short-Term Rentals	Application requirements	G. Such other information the **community** development ~~services~~ director or designee deems reasonably necessary to administer this chapter.	Outdated
20.139.070(E)(1-2) Short-Term Rentals	Violation and repeat offenses	E. Violation of this chapter shall be processed as outlined in Chapter 20.42. 1. The **community** development ~~services~~ director shall determine whether a short-term rental permit and license should be suspended, modified, or revoked, and notify the applicant of that determination in writing. 2. The **community** development ~~services~~ director's determination under subsection (E)(1) of this section shall be appealable to the Walla Walla hearing examiner as provided in Chapter 20.38.	Outdated
20.139.100(C)(1-2), (E)(1-2) and (F)(1-2) Short-Term Rentals	Elimination of type 2 short-term rentals.	C. Type 2 short-term rentals established and existing as of November 9, 2017, must obtain a short-term rental permit and license, and must apply for such permit and license by no later than February 1, 2018. In addition to the information required by Chapter 20.14 and Section 20.139.040, the applicant must	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		provide proof of a lawfully established and existing short-term type 2 rental use predating November 9, 2017, as provided in subsection B of this section and the scope and extent of such use. Failure to timely apply for a short-term rental permit and license or to provide proof of lawful use shall be conclusive evidence that such use was not lawfully established or existing as of November 9, 2017, and neither a permit nor a license shall be issued for such locations. 1. The **community** development ~~services~~ director shall determine whether a type 2 short-term rental use was lawfully established and existing as of November 9, 2017, and notify the applicant of that determination in writing. 2. The **community** development ~~services~~ director's determination under subsection (C)(1) of this section shall be appealable to the Walla Walla hearing examiner as provided in Chapter 20.38. E. Permits and licenses for short-term rentals must be timely renewed each year. Renewal applications must provide proof that type 2 short-term rental use continued throughout the preceding year. Type 2 short-term rental use must cease if such use has been discontinued or abandoned. Intent to discontinue and abandon a type 2 short-term rental use shall be presumed if a location was not rented at least a total of twenty-nine days during the preceding year. An owner may rebut such presumption by presenting proof that the failure to sufficiently rent a location was due to conditions over which the owner had no control. Discontinued and abandoned uses may not be reestablished, and no permit or license for a	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		discontinued or abandoned type 2 short-term rental use shall be renewed. 1. The **community** development ~~services~~ director shall determine whether a type 2 short-term rental use has been discontinued or abandoned, and notify the applicant of that determination in writing. 2. The **community** development ~~services~~ director's determination under subsection (E)(1) of this section shall be appealable to the Walla Walla hearing examiner as provided in Chapter 20.38. F. Type 2 short-term rental use must cease if a location is not rented for short-term use for six consecutive months or more. When a location is not rented for type 2 short-term use for six consecutive months or more, the use shall be deemed vacated even if the use has been unintentionally vacated. 1. The **community** development ~~services~~ shall determine whether a type 2 short-term rental use has been vacated, and notify the applicant of that determination in writing. 2. The **community** development ~~services~~ director's determination under subsection (F)(1) of this section shall be appealable to the Walla Walla hearing examiner as provided in Chapter 20.38.	
20.170.032 Wireless Communication Facilities	Permit applications	Any wireless communication service provider wishing to receive authorizations and permits to develop and operate a wireless communication facility or a person wishing to receive authorizations and permits to develop and operate an amateur radio tower in the city of Walla Walla shall submit an	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		application package to city **community** development ~~services~~ that contains the following information:	
20.171.070(C)(1) and (D) Small Wireless Communications Facilities	New poles in the rights-of-way for small wireless facilities and installations in a design zone	C. The concealment element design shall include the design of the screening, fencing or other concealment technology for a tower, pole, or equipment structure, and all related transmission equipment or facilities associated with the proposed small wireless facility, including but not limited to fiber and power connections. 1. The concealment element design should seek to minimize the visual obtrusiveness of the small wireless facility. The proposed pole or structure should have similar designs to existing neighboring poles in the rights-of-way, including similar height to the extent technically feasible. If the proposed small wireless facility is placed on a replacement pole in a design zone, then the replacement pole shall be of the same general design as the pole it is replacing, unless the **community** development ~~services~~ department otherwise approves a variation due to aesthetic or safety concerns. Any concealment element design for a small wireless facility on a decorative pole should attempt to mimic the design of such pole and integrate the small wireless facility into the design of the decorative pole. Other concealment methods include, but are not limited to, integrating the installation with architectural features or building design components, utilization of coverings or concealment devices of similar material, color, and texture, or the appearance thereof, as the surface against which the installation will be seen or on which it will be installed, landscape design, or other camouflage strategies	Outdated/ Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		appropriate for the type of installation. Applicants are required to utilize designs in which all conduit and wirelines are installed internally in the structure. Further, applicant designs should, to the extent technically possible, comply with the generally applicable design standards adopted pursuant to Section 20.171.060. D. Even if an alternative location is established pursuant to subsections (A)(1) and (2) of this section, the director may determine that a new pole in the right-of-way is in fact a superior alternative based on the impact to the city, the concealment element design, ~~the city's Comprehensive Plan~~ and the added benefits to the community.	
20.178.050 Design Standards for Downtown Walla Walla	Building height	**1.** All structures in the downtown area that front Rose **Street**, Main **Street**, ~~and~~ Alder Street~~s~~ and Second Avenue shall be at least two full stories above sidewalk level~~, and.~~ ~~m~~**M**ultiple stories are encouraged. The main level of a structure shall generally be at sidewalk level, and no split**-**level structures or split**-**entry malls are permitted. Balconies and cantilevers are permitted subject to applicable permits to occupy **the** right-of-way. **2. Buildings fronting on other streets not identified in 1. may be** ~~S~~single-story buildings **but** must be designed and built to be structurally capable of supporting at least one additional level.	Clarification
20.184.060(B) Manufactured Home Parks	Final manufactured home park plan approval	B. The plan shall provide certification of approval of the **community** development ~~services~~ director and the city engineer after review by the SPRC.	Outdated

WWMC	Section	Proposed Amendment	Category and Notes
Title 21: Environment			
21.04.010(A) Critical Areas	Authority	A. As provided herein, the **community** development ~~services~~ director ("director") is given the authority to interpret and apply, and the responsibility to enforce, this chapter to accomplish the stated purpose.	Outdated
21.04.020 Environment	Definitions: Development services department and Director	" **Community** development ~~services~~ department" (known and referred to alternatively herein as the "city **community** development ~~services~~ department," "department," or "staff") means the department or such other person(s) to whom the city manager assigns the primary responsibility of administering and enforcing this code. "Director" means the director of the **community** development ~~services~~ department or such other person to whom the city manager assigns the primary responsibility of administering and enforcing this code, and such other staff granted authority to act on behalf of the director or other assigned person.	Outdated
21.04.035(A) Environment	Critical area maps	A. The approximate location and extent of critical areas will be displayed on various inventory maps available at the city **community** development ~~services~~ department or online. These maps will be updated as inventories are completed in compliance with the requirements of the Growth Management Act, and additional maps may be added as appropriate. These maps include:	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
21.04.055 Environment	Administrative rules	The city **community** development ~~services~~ department is authorized to adopt such administrative rules and regulations as necessary and appropriate to implement this chapter and to prepare and require the use of such forms as necessary for its administration.	Outdated
21.04.075(C) Environment	Relationship to other regulations	C. Compliance with the provisions of this chapter does not constitute compliance with other federal, state, and local regulations and permit requirements that may be required (for example, shoreline substantial development permits, hydraulic project approvals permits, Army Corps of Engineers Section 404 permits, or National Pollutant Discharge Elimination System permits). The applicant is responsible for complying with these requirements, apart from the process established in this chapter. Where applicable, the **community** development ~~services~~ director will encourage use of information such as permit applications to other agencies or special studies prepared in response to other regulatory requirements to support required documentation submitted for critical areas review.	Outdated
21.04.700 Environment	Landfill Vicinity Development Standards	~~All enclosed structures, requiring a building permit, within one thousand feet of a sanitary landfill or former landfill site/parcel must be protected from potential landfill gas migration. The method for ensuring a structure's protection from landfill gas shall be addressed in a report submitted by a licensed professional engineer, at the cost of the developer, to the city of Walla Walla for review.~~	Clarification Moved to Title 20

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~The report shall contain a description of the investigation and recommendation(s) for preventing the accumulation of explosive concentrations of landfill gas within or under enclosed portions of the proposed building or structure. Any changes to the design shall be documented in writing and stamped by the landfill gas design engineer and the contractor shall provide as-built drawings to the city documenting the changes.~~	
21.08.120(A) State Environmental Policy Act	Preparation of EIS – Additional considerations	A. Preparation of draft and final EIS's and supplemental environmental impact statements (SEIS's) is the responsibility of the **community** development ~~services~~ department under the direction of the responsible official. Before the city issues an EIS, the responsible official shall be satisfied that it complies with this chapter and Chapter 197-11 WAC.	Outdated
21.08.140(A-B) State Environmental Policy Act	Designation of department to perform consulted agency responsibilities for the city	A. The **community** development ~~services~~ department shall be responsible for preparation of written comments for the city in response to a consultation request prior to a threshold determination, participation in scoping, or reviewing a DEIS. B. The **community** development ~~services~~ department shall be responsible for the city's compliance with WAC 197-11-550 whenever the city is a consulted agency and is authorized to develop operating procedures that will ensure that responses to consultation requests are prepared in a timely fashion and include data from all appropriate departments of the city.	Outdated
21.08.170(A)(3)(c, e and f) and (A)(4)(g)	Appeals	A. The city establishes the following administrative appeal procedures under RCW 43.21C.075 and WAC 197-11-680:	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
State Environmental Policy Act		(3)(c) Appeals must be consolidated with an appeal of the development ~~authorization~~ decision and proceed as provided in Chapter 20.38 of this code. SEPA determinations shall be appealable only upon issuance of the final development ~~authorization~~ decision. e. A record for an appeal shall be prepared by the **community** development ~~services~~ department and made available for public review and copying at least seven calendar days prior to the appeal hearing. f. An appeal of a SEPA determination under this subsection must be filed within fourteen calendar days after service of the notice of decision/action for the proposal under Section 20.14.090 is deemed complete under Section 20.14.050 or Section 20.14.055. If Section 20.14.090 requires notice to be given by more than one method, the appeal period shall commence on the earliest date that the appellant is deemed to receive any of the methods of notice. Appeals must be filed with the **community** development ~~services~~ department before 5:00 p.m. on the last business day of the appeal period. (4)(g) An appeal of a SEPA determination under this subsection must be filed within fourteen calendar days after the determination is made without regard to the date of service of notice of the determination. Appeals must be filed with the **community** development ~~services~~ department before 5:00 p.m. on the last business day of the appeal period.	
21.08.173(B) State Environmental Policy Act	Notice – Statute of limitations	B. The form of the notice shall be substantially in the form provided in WAC 197-11-990. The notice shall be published by	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		the **community** development ~~services~~ department, applicant or proponent pursuant to RCW 43.21C.080.	
21.10.010 Floodplain Management	Authorization	RCW 35A.63.100 authorizes the Walla Walla city council, by ordinance or other action ~~to the extent the Walla Walla city council~~ deem**ed**~~s~~ necessary or appropriate, to i~~mplement or give effect to the comprehensive plan or parts thereof in developing the city of Walla Walla and in~~ regulate~~ing the use of~~ land **within the city.**	Clarification Caselaw- *Citizens v. Mount Vernon, 133 Wash.2d 861, 873-74 (1997)*
21.10.050 Floodplain Management	Definitions	Unless specifically defined in this section, words or phrases used in this chapter shall be interpreted so as to give them the meaning they have in common usage and to give this chapter its most reasonable application: "Administrator" (known and referred to alternatively herein as the " **community** development ~~services~~ director," ~~"development services manager,"~~ "director," or "zoning administrator") means the director of the **community** development ~~services~~ department or such other person to whom the city manager assigns the primary responsibility of administering and enforcing this code, and such other staff granted authority to act on behalf of director.	Outdated
21.10.070 Floodplain Management	Special flood hazard area – Established	The areas of special flood hazard, as may be annexed to the city of Walla Walla, identified by the Federal Insurance Administration in a scientific and engineering report entitled,	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		"The Flood Insurance Study for the Unincorporated Areas in Walla Walla County," dated January 18, 2002, or as amended, with accompanying flood insurance rate maps (FIRM) is adopted by reference and declared to be a part of this chapter. The flood insurance study and FIRM are on file at the **community** development ~~services~~ department.	

DRAFT

SEPA[1] Environmental Checklist

Purpose of checklist

Governmental agencies use this checklist to help determine whether the environmental impacts of your proposal are significant. This information is also helpful to determine if available avoidance, minimization, or compensatory mitigation measures will address the probable significant impacts or if an environmental impact statement will be prepared to further analyze the proposal.

Instructions for applicants

This environmental checklist asks you to describe some basic information about your proposal. Please answer each question accurately and carefully, to the best of your knowledge. You may need to consult with an agency specialist or private consultant for some questions. **You may use "not applicable" or "does not apply" only when you can explain why it does not apply and not when the answer is unknown.** You may also attach or incorporate by reference additional studies reports. Complete and accurate answers to these questions often avoid delays with the SEPA process as well as later in the decision-making process.

The checklist questions apply to **all parts of your proposal**, even if you plan to do them over a period of time or on different parcels of land. Attach any additional information that will help describe your proposal or its environmental effects. The agency to which you submit this checklist may ask you to explain your answers or provide additional information reasonably related to determining if there may be significant adverse impact.

Instructions for lead agencies

Please adjust the format of this template as needed. Additional information may be necessary to evaluate the existing environment, all interrelated aspects of the proposal and an analysis of adverse impacts. The checklist is considered the first but not necessarily the only source of information needed to make an adequate threshold determination. Once a threshold determination is made, the lead agency is responsible for the completeness and accuracy of the checklist and other supporting documents.

Use of checklist for nonproject proposals

For nonproject proposals (such as ordinances, regulations, plans and programs), complete the applicable parts of sections A and B, plus the Supplemental Sheet for Nonproject Actions (Part D). Please completely answer all questions that apply and note that the words "project," "applicant," and "property or site" should be read as "proposal," "proponent," and "affected geographic area," respectively. The lead agency may exclude (for non-projects) questions in "Part B: Environmental Elements" that do not contribute meaningfully to the analysis of the proposal.

[1] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/Checklist-guidance

A. Background

Find help answering background questions[2]

1. **Name of proposed project, if applicable:**
   Annual 2026 Municipal Code Amendments
2. **Name of applicant:**
   City of Walla Walla c/o Jon Maland, Senior Planner
3. **Address and phone number of applicant and contact person:**
   15 North 3rd Avenue, Walla Walla, WA 99362. (509) 524-4710
4. **Date checklist prepared:**
   06/29/2026
5. **Agency requesting checklist:**
   City of Walla Walla
6. **Proposed timing of schedule (including phasing, if applicable):**
   To be determined; adoption tentatively scheduled for October/ November 2026
7. **Do you have any plans for future additions, expansion, or further activity related to or connected with this proposal? If yes, explain.**
   No - non-project action. Any future projects that result from this code change will be evaluated under SEPA guidelines at that time, as appropriate.
8. **List any environmental information you know about that has been prepared, or will be prepared, directly related to this proposal.**
   The 2018 Walla Walla Comprehensive Plan, and Final Environmental Impact Statement, issued May 22, 2018.
9. **Do you know whether applications are pending for governmental approvals of other proposals directly affecting the property covered by your proposal? If yes, explain.**
   No specific property or parcel is covered by this non-project/ non-site-specific action.
10. **List any government approvals or permits that will be needed for your proposal, if known.**
    Washington State Department of Commerce review for code changes is required.
11. **Give brief, complete description of your proposal, including the proposed uses and the size of the project and site. There are several questions later in this checklist that ask you to describe certain aspects of your proposal. You do not need to repeat those answers on this page. (Lead agencies may modify this form to include additional specific information on project description.)**
    Comprehensive Plan implementing Development Code amendments for 2026. Includes amendments to Titles 2, 3, 5, 10, 12, 13, 15 19, 20, and 21.
12. **Location of the proposal. Give sufficient information for a person to understand the precise location of your proposed project, including a street address, if any, and section,**

[2]

township, and range, if known. If a proposal would occur over a range of area, provide the range or boundaries of the site(s). Provide a legal description, site plan, vicinity map, and topographic map, if reasonably available. While you should submit any plans required by the agency, you are not required to duplicate maps or detailed plans submitted with any permit applications related to this checklist.

No specific site - city wide.

B. Environmental Elements

1. Earth

Find help answering earth questions[3]

a. General description of the site:

The Municipal Code amendments/update is not site specific.

Circle or highlight one: Flat, rolling, hilly, steep slopes, mountainous, other:

The City of Walla Walla is generally flat with a gradual slope that is higher in the east and lower in the west portions of the city.

b. What is the steepest slope on the site (approximate percent slope)?

Not applicable.

c. What general types of soils are found on the site (for example, clay, sand, gravel, peat, muck)? If you know the classification of agricultural soils, specify them, and note any agricultural land of long-term commercial significance and whether the proposal results in removing any of these soils.

Walla Walla largely has Yakima series soils, loams that are well drained.

d. Are there surface indications or history of unstable soils in the immediate vicinity? If so, describe.

Walla Walla generally has a moderate liquefaction potential.

e. Describe the purpose, type, total area, and approximate quantities and total affected area of any filling, excavation, and grading proposed. Indicate source of fill.

N/A non-project action

f. Could erosion occur because of clearing, construction, or use? If so, generally describe.

N/A non-project action - not specific to one parcel.

g. About what percent of the site will be covered with impervious surfaces after project construction (for example, asphalt or buildings)?

N/A - non-project action - not specific to one parcel.

[3] https://ecology.wa.gov/regulations-permits/sepa/environmental-review/sepa-guidance/sepa-checklist-guidance/sepa-checklist-section-b-environmental-elements/environmental-elements-earth

h. Proposed measures to reduce or control erosion, or other impacts to the earth, if any.

N/A - non project action.

2. Air

Find help answering air questions[4]

a. What types of emissions to the air would result from the proposal during construction, operation, and maintenance when the project is completed? If any, generally describe and give approximate quantities if known.

N/A - non project/ non site specific action

b. Are there any off-site sources of emissions or odor that may affect your proposal? If so, generally describe.

N/A - non project/ non site specific action

c. Proposed measures to reduce or control emissions or other impacts to air, if any:

N/A - non project/ non site specific action

3. Water

Find help answering water questions[5]

a. Surface:

Find help answering surface water questions[6]

1. **Is there any surface water body on or in the immediate vicinity of the site (including year-round and seasonal streams, saltwater, lakes, ponds, wetlands)? If yes, describe type and provide names. If appropriate, state what stream or river it flows into.**

   Walla Walla has many year-around streams throughout the city, including Mill Creek, Yellowhawk Creek, Stone Creek, Garrison Creek, and others.

2. **Will the project require any work over, in, or adjacent to (within 200 feet) the described waters? If yes, please describe and attach available plans.**

   No - non site-specific action.

3. **Estimate the amount of fill and dredge material that would be placed in or removed from surface water or wetlands and indicate the area of the site that would be affected. Indicate the source of fill material.**

   N/A

[4] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-Air
[5] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-3-Water
[6] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-3-Water/Environmental-elements-Surface-water

4. **Will the proposal require surface water withdrawals or diversions? Give a general description, purpose, and approximate quantities if known.**

   No - non project action.

5. **Does the proposal lie within a 100-year floodplain? If so, note location on the site plan.**

   Some portions of the southern end of Walla Walla are within a 100-year floodplain for Russell Creek.

6. **Does the proposal involve any discharges of waste materials to surface waters? If so, describe the type of waste and anticipated volume of discharge.**

   No - non project action.

b. Ground:

Find help answering ground water questions[7]

1. **Will groundwater be withdrawn from a well for drinking water or other purposes? If so, give a general description of the well, proposed uses and approximate quantities withdrawn from the well. Will water be discharged to groundwater? Give a general description, purpose, and approximate quantities if known.**

   No – non-project action. Any water used within the city for any projects that might stem from this code update would use City Water, not wells.

2. **Describe waste material that will be discharged into the ground from septic tanks or other sources, if any (domestic sewage; industrial, containing the following chemicals…; agricultural; etc.). Describe the general size of the system, the number of such systems, the number of houses to be served (if applicable), or the number of animals or humans the system(s) are expected to serve.**

   None, non-project action. Any waste material that would be a result of any project from this code change would be required to use the City's municipal wastewater system.

c. Water Runoff (including stormwater):

1. **Describe the source of runoff (including storm water) and method of collection and disposal, if any (include quantities, if known). Where will this water flow? Will this water flow into other waters? If so, describe.**

   Not applicable - non-project action.

2. **Could waste materials enter ground or surface waters? If so, generally describe.**

   No – non-project action.

3. **Does the proposal alter or otherwise affect drainage patterns in the vicinity of the site? If so, describe.**

   No. Any projects that might result from the code change would be required to handle their own stormwater impacts on the site.

[7] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-3-Water/Environmental-elements-Groundwater

d. **Proposed measures to reduce or control surface, ground, and runoff water, and drainage pattern impacts, if any:**

Any project resulting from the code change would be subject to the City of Walla Walla stormwater code and the Eastern Washington Stormwater Manual.

4. Plants

Find help answering plants questions

a. **Check the types of vegetation found on the site:** Non-site specific action

- ☐ **deciduous tree: alder, maple, aspen, other**
- ☐ **evergreen tree: fir, cedar, pine, other**
- ☐ **shrubs**
- ☐ **grass**
- ☐ **pasture**
- ☐ **crop or grain**
- ☐ **orchards, vineyards, or other permanent crops.**
- ☐ **wet soil plants: cattail, buttercup, bullrush, skunk cabbage, other**
- ☐ **water plants: water lily, eelgrass, milfoil, other**
- ☐ **other types of vegetation**

b. **What kind and amount of vegetation will be removed or altered?**

None, non-project action

c. **List threatened and endangered species known to be on or near the site.**

Not applicable - non project action

d. **Proposed landscaping, use of native plants, or other measures to preserve or enhance vegetation on the site, if any.**

Not applicable - non project action

e. **List all noxious weeds and invasive species known to be on or near the site.**

Not applicable - non project action

5. Animals

Find help answering animal questions[8]

a. **List any birds and other animals that have been observed on or near the site or are known to be on or near the site.**

Examples include:

[8] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-5-Animals

Non-site specific action/ project

- **Birds: hawk, heron, eagle, songbirds, other:**
- **Mammals: deer, bear, elk, beaver, other:**
- **Fish: bass, salmon, trout, herring, shellfish, other:**

b. List any threatened and endangered species known to be on or near the site.

Bull trout, steelhead

c. Is the site part of a migration route? If so, explain.

Pacific Flyway- nesting and migratory bird route

d. Proposed measures to preserve or enhance wildlife, if any.

The amendments to the CAO, should help protect wildlife habitat in the city.

e. List any invasive animal species known to be on or near the site.

Not applicable - non project action

6. Energy and natural resources

Find help answering energy and natural resource questions[9]

a. What kinds of energy (electric, natural gas, oil, wood stove, solar) will be used to meet the completed project's energy needs? Describe whether it will be used for heating, manufacturing, etc.

None, non-project action

b. Would your project affect the potential use of solar energy by adjacent properties? If so, generally describe.

No, non project action

c. What kinds of energy conservation features are included in the plans of this proposal? List other proposed measures to reduce or control energy impacts, if any.

None, non-project action. Any project resulting will need to abide by Washington State Energy Code requirements.

7. Environmental health

Health Find help with answering environmental health questions[10]

a. Are there any environmental health hazards, including exposure to toxic chemicals, risk of fire and explosion, spill, or hazardous waste, that could occur because of this proposal? If so, describe.

No, non-project action.

[9] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-6-Energy-natural-resou

[10] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-7-Environmental-health

1. **Describe any known or possible contamination at the site from present or past uses.**
   None - non site-specific action. Some sites in Walla Walla remain contaminated from past uses (former gas station sites, landfill, etc).
2. **Describe existing hazardous chemicals/conditions that might affect project development and design. This includes underground hazardous liquid and gas transmission pipelines located within the project area and in the vicinity.**
   Natural gas pipelines run through Walla Walla. All ground-disturbing projects are required to call before digging to ensure no impact.
3. **Describe any toxic or hazardous chemicals that might be stored, used, or produced during the project's development or construction, or at any time during the operating life of the project.**
   Not applicable - non project action
4. **Describe special emergency services that might be required.**
   None, non-project action
5. **Proposed measures to reduce or control environmental health hazards, if any.**
   N/A, non-project action. Any potential future project would be subject to SEPA unless categorically exempt.

b. Noise

1. **What types of noise exist in the area which may affect your project (for example: traffic, equipment, operation, other)?**
   General traffic noise throughout Walla Walla, in northern portions of the city, some aircraft noise from Walla Walla Regional Airport flights.
2. **What types and levels of noise would be created by or associated with the project on a short-term or a long-term basis (for example: traffic, construction, operation, other)? Indicate what hours noise would come from the site)?**
   None, non-project action
3. **Proposed measures to reduce or control noise impacts, if any:**
   Not applicable, non-project action. The CAO seeks to protect critical areas.

8. Land and shoreline use

Find help answering land and shoreline use questions[11]

a. **What is the current use of the site and adjacent properties? Will the proposal affect current land uses on nearby or adjacent properties? If so, describe.**
   Land use depends on the specific site, this is a non-site-specific action.

b. **Has the project site been used as working farmlands or working forest lands? If so, describe. How much agricultural or forest land of long-term commercial significance will be converted to other uses because of the proposal, if any? If resource lands have**

[11] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-8-Land-shoreline-use

not been designated, how many acres in farmland or forest land tax status will be converted to nonfarm or nonforest use?

Not applicable, non site-specific action

1. **Will the proposal affect or be affected by surrounding working farm or forest land normal business operations, such as oversize equipment access, the application of pesticides, tilling, and harvesting? If so, how?**

No, non project action

c. Describe any structures on the site.

Not applicable, non-project action

d. Will any structures be demolished? If so, what?

Not applicable, non site-specific action

e. What is the current zoning classification of the site?

Not applicable, non-project action

f. What is the current comprehensive plan designation of the site?

Not applicable, non-project action

g. If applicable, what is the current shoreline master program designation of the site?

Not applicable, non site-specific action

h. Has any part of the site been classified as a critical area by the city or county? If so, specify.

No, non-project action- many known critical areas throughout the City.

i. Approximately how many people would reside or work in the completed project?

Not applicable, non site-specific action

j. Approximately how many people would the completed project displace?

None, non-project action

k. Proposed measures to avoid or reduce displacement impacts, if any.

Not applicable, non-project action

l. Proposed measures to ensure the proposal is compatible with existing and projected land uses and plans, if any.

None, non site-specific action

m. Proposed measures to reduce or control impacts to agricultural and forest lands of long-term commercial significance, if any:

None, non site specific action. The City abides by the Growth Management Act (GMA)

9. Housing

Find help answering housing questions[12]

a. **Approximately how many units would be provided, if any? Indicate whether high, middle, or low-income housing.**

Not applicable, non project action

b. **Approximately how many units, if any, would be eliminated? Indicate whether high, middle, or low-income housing.**

Not applicable, non project action

c. **Proposed measures to reduce or control housing impacts, if any:**

None, non project action

10. Aesthetics

Find help answering aesthetics questions[13]

a. **What is the tallest height of any proposed structure(s), not including antennas; what is the principal exterior building material(s) proposed?**

Not applicable, non site-specific action

b. **What views in the immediate vicinity would be altered or obstructed?**

Not applicable

c. **Proposed measures to reduce or control aesthetic impacts, if any:**

Not applicable, non-project action

11. Light and glare

Find help answering light and glare questions[14]

a. **What type of light or glare will the proposal produce? What time of day would it mainly occur?**

Not applicable, non-project action

b. **Could light or glare from the finished project be a safety hazard or interfere with views?**

No, non site-specific action

c. **What existing off-site sources of light or glare may affect your proposal?**

None, non-project action

d. **Proposed measures to reduce or control light and glare impacts, if any:**

Not applicable

[12] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-9-Housing
[13] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-10-Aesthetics
[14] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-11-Light-glare

12. Recreation

Find help answering recreation questions

a. **What designated and informal recreational opportunities are in the immediate vicinity?**

Not applicable, non project action

b. **Would the proposed project displace any existing recreational uses? If so, describe.**

No it would not, as this is a non site specific action

c. **Proposed measures to reduce or control impacts on recreation, including recreation opportunities to be provided by the project or applicant, if any:**

None, non project action

13. Historic and cultural preservation

Find help answering historic and cultural preservation questions[15]

a. **Are there any buildings, structures, or sites, located on or near the site that are over 45 years old listed in or eligible for listing in national, state, or local preservation registers? If so, specifically describe.**

Walla Walla has multiple buildings on the local, state, and national registers. The Downtown District is listed on the national register of historic places. No impacts to structures, non-project action

b. **Are there any landmarks, features, or other evidence of Indian or historic use or occupation? This may include human burials or old cemeteries. Are there any material evidence, artifacts, or areas of cultural importance on or near the site? Please list any professional studies conducted at the site to identify such resources.**

Walla Walla is the homeland of the Cayuse, Walla Walla, and Umatilla people. No impacts, non-project action.

c. **Describe the methods used to assess the potential impacts to cultural and historic resources on or near the project site. Examples include consultation with tribes and the department of archeology and historic preservation, archaeological surveys, historic maps, GIS data, etc.**

None, non site specific action

d. **Proposed measures to avoid, minimize, or compensate for loss, changes to, and disturbance to resources. Please include plans for the above and any permits that may be required.**

None, non project action

[15] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-13-Historic-cultural-p

14. Transportation

Find help with answering transportation questions[16]

a. **Identify public streets and highways serving the site or affected geographic area and describe proposed access to the existing street system. Show on site plans, if any.**

Walla Walla's Road network is made up of all street classifications, including private lanes. No impacts, non-project action

b. **Is the site or affected geographic area currently served by public transit? If so, generally describe. If not, what is the approximate distance to the nearest transit stop?**

Walla Walla Valley Transit serves the City of Walla Walla.

c. **Will the proposal require any new or improvements to existing roads, streets, pedestrian, bicycle, or state transportation facilities, not including driveways? If so, generally describe (indicate whether public or private).**

No, non site specific action

d. **Will the project or proposal use (or occur in the immediate vicinity of) water, rail, or air transportation? If so, generally describe.**

No, non project action- individual proposed will be regulated by the CAO.

e. **How many vehicular trips per day would be generated by the completed project or proposal? If known, indicate when peak volumes would occur and what percentage of the volume would be trucks (such as commercial and nonpassenger vehicles). What data or transportation models were used to make these estimates?**

Not applicable, non-project action

f. **Will the proposal interfere with, affect, or be affected by the movement of agricultural and forest products on roads or streets in the area? If so, generally describe.**

No, non site-specific action

g. **Proposed measures to reduce or control transportation impacts, if any:**

None, non project action

15. Public services

Find help answering public service questions[17]

a. **Would the project result in an increased need for public services (for example: fire protection, police protection, public transit, health care, schools, other)? If so, generally describe.**

No, non project action

b. **Proposed measures to reduce or control direct impacts on public services, if any.**

None, non project action

[16] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-14-Transportation

[17] https://ecology.wa.gov/regulations-permits/sepa/environmental-review/sepa-guidance/sepa-checklist-guidance/sepa-checklist-section-b-environmental-elements/environmental-elements-15-public-services

16. Utilities

Find help answering utilities questions[18]

a. **Circle utilities currently available at the site: electricity, natural gas, water, refuse service, telephone, sanitary sewer, septic system, other:**

All of these utilities are available throughout Walla Walla

b. **Describe the utilities that are proposed for the project, the utility providing the service, and the general construction activities on the site or in the immediate vicinity which might be needed.**

None, non project action

C.Signature

Find help about who should sign[19]

The above answers are true and complete to the best of my knowledge. I understand that the lead agency is relying on them to make its decision.

X Jon Maland

Position and agency/organization:

Date submitted:

D.Supplemental sheet for nonproject actions

Find help for the nonproject actions worksheet[20]

Do not use this section for project actions.

Because these questions are very general, it may be helpful to read them in conjunction with the list of the elements of the environment.

[18] https://ecology.wa.gov/regulations-permits/sepa/environmental-review/sepa-guidance/sepa-checklist-guidance/sepa-checklist-section-b-environmental-elements/environmental-elements-16-utilities
[19] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-C-Signature
[20] https://ecology.wa.gov/regulations-permits/sepa/environmental-review/sepa-guidance/sepa-checklist-guidance/sepa-checklist-section-d-non-project-actions

When answering these questions, be aware of the extent the proposal, or the types of activities likely to result from the proposal, would affect the item at a greater intensity or at a faster rate than if the proposal were not implemented. Respond briefly and in general terms.

1. **How would the proposal be likely to increase discharge to water; emissions to air; production, storage, or release of toxic or hazardous substances; or production of noise?**

   The proposed code changes are not expected to result in the above increases. CAO update provides protection of critical areas.

   - **Proposed measures to avoid or reduce such increases are:**

   None proposed.

2. **How would the proposal be likely to affect plants, animals, fish, or marine life?**

   The proposal is not anticipated to have significant impacts on plants, animals, or fish. The CAO attempts to reduce negative impacts.

   - **Proposed measures to protect or conserve plants, animals, fish, or marine life are:**

   The CAO amendments/update will include measures to protect or conserve plants, animals, etc.

3. **How would the proposal be likely to deplete energy or natural resources?**

   The code updates are not expected to deplete energy or natural resources.

   - **Proposed measures to protect or conserve energy and natural resources are:**

   The code updates are not expected to directly protect or conserve energy.

4. **How would the proposal be likely to use or affect environmentally sensitive areas or areas designated (or eligible or under study) for governmental protection, such as parks, wilderness, wild and scenic rivers, threatened or endangered species habitat, historic or cultural sites, wetlands, floodplains, or prime farmlands?**

   The CAO amendments/update will provide for regulations that protect environmentally sensitive areas and critical area habitats.

   - **Proposed measures to protect such resources or to avoid or reduce impacts are:**

   Any projects would be subject to SEPA review and mitigation unless otherwise categorically exempt.

5. **How would the proposal be likely to affect land and shoreline use, including whether it would allow or encourage land or shoreline uses incompatible with existing plans?**

   The city code and shoreline management program regulates the compatibility of proposals with shoreline uses.

   - **Proposed measures to avoid or reduce shoreline and land use impacts are:**

   None proposed.

6. **How would the proposal be likely to increase demands on transportation or public services and utilities?**

   The proposed code changes are not expected to directly increase demands on transportation or public services.

   - **Proposed measures to reduce or respond to such demand(s) are:**

   None proposed.

7. Identify, if possible, whether the proposal may conflict with local, state, or federal laws or requirements for the protection of the environment.

No conflicts with local, state, or federal laws or requirements for environmental protection.

City of Walla Walla
Development Services

Washington State Environmental Policy Act – SEPA

Adoption/Addendum of an existing Environmental Document
File# PLN5-26-0001

Date of Issuance: August 17, 2026

Description of Proposal: Walla Walla Municipal Code (WWMC) Amendments-Comprehensive Plan implementing Municipal Code Amendments – 2026

Chapter/Sections: 2.17, 2.27, 2.28, 3.23, 5.02, 5.04, 5.05, 5.09, 10.17. 10.27, 12.14, 13.050.060, 13.07.020, 15.36.020, 19.02.050, 19.06.020, 19.18.040, 19.26.015, 19.26.040, 19.30.010, 19.40.020, 20.10, 20.14.030, 20.14.065, 20.14.095, 20.36.020, 20.38.050, 20.42.020, 20.42.070, 20.46.080, 20.46.110, 20.48.050. 20.50.130, 20.50.170, 20.134.10, 20.139.040, 20.139.070, 20.139.100, 20.170.032, 20.171.070, 20.184.060, 21.040.010, 21.040.020, 21.04.035, 21.04.055, 21.04.075, 21.08.120, 21.08.170, 21.08.173, 21.10.050, 21.10.070 - WWMC 12.64.020, WWMC 13.03.601, WWMC 13.04.040, 13.04.150, WWMC 15.04.005, WWMC 19.02.030, WWMC 19.020.050, WWMC 20.02.040, WWMC 20.02.050, WWMC 20.02.080 (B) (D), (I)(1) and (I)(2)(J)-new letter. **WWMC 20.02.130, WWMC 20.10.080, WWMC 20.14.065, WWMC 20.18.050, 20.22.040, 20.28.020, WWMC 20.34.040, WWMC 20.48.045 , WWMC 20.50.020, WWMC 20.50.105 (New Chapter A-F), WWMC 20.50.170, WWMC 20.127.007, WWMC 20.100.040, WWMC 20.106.010, WWMC 20.110, WWMC 20.171.070, WWMC 20.178.050, WWMC 21.04.700, WWMC 21.10.010,.**

Proponent: City of Walla Walla, 15 N. 3rd Avenue, Walla Walla, WA 99362

Location of current proposal: All of the City of Walla Walla and City of Walla Walla Urban Growth Area (UGA).

Title of document being adopted: The City of Walla Walla Comprehensive Plan, Walla Walla 2040, and the Final Environmental Impact Statement (FEIS).

The agency that prepared the document being adopted: City of Walla Walla

Date the adopted document was prepared: 5/18/2018

Description of document (or portion) being adopted: The City of Walla Walla Comprehensive Plan, Walla Walla 2040, and the Final Environmental Impact Statement (FEIS), dated May 22, 2018.

Addendum to the FEIS: Pursuant to WAC 197-11-600(4)(c) and the addendum procedures in WAC 197-11-625, the City is issuing this Addendum to the 2018 FEIS. This Addendum provides additional information and analysis based on the June 29, 2026, Environmental Checklist. The information presented does not substantially change the analysis of probable significant adverse impacts or the range of alternatives considered in the 2018 FEIS. The original FEIS remains valid and is not modified or replaced by this Addendum.

If the document being adopted has been challenged (WAC 197-11-630), please describe: No.

The document is available to be read at: City of Walla Walla Development Services office at 55 East Moore Street, Walla Walla, WA.

The City of Walla Walla has identified, adopted, and incorporated by reference this document as being appropriate for this proposal, after independent review. The document meets our environmental review needs for the current proposal and will accompany the proposal to the decision makers. We have determined that this proposal will not have a probable significant adverse impact on the environment. An Environmental Impact Statement (EIS) is not required under RCW 43.21C.030(2)(c).

Name of agency adopting document: City of Walla Walla

Contact person: Jon Maland, AICP, Sr. Planner, Phone:(509) 524-4710

Responsible Official: J Preston Frederickson, Director

Address: City of Walla Walla Development Services
55 East Moore Street, Walla Walla, WA 99362

Issue Date: August 17, 2026

Signature: _____ **Date:** August 17, 2026

City of Walla Walla Planning Commission
Development Services
55 E. Moore Street
Walla Walla, WA 99362

CITY OF WALLA WALLA PLANNING COMMISSION
DRAFT MEETING MINUTES
Monday, July 6, 2026 – 6:30 P.M.
Hybrid Meeting – In Person and via *Zoom*
Council Chambers, 15 N 3rd Avenue, Walla Walla

1. CALL TO ORDER

Vice-Chair Walden called the meeting to order at 6:30 p.m.

2. ROLL CALL

Members Present: Arlene Alen, Member
John Gahbauer, Member
Kristin Jensen, Member
Liz Jessee, Member
Jeff Strickler, Member
Jennifer Walden, Vice-Chair

Members Excused: Jim Williams, Chair

Staff Present: Emily Arteche, Deputy Director
Jon Maland, Sr. Planner
Pam Ransier, Administrative Permit Coordinator
Monte Willis, Council Liaison

Quorum was established.

3. PUBLIC COMMENT

No members of the public provided comment.

4. APPROVAL OF MINUTES

A. Special Meeting – June 1, 2026

MOTION: **Commissioner Alen** moved, and **Commissioner Gahbauer** seconded to approve the special meeting minutes for June 1, 2026 as presented.
Motion carried 6- 0

B. Regular Meeting – June 1, 2026

MOTION: **Commissioner Alen** moved, and **Commissioner Jessee** seconded to approve the regular meeting minutes for June 1, 2026 as presented.
Motion carried 6- 0

C. Special Meeting – June 22, 2026

MOTION: **Commissioner Alen** moved, and **Commissioner Gahbauer** seconded to approve the special meeting minutes for June 22, 2026 as presented.

Motion carried 6- 0

5. OLD BUSINESS

A. Comprehensive Plan Update — Public Hearing

The public hearing for the 2026 Comprehensive Plan Update was opened at the June 1, 2026, regular Planning Commission meeting, and was approved by motion to continue the public hearing until July 6, 2026.

Vice-Chair Walden asked if any member of the public wished to provide public testimony. Seeing there were no members of the public in person or online, she closed the public hearing at 6:33 p.m.

6. NEW BUSINESS

A. Annual Code Amendments — Workshop

Using a PowerPoint presentation, **Emily Arteche, Deputy Director,** reviewed the proposed amendments to the Walla Walla Municipal Code. Many of the changes were related to the forthcoming department name change from Development Services to Community Development, caselaw results that require changes, or were the result of state mandated code changes.

The commissioners asked clarifying questions and provided thoughtful feedback to staff as input to the final draft of the amendments.

The final draft of the proposed code amendments will be presented to the Planning Commission September 14, 2026, for recommendation to City Council. The City Council will hold a workshop on the code amendments on September 21, 2026, with action at a future date.

B. September Meeting Date

Staff noted the September regular Planning Commission meeting date fell on Labor Day and requested formal approval to move the date one week later to September 14, 2026.

MOTION: **Commissioner Jensen** moved, and **Commissioner Alen** seconded to change the September meeting date to September 14, 2026, in observance of the Labor Day holiday.

Motion carried 6- 0

7. STAFF UPDATES

- Plan review for Five Below and Get Air Trampoline is underway.
- WaFed's new branch on West Alder Street is under construction.
- Bath & Bodyworks continues work on tenant improvements and entrance construction.
- The first review of MC Gateway community has been completed and staff is waiting for plan revisions.
- A guest speaker will attend the August meeting to discuss upcoming changes to the Critical Areas Ordinance.

8. ADJOURNMENT

MOTION: **Commissioner Jensen** moved, and **Commissioner Jessee** seconded to adjourn.

Motion carried 6- 0

Meeting adjourned at 7:19 p.m.

City of Walla Walla Planning Commission
Development Services
55 E. Moore Street
Walla Walla, WA 99362

CITY OF WALLA WALLA PLANNING COMMISSION
DRAFT MEETING MINUTES
Monday, August 3, 2026 – 6:30 P.M.
Hybrid Meeting – In Person and via *Zoom*
Council Chambers, 15 N 3rd Avenue, Walla Walla

1. CALL TO ORDER

Chair Williams called the meeting to order at 6:30 p.m.

2. ROLL CALL

Members Present: Jim Williams, Chair
Arlene Alen, Member
Kristin Jensen, Member
Liz Jessee, Member
Jeff Strickler, Member
Jennifer Walden, Vice-Chair

Members Excused: John Gahbauer, Member

Staff Present: Emily Arteche, Deputy Director
Jon Maland, Sr. Planner
Pam Ransier, Administrative Permit Coordinator
Monte Willis, Council Liaison

Quorum was established.

3. PUBLIC COMMENT

No members of the public provided comment.

4. APPROVAL OF MINUTES

A. Regular Meeting – July 6, 2026

MOTION: **Commissioner Jenson** moved, and **Commissioner Alen** seconded to approve the regular meeting minutes for July 6, 2026 as presented.
Motion carried 6- 0

5. OLD BUSINESS

A. Comprehensive Plan Update — Commission Action

Chair Williams introduced the Comprehensive Plan Update and outlined the next steps to move the draft plan forward in the approval process, including a recommendation by the Planning Commission to City Council.

MOTION: **Commissioner Strickler** moved, and **Commissioner Walden** seconded to recommend approval of the draft 2046 Comprehensive Plan to the City Council.
Discussion: **Commissioner Jessee** noted that a county document related to extreme

weather is in the process of being revised and the document link from the county's website will be available to include in the final version of the 2046 Comprehensive Plan.

Motion carried 6- 0

B. Emily Arteche, Deputy Director, presented a minor change to the list of upcoming code amendments. This change is related to when the city will accept annexation petitions. The requested amendment was received in Development Services after the July workshop. No action is needed at this time.

6. NEW BUSINESS

A. Critical Area Ordinance Amendments **Workshop**

Ms. Arteche, introduced **Nell Lund,** Senior Ecologist with Facet, the city's consultant for the 10-year Critical Areas Ordinance (CAO) update. Using a PowerPoint presentation, Ms. Lund gave an overview of the CAO and what the ordinance governs. Primarily wetlands, aquifer recharge areas, fish and wildlife conservation areas, frequently flooded areas, and geologically hazardous areas. She stressed the importance of using Best Available Science (BAS) during the update process. **Ms. Arteche** explained that Mill Creek was not included in this work as it is a waterway of the state and is included in the Shoreline Master Program, not the CAO.

Commissioners asked clarifying questions and staff and Ms. Lund responded.

Chair Williams asked staff to provide to the commission as soon as possible any public comments on the amendments received prior to the next meeting.

The final draft of the proposed code amendments will be presented to the Planning Commission September 14, 2026, for recommendation to City Council. The City Council will hold a workshop on the code amendments on September 21, 2026, with action at a future date.

7. STAFF UPDATES

- MC Gateway, a planned community near the airport, is working with the city on a development agreement outlining all aspects of the future development.
- A proposed 14-lot residential development on Fern Avenue will go before the Hearing Examiner on August 13, 2026.
- A variance request for a subdivision on E Sumach Street will also go before the Hearing Examiner on August 13. The variance is related to access to a 15-lot subdivision with geographical constraints that prevent a second access point. This variance was originally approved in 2023 but expired before the development could move forward.
- Staff are finalizing a binding site plan for the WinCo property that will create eight building pads.
- Shoreline review is underway for bridge replacement projects at 4th Avenue and 6th Avenue.
- Staff are working on the environmental review for a planned community located near Highway 125, south Myra Road and Village Way.

8. ADJOURNMENT

MOTION: **Commissioner Jessee** moved, and **Commissioner Jessen** seconded to adjourn.

Motion carried 6- 0

Meeting adjourned at 7:15 p.m.

Washington State Department of Commerce

THANK YOU

We have received your amendment submission. Please allow 1-3 business days for review. Please keep the Submittal ID as your receipt and for any future questions. We will also send an email receipt to all contacts listed in the submittal.

Submittal ID: 2026-S-15146

Submittal Date Time: 08/04/2026

Submittal Information

Jurisdiction	City of Walla Walla
Submittal Type	60-day Notice of Intent to Adopt Amendment
Amendment Type	Development Regulation Amendment

Amendment Information

Brief Description
Proposed 2026 Annual Municipal Code Amendments

☐ **Yes, this is a part of the 10-year periodic update schedule, required under RCW 36.70A.130.**

Planning Commissions Date 09/14/2026

City Council Date 10/14/2026

Anticipated/Proposed Date of Adoption 10/28/2026

Categories

Submittal Category
Development Regulations
Zoning Code

Attachments

Attachment Type	File Name	Upload Date
Development Regulation Amendment - Draft	PC 2026 Draft Implementing Code Amendments Table 8_3_2026.pdf	08/04/2026 10:07 AM

Contact Information

Prefix	Mr.
First Name	Jonathan
Last Name	Maland
Title	Senior Planner
Work	(509) 524-4710
Cell	
Email	jmaland@wallawallawa.gov

☐ **Yes, I would like to be contacted for Technical Assistance.**

Certification

■ **I certify that I am authorized to submit this Amendment for the Jurisdiction identified in this Submittal and all information provided is true and accurate to the best of my knowledge.**

Full Name	Jonathan Maland
Email	jmaland@wallawallawa.gov

NOTICE OF APPLICATION and NOTICE OF PUBLIC HEARING

Walla Walla Municipal Code (WWMC) Amendments - Comprehensive Plan implementing Municipal Code Amendments – 2026

Amendments to Walla Walla Municipal Code Chapter 21.04 - Critical Area Ordinance.
FILE# PLN5-26-0001

Project Summary: This is a proposal to revise various sections of the Walla Walla Municipal Code. The specific code sections and details of the proposed revisions are described below.

Notice is hereby given on this date, **August 18, 2026**, that a development regulation amendment application/proposal described in this notice has been filed with the City of Walla Walla Development Services. The application documents may be reviewed at the City of Walla Walla Development Services Department at 55 E. Moore Street, Walla Walla, or by visiting the city's website at https://www.wallawallawa.gov/government/development-services/public-notice.

Public Hearing: Notice is also hereby given by the City of Walla Walla that a **Public Hearing will be held on the application/proposal by the City of Walla Walla Planning Commission on Monday, September 14, 2026, at 6:30 P.M. at the City Hall Council Chambers, 15 N. 3rd Avenue, Walla Walla, WA (N. 3rd Avenue and Rose Street).**

Members of the public may also attend and participate in the public hearing virtually using this Zoom meeting link https://bit.ly/4pbogQ1 or listen to the meeting by calling 253-215-8782 and entering meeting ID 818 2953 1983.

State Environmental Policy Act (SEPA): The City of Walla Walla Development Services has determined that this proposal is unlikely to have a significant adverse impact on the environment. An environmental impact statement (EIS) is not required under RCW 43.21C.030(2)(c). The City of Walla Walla issued an Adoption/Addendum of an existing Environmental Document on August 18, 2026. We have reviewed the following existing environmental documents: Walla Walla Comprehensive Plan Final Environmental Impact Statement (FEIS), issued May 22, 2018, and Walla Walla Comprehensive Plan - Walla Walla 2040, Ordinance 2018-15, adopted June 13, 2018. The relevant content of these documents is briefly described as an Environmental Impact Statement for the Walla Walla Comprehensive Plan, which evaluates proposed actions, alternatives, and environmental impacts of activities allowed by the Walla Walla Comprehensive Plan & Environmental Impact Statement.

If reference is made below to the application or determination of completeness, copies of the referenced materials are attached hereto.

1. **Applicant:** City of Walla Walla Development Services Department, 55 E. Moore St., Walla Walla, WA 99362
2. **Date of Application:** June 29, 2026
3. **Complete Application:** June 29, 2026
4. **Location of Proposed Action:** Throughout the City Limits of Walla Walla.

5. **Proposed Code Amendments:** Updates to the following chapters and sections of the Walla Walla Municipal Code (WWMC) are summarized below and are being proposed; contact the Development Services Department for the complete text.

   Chapter/Sections: 2.17, 2.27, 2.28, 3.23, 5.02, 5.04, 5.05, 5.09, 10.17. 10.27, 12.14, 13.050.060, 13.07.020, 15.36.020, 19.02.050, 19.06.020, 19.18.040, 19.26.015, 19.26.040, 19.30.010, 19.40.020, 20.10, 20.14.030, 20.14.065, 20.14.095, 20.36.020, 20.38.050, 20.42.020, 20.42.070, 20.46.080, 20.46.110, 20.48.050. 20.50.130, 20.50.170, 20.134.10, 20.139.040, 20.139.070, 20.139.100, 20.170.032, 20.171.070, 20.184.060, 21.040.010, 21.040.020, 21.04.035, 21.04.055, 21.04.075, 21.08.120, 21.08.170, 21.08.173, 21.10.050, 21.10.070 - Amend "Development Services" to "Community Development or Community Development department" and/or "Development Services director to Community Development director" within the applicable Titles and Sections of the Walla Walla Municipal Code.

   WWMC 12.64.020 - Amend text to Future Land Use Map

   WWMC 13.03.601 - City Manager's discretion on sewer services.

   WWMC 13.04.040 and 13.04.150 - City Manager's discretion on water services.

   WWMC 15.04.005 - Calculation of permit fees for a permit-ready accessory dwelling unit.

   WWMC 19.02.030- Amend text for clarification with case law.

   WWMC 19.020.050- Amend from Authorization to Permit

   WWMC 20.02.040- Remove text of "This code is the principal means of implementing the Plan"

   WWMC 20.02.050- Amend for the text of MHC | Mobile/Manufactured Home Park Community

   WWMC 20.02.080 (B) (D), (I)(1) and (I)(2)(J)-new letter- Amend text for accepting annexation petitions anytime during the year and for clarification with case law.

   WWMC 20.02.130- Amend text for clarification with case law.

   WWMC 20.10.080 - Amend text for clarification on City Council decisions.

   WWMC 20.14.065 – Amend text for designated permit responsible official and contact information

   WWMC 20.18.050, 20.22.040, 20.28.020- Amend text for clarification with case law.

   WWMC 20.34.040 - Amend text for the Hearing Examiner to conduct the public hearing and make a recommendation to the City Council on development agreements.

   WWMC 20.48.045- Amend text for Future Land Use Map.

   WWMC 20.50.020- Amend text for Affordable Housing Development on Properties Owned by Religious Organizations in RCW 35.63.280, RCW 35A.63.300, RCW 36.70A.545.

   WWMC 20.50.105 (New Chapter A-F)- Landfill Vicinity Development Standards

   WWMC 20.50.170- Urban planned community modifications, amend for "who has been formally"

   WWMC 20.127.007 - Amend for downtown parking exemption.

WWMC 20.100.040 - Amend to comply with Washington State SB 5509 on daycares, HB 2266 on Emergency Housing/ Shelter, and SB 6026 on the prioritization of commercial uses along the street facing public frontage with residential in the rear of the building; will be applied.

WWMC 20.106.010 - Amend text for clarification with case law.

WWMC 20.110 - Amend this section for Retaining Walls within the Fence code.

WWMC 20.171.070 - Amend text section on the city's Comprehensive Plan.

WWMC 20.178.050- Amend this section on building height in the downtown design standards.

WWMC 21.04.700 - This section moved to Title 20.

WWMC 21.10.010 - Amend this section for text clarification and for clarification with case law.

WWMC Chapter 21.04 - Amendments to the Critical Area Ordinance. Under the Washington State Growth Management Act (GMA), the City of Walla Walla must incorporate best available science" (BAS) when developing policies and regulations to protect the functions and values of critical areas. Additionally, "special consideration" must be given to conservation or protection measures necessary to preserve or enhance anadromous fisheries.

Public Comment: Comments upon this application must be submitted in writing to the City of Walla Walla Development Services at 55 East Moore Street, Walla Walla, WA 99362, or by email to permits@wallawallawa.gov.

The comment period will open on August 18, 2026, and comments must be actually received by the Development Services Department before 5:00 P.M. on Friday, September 4, 2026. **Comments, both oral and written, may also be submitted at the Planning Commission Public Hearing on Monday, September 14, 2026, at 6:30 P.M.**

Interested persons and parties may also receive a copy of any decision(s) made on the proposal by filing a special notice request with the City of Walla Walla as provided in section 20.14.015 of the Walla Walla Municipal Code. Appeal rights are outlined in Chapter 20.38 of the Walla Walla Municipal Code and other code provisions referenced therein. A staff report and information packet with all submitted documents will be available for review on the City of Walla Walla Development Services Department website.

City of Walla Walla Development Services, 55 E. Moore Street, Walla Walla, WA 99362
(509) 524-4710 Email: permits@wallawallawa.gov

Emily Davis

From: Richard McFarland <estatewagons@att.net>
Sent: Friday, September 4, 2026 4:59 PM
To: Permits
Subject: Public Comment - FILE # PLN5-26-0001

To Whom It May Concern: Please enter my comments on the Walla Walla Municipal Code Amendments - Comprehensive Plan implementing Municipal Code Amendmentgs - 2026.

Regarding the first amendment listed which has too many numbers to enter - but it's about changing the name of Development Services to "Community Development". WHY? Why confuse everyone by renaming the city's planning and zoning department and using the same name as the county's planning and zoning department? It makes no sense.

WWMC 13.03.01 > changing "the city's discretion to the City Manager's discretion. Why? Why eliminate the city council from the job they're elected to do?

WWMC 13.04.040 and 13.04.150 > the same question applies to the one above - Why? Why eliminate the city council from the job they're elected to do?

WWMC 20.02 080 Finally - why after justifying having one time period each year for annexation as it's far more efficient - especially with limited staffing these days...would you go back to accepting annexation applications year 'round. Makes no sense

Sincerely RL McFarland

ar-6053 **Pgs. 901-2635**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: Critical Areas Ordinance Municipal Code Amendments - Public Hearing

Submitted For: Lisa Wasson-Seilo, Development Services Department

Add'l Contributors: Jon Maland, Senior Planner; Emily Arteche, Deputy Director

Financial Comments:

NA

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

Public hearing on the Critical Areas Ordinance (CAO) Municipal Code amendments

---

Information

HISTORY:

The draft Critical Area Ordinance (CAO) code amendments are contained in the Walla Walla Municipal Code under Title 21, Environment, and specifically Chapter 21.04, Critical Areas. Categories include state-mandated, clarification, and outdated. The Planning Commission workshopped these amendments on August 3, 2026.

The majority of the code amendments relate to a state mandate under the Revised Code of Washington (RCW) 36.70A.172, which requires the City to incorporate “best available science” (BAS) when developing policies and regulations to protect the functions and values of critical areas. Additionally, “special consideration” must be given to conservation or protection measures to preserve or enhance anadromous fisheries, or species that hatch in fresh water, migrate to the ocean to grow as adults, and return to fresh water to spawn. To this end, the riparian buffer zones on either side of the City’s creeks and streams, with the exception of Mill Creek, are proposed to increase to 100 feet. Code amendments are also proposed relating to disconnected buffers, or areas where an existing man-made structure is within the buffer zone. Allowances for modifying the standard buffer width are proposed when certain conditions are met.

Comments were received from the Washington State Department of Fish and Wildlife, and changes were made to reflect the agency’s comments – those are noted in the category section of the table in your meeting packet. Other public comments were received and are included in the attached Planning Commission meeting packet if they were submitted before the packets were sent out; the remainder of the comment letters are attached to this agenda report.

The Planning Commission held a public hearing on the CAO code amendments on September 14, 2026. Thirteen community members spoke during the public hearing and provided public testimony. The Planning Commission had a thorough discussion on the critical areas ordinance code amendments following the closing of the public hearing. The Commission voted to recommend that City Council direct Development Services to revise the draft Critical Areas Ordinance to align with infill and Urban Growth Area goals of the Comprehensive Plan, following available science matching local conditions and also taking into consideration the Washington statute (WAC 365-195-915(1)(c) that allows a city to adopt critical area regulations that depart from science-based recommendations on the basis of legal, social, cultural, economic, and political information.

POLICY ISSUES:

The proposed CAO code amendments will revise and update Chapter 21.04 Critical Areas of the Municipal Code to improve clarity and usability for the public and for staff, to comply with recently passed state legislation, to remove and update outdated language, and to ensure that the Municipal Code continues to meet the needs of the Walla Walla community without creating confusion or redundancy.

PLAN COMPLIANCE:

COMPREHENSIVE PLAN:
The draft Critical Areas Ordinance (CAO) code amendments are supported by the following Comprehensive Plan - Walla Walla 2046 Goals and Policies:

Environment and Natural Resources (ENR) Goal 1: Water, air, and soil resources in Walla Walla are protected.
ENR Policy 1.3: Identify and protect critical areas, and keep the City's Critical Areas Ordinance updated, in accordance with the Periodic Update Cycle.

ENR Goal 4: The integrity of Walla Walla's riparian ecosystem is protected by avoiding development and other land use activities within Riparian Management Zones (RMZs).
ENR Policy 4.1: Take measures to safeguard existing wetlands to prevent continual loss and degradation.

ENR Policy 5.1: Ensure that buffers are adequately defined, regulated, and controlled to limit the disturbance of vegetation and disruption of ecological function.

Climate Resilience (CR) Policy 1.4: Address climate change impacts (such as increased flooding, reduced winter streamflow, extreme heat risks, heightened wildfire threats, and broader ecosystem vulnerabilities), in future planning, design, and management of critical infrastructure, services, and natural resources.

CR Policy 4.1: Prioritize the protection and restoration of critical habitats such as floodplains, wetlands, and riparian ecosystems and other critical areas to reduce the severity of climate impacts, support long-term ecosystem health, and improve climate adaptability.

CR Policy 4.2: Continue to support fish and habitat recovery efforts to improve the climate resilience of streams and watersheds.

CR Policy 4.3: Coordinate climate resilience efforts in future updates of other city plans, including the Shoreline Master Program and critical areas regulations, through conservation area designations, buffers, and the development of open space corridors.

ALTERNATIVES:

Public hearing only at this time.

STAFF RECOMMENDATION:

Staff recommends that the City Council open the public hearing and receive all public testimony.

CITY MANAGER COMMENTS:

Concur with the staff recommendation and approved to hold the public hearing.

Attachments

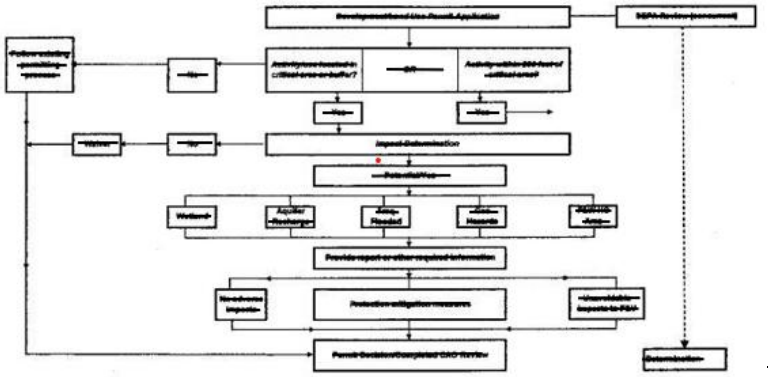
Staff Recommended Draft Critical Areas Code Amendments Table
Critical Areas Ordinance Update - 09.21.2026 WS Presentation
Planning Commission Meeting Packet - 09.14.2026
Draft Minutes from 09.14.2026 Planning Commission Meeting
Public Comment - Howard Boggs - 08.26.2026
Public Comment - Bailee Butcher - 09.11.2026
Public Comment - Drew Davis - 09.11.2026
Public Comment - Dave Campbell - 09.14.2026
Public Comment - Michael Melder - 09.14.2026
Public Comment - Travis Watts - 09.14.2026
Public Comment - Jim Hayner - 09.14.2026
Public Comment - Patrick Flores - 09-21-2026
Public Comment - Jim Hayner - 09.22.2026
Public Comment - WWV Association of Realtors - 10.08.2026
Critical Areas Ordinance Update - Stream Buffer Analysis
Wetlands in Washington State - Volume 1
Critical Areas Ordinance Update - Gap Analysis
Wetlands in Washington State - Volume 2
Walla Walla County Best Available Science Review
Critical Areas Ordinance Update - Best Available Science Review
Riparian Ecosystems, Volume 1

2026 Draft Critical Areas Code (CAO) Amendments Table

City Council Public Hearing – October 14, 2026

KEY:
BOLD (NEW)
STRIKEOUT (PROPOSED DELETION)

CATEGORIES: OUTDATED, CLARIFICATION, STATE MANDATED

WWMC	Section	Proposed Amendment	Category and Notes
Title 21: Environment			
Chapter 21.04.005 (B) Critical Areas	Purpose	B. This chapter is to implement the goals, policies, guidelines, and requirements of the city of Walla Walla ("city") urban area comprehensive plan and the Growth Management Act. **Development regulations must protect all functions and values of critical areas to ensure no net loss of ecological functions and values. The city must give special consideration to conservation and protection measures necessary to preserve or enhance anadromous fisheries (WAC 365-190-080).**	State Mandated RCW 36.70A.172
21.04.015 Critical Areas	Applicability	~~Figure 1~~ 	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Chapter 21.04.020 Critical Areas	Definitions	"Best available science" means current scientific information used in the process to designate, protect, or restore critical areas that is derived from a valid scientific process as defined by WAC 365-195-900 through 365-195-925. Sources of best available science are included in ~~"Citations of Recommended Sources of Best Available Science for Designating and Protecting Critical Areas" published by the state Office of Community Development.~~ **The Washington State Department of Commerce's Critical Areas Handbook; A Handbook for Reviewing Critical Areas Regulations.** "Critical aquifer recharge areas" means areas designated by WAC 365-190~~-080(2)~~**100** ~~that are determined to have a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030(2).~~ **and are areas with geologic conditions associated with critical recharging of aquifers used for potable water, including areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water, or is susceptible to reduced recharge**. "Erosion hazard areas" ~~means at least~~ **are** those areas ~~identified by the~~ **containing soils which, according to the** United States Department of Agriculture Natural Resources Conservation Service ~~as having a~~ **Soil Survey Program**, **may experience significant erosion, including** severe rill and inter-rill erosion hazard. **Erosion hazard areas also include channel migration zones in WAC 365-190-030.** **"Frequently flooded areas" as defined in WAC 365-190-030 means lands in the flood plain subject to at least a one percent or greater chance of flooding in any given year, or within areas subject to flooding due to high groundwater. These areas include, but are not limited to, streams, rivers, lakes, wetlands, and areas where high groundwater forms ponds on the ground surface.**	State Mandated and Clarification RCW 36.70A.172 And WDFD Comments

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		"Groundwater" means water in a saturated zone or stratum beneath the surface of land or a surface water body**;** ~~.~~ **whatever may be the geological formation or structure in which such water stands or flows, percolates or otherwise moves as defined in WAC 173-100-040.** “Habitats of Local Importance.” These areas include a seasonal range or habitat element with which a given species has a primary association and which, if altered, may reduce the likelihood that the species will maintain and reproduce over the long term. These might include areas of high relative density or species richness, breeding habitat, winter range, and movement corridors. These might also include habitats that are ~~of~~ limited **in** availability or high vulnerab~~ility~~**le** to **change** ~~alterations~~, such as cliffs, talus, and wetlands **as defined in** ~~(~~WAC 365-190-030.~~)~~ "Hazard areas" means areas designated as frequently flooded areas or geologically hazardous areas due to potential for erosion, landslide, seismic activity, extreme slopes, or other geological condition**s**. "Landslide hazard areas" ~~means~~ **as defined in WAC 365-190-120, includes** areas ~~that are potentially~~ subject to **landslides based on** ~~risk of mass movement due to~~ a combination of geologic ~~landslide resulting from a combination of geologic~~, topographic, and hydrologic factors. The**y**~~se~~ include areas ~~are typically~~ susceptible to landslides because of a combination of ~~factors including:~~ bedrock, soil, slope gradient, slope aspect, ~~geologic~~ structure, **hydrology** ~~ground water,~~ or other factors**, and include, at a minimum, the following:** **1. Areas of historic failures, such as:** **a. Those areas delineated by the United States Department of Agriculture Natural Resources Conservation Service as having a significant limitation for building site development;** **b. Areas designated as quaternary slumps, earthflows, mudflows, lahars,**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		or landslides on maps published by the United States Geological Survey or Washington Department of Natural Resources. **2. Areas with all three of the following characteristics:** **a. Slopes steeper than 15 percent;** **b. Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and** **c. Springs or groundwater seepage.** **3. Areas that have shown movement during the Holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of this epoch;** **4. Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;** **5. Slopes having gradients steeper than 80 percent subject to rockfall during seismic shaking;** **6. Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action, including stream channel migration zones;** **7. Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding;** **8. Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of bedrock. A slope is delineated by establishing its toe and top and measured by averaging the inclination over at least 10 feet of vertical relief.** "Mitigation" means avoiding, minimizing or compensating for adverse critical areas impacts **and** • ***Occurs at the same time as, or in advance of, a project's planned environmental impacts;*** • ***Is located in a site either on, near, or distant from the project's impacts; and***	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		• ***provides either the same or different biological functions and values as the functions and values impacted by the project. (RCW 90.74.010)*** Mitigation, in the following order of preference, is: 1. Avoiding the impact altogether by not taking a certain action or parts of an action; 2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps, such as project redesign, relocation, or timing, to avoid or reduce impacts; 3. Rectifying the impact to wetlands, critical aquifer recharge areas, and habitat conservation areas by repairing, rehabilitating or restoring the affected environment to the conditions existing at the time of the initiation of the project; 4. Minimizing or eliminating the hazard by restoring or stabilizing the hazard area through engineered or other methods; 5. Reducing or eliminating the impact or hazard over time by preservation and maintenance operations during the life of the action; 6. Compensating for the impact to wetlands, critical aquifer recharge areas, and habitat or critical areas by replacing, enhancing, or providing substitute resources or environments; and 7. Monitoring the hazard or other required mitigation and taking remedial action when necessary. Mitigation for individual actions may include a combination of the above measures. **"reasonable use" means the application of the critical area regulations would deny all reasonable use of the property, and no other reasonable economic use has less impact to critical areas and proposed development does not pose a threat to public health, safety, or welfare.** "On-site mitigation" means on or adjacent to the project impact site or in the same **watershed,** ~~stream reach,~~ based on resource needs.	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~"Shorelands or shoreland areas"~~ ~~means those lands extending landward for two hundred feet in all directions as measured on a horizontal plane from the ordinary high water mark; floodways and contiguous floodplain areas landward two hundred feet from such floodways; and all wetlands and river deltas associated with the streams and lakes which are subject to the provisions of the City of Walla Walla Shoreline Master Program; the same to be designated as to location by the Department of Ecology.~~ ~~"Shorelines"~~ ~~means all of the water areas of the state as defined in RCW 90.58.030, including reservoirs and their associated shorelands, together with the lands underlying them except:~~ ~~1. Shorelines of statewide significance;~~ ~~2. Shorelines on segments of streams upstream of a point where the mean annual flow is twenty cubic feet per second or less and the wetlands associated with such upstream segments; and~~ ~~3. Shorelines on lakes less than twenty acres in size and wetlands associated with such small lakes.~~ ~~"Shorelines of statewide significance"~~ ~~means those areas defined in RCW 90.58.030(2)(e).~~ ~~"Shorelines of the state"~~ ~~means the total of all shorelines, as defined in RCW 90.58.030(2)(d), and shorelines of statewide significance within the state, as defined in RCW 90.58.030(2)(c).~~ "Water typing system" means waters classified according to WAC 222-16-030~~;~~ ~~including the following:~~**.** 1.~~"Type S Water"means all waters, within their bankfull width, inventoried as shorelines of the state under Chapter 90.58 RCW and the rules promulgated pursuant to Chapter 90.58 RCW including periodically inundated areas of their associated wetlands.~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		For purposes of this definition: **a. "Dwelling unit"** **means a home, apartment, residential condominium unit or mobile home, serving as the principal place of residence.** **b. "Camping unit"** **means an area intended and used for:** **i. Overnight camping or picnicking by the public, containing at least a fireplace, picnic table and access to water and sanitary facilities; or** **ii. A permanent home or condominium unit or mobile home not qualifying as a dwelling unit because of part-time occupancy.** **c. "Public accommodation facility"** **means a business establishment open to and licensed to serve the public, such as a restaurant, tavern, motel or hotel.** **d. "Natural waters"** **only excludes water conveyance systems which are artificially constructed and actively maintained for irrigation.** **e. "Seasonal low flow" and "seasonal low water"** **mean the conditions of the seven-day, two-year low water situation, as measured or estimated by accepted hydrologic techniques recognized by the department.** **f. "Channel width and gradient"** **means a measurement over a representative section of at least five hundred linear feet with at least ten evenly spaced measurement points along the normal stream channel but excluding unusually wide areas of negligible gradient such as marshy or swampy areas, beaver ponds and impoundments. Channel gradient may be determined utilizing stream profiles plotted from United States Geological Survey topographic maps (see board manual section 23).** **g. "Intermittent streams"** **means those segments of streams that normally go dry.** **h. "Fish habitat"**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		means habitat which is used by any fish at any life stage at any time of the year, including potential habitat likely to be used by fish which could be recovered by restoration or management, and includes off-channel habitat. ~~2, "Type F Water"means segments of natural waters, other than Type S Waters, which are within the bankfull widths of defined channels and periodically inundated areas of their associated wetlands, or within lakes, ponds, or impoundments having a surface area of one-half acre or greater at seasonal low water and which in any case contain fish habitat or are described by one of the following four categories:~~ ~~a. Waters which are diverted for domestic use by more than ten residential or camping units or by a public accommodation facility licensed to serve more than ten persons, where such diversion is determined by the department to be a valid appropriation of water and the only practical water source for such users. Such waters shall be considered to be Type F Water upstream from the point of such diversion for one thousand five hundred feet or until the drainage area is reduced by fifty percent, whichever is less;~~ ~~b. Waters which are diverted for use by federal, state, tribal or private fish hatcheries. Such waters shall be considered Type F Water upstream from the point of diversion for one thousand five hundred feet, including tributaries if highly significant for protection of downstream water quality. The department may allow additional harvest beyond the requirements of Type F Water designation, provided the department determines after a landowner-requested on-site assessment by the Department of Fish and Wildlife, Department of Ecology, the affected tribes and interested parties that:~~ ~~i. The management practices proposed by the landowner will adequately protect water quality for the fish hatchery; and~~ ~~ii. Such additional harvest meets the requirements of the water type designation that would apply in the absence of the hatchery;~~ ~~c. Waters which are within a federal, state, local, or private campground having more than ten camping units; provided, that the water shall not be considered to enter a campground until it reaches the boundary of the park lands available~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~for public use and comes within one hundred feet of a camping unit, trail or other park improvement;~~ ~~d. Riverine ponds, wall-based channels, and other channel features that are used by fish for off-channel habitat. These areas are critical to the maintenance of optimum survival of fish. This habitat shall be identified based on the following criteria:~~ ~~i. The site must be connected to a fish habitat stream and accessible during some period of the year; and~~ ~~ii. The off-channel water must be accessible to fish.~~ ~~3. "Type Np Water"means all segments of natural waters within the bankfull width of defined channels that are perennial non-fish-habitat streams. Perennial streams are flowing waters that do not go dry any time of a year of normal rainfall and include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow.~~ ~~4. "Type Ns Water"means all segments of natural waters within the bankfull width of the defined channels that are not Type S, F, or Np Waters. These are seasonal, non-fish-habitat streams in which surface flow is not present for at least some portion of a year of normal rainfall and are not located downstream from any stream reach that is a Type Np Water. Type Ns Waters must be physically connected by an above-ground channel system to Type S, F, or Np Waters.~~ "Wetland category" means wetlands that are categorized into Category I, II, III or IV based upon the categorization procedures in the Washington State Wetland Rating System for Eastern Washington **2014 update**, as amended (Hruby T. 20~~0~~**1**4). "Wetlands" **as defined by WAC 365-190-030** means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do not	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from non-wetland areas to mitigate the conversion of wetlands. ~~For identifying and delineating a wetland, local government shall use the approved federal delineation manual and regional supplement, as amended.~~	
21.04.035(A) Critical Areas	Critical area maps.	A. The approximate location and extent of critical areas will be displayed on various inventory maps available at the city **community** development ~~services~~ department or online. These maps will be updated as inventories are completed in compliance with the requirements of the Growth Management Act, and additional maps may be added as appropriate. These **Comprehensive Plan** maps include: 1. City of Walla Walla Critical Area Map ~~1~~: Critical Aquifer Recharge Areas; 2. City of Walla Walla Critical Area Map ~~2.~~ Wetlands; 3. City of Walla Walla Critical Area Map ~~3~~: Frequently Flooded Areas; 4. City of Walla Walla Critical Area Map ~~4~~: Geologically Hazard Areas; 5. City of Walla Walla Critical Area Map~~-5~~: Fish and Wildlife Habitat Conservation Areas;	Clarification
Chapter 21.04.060(4)(a) Critical Areas	Permit processing.	Field markings are intended to prevent disturbance of critical areas and buffers and may include ~~such~~ items such as temporary fences;	Clarification
Chapter 21.04.085(B)(2-3, 7-23) Critical Areas	Allowed activities.	The following developments, activities, and associated uses are allowed in critical areas, and do not require approval or submission of a critical area report, provided they are consistent with the provisions of other local, state, and federal laws and requirements. Activities may intrude into the critical area or required buffer **provided such activities are otherwise consistent with this**	State Mandated RCW 36.70A.172 and WDFW Comments

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		chapter and other applicable regulations. The director may apply conditions to an underlying permit or approval to ensure that the activities are consistent with the provisions of this chapter, ~~subject to any listed conditions, related permits,~~ and in conformance with other portions of the Walla Walla Municipal Code and applicable state or federal law or regulation. **Any proposal to modify a critical area or its buffer must demonstrate compliance with mitigation sequencing under WWMC 21.04.110.** (B)(2) Maintenance, operation and/or repair of existing rights-of-way, trails, roads, utilities, **fences,** buildings and other facilities within critical areas and buffers; provided, that the activity does not further alter, impact, or encroach upon the sensitive area or buffer or further affect the functions of sensitive areas, and there is no increased risk to life or property as a result of the proposed operation, maintenance, or repair; and provided further, that: (B)(3) Maintenance of existing, lawfully established landscap~~eing~~ **features** and gardens within a regulated critical area or its buffer, including but not limited to **maintaining fences, trellises, pathways and patio,** mowing lawns, weeding, removal of noxious and invasive species, harvesting and replanting of garden crops, pruning and planting native vegetation, pruning of existing ornamental vegetation to maintain the condition and appearance of such areas as they existed prior to adoption of this code; provided, that native growth protection areas, mitigation sites, or other areas protected via conservation easements or similar restrictive covenants are not covered by this exception. (B)(7) ~~Low-impact activities such as hiking, canoeing, nature study, photography, fishing, education or scientific research.~~ **Replacement modification, installation, or construction of fences; provided, wildlife passage is considered where feasible, and no fill or discharge occurs outside the existing improved area and with appropriate best management practices to control erosion, sedimentation and other potential impacts.**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		Excluded is work within a water body or wetland, including but not limited to fence posts. (B)(8) **Low-impact activities such as hiking, canoeing, nature study, photography, fishing, education or scientific research.** ~~Public and private pedestrian trails, provided they are subject to the following:~~ ~~a. The trail surface shall not exceed five feet in width;~~ ~~b. The trail surface shall consist of gravel, a pervious surface or a boardwalk;~~ ~~c. The trail shall meet all other city requirements including water quality standards;~~ ~~d. Sensitive area and/or buffer widths shall be increased, where possible, equal to the width of the trail corridor, including disturbed areas; and~~ ~~e. Trails proposed to be located in landslide or erosion hazard areas shall be constructed in a manner that does not increase the risk of landslide or erosion and in accordance with an approved geotechnical report. Low-impact activities such as hiking, canoeing, nature study, photography, fishing, education or scientific research.~~ (B)(9) **Public and private pedestrian trails, provided they are subject to the following:** **a. The trail surface shall not exceed five feet in width;** **b. The trail surface shall consist of gravel, a pervious surface or a boardwalk;** **c. The trail shall meet all other city requirements including water quality standards;** **d. Sensitive area and/or buffer widths shall be increased, where possible, equal to the width of the trail corridor, including disturbed areas; and** **e. Trails proposed to be located in landslide or erosion hazard areas shall be constructed in a manner that does not increase the risk of landslide or erosion and in accordance with an approved geotechnical report.** ~~The following vegetation removal activities:~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~a. The removal of the noxious weed species designated by Washington State in Chapter 16-750 WAC or the local weed control authority with hand labor and light equipment, or other invasive species;~~ ~~b. The removal of hazard trees from sensitive areas and buffers that are posing a threat to public safety, or an imminent risk of damage to a permanent structure with consultation from a certified arborist.~~ ~~Public and private pedestrian trails, provided they are subject to the following:~~ ~~a. The trail surface shall not exceed five feet in width;~~ ~~b. The trail surface shall consist of gravel, a pervious surface or a boardwalk;~~ ~~c. The trail shall meet all other city requirements including water quality standards;~~ ~~d. Sensitive area and/or buffer widths shall be increased, where possible, equal to the width of the trail corridor, including disturbed areas; and~~ ~~e. Trails proposed to be located in landslide or erosion hazard areas shall be constructed in a manner that does not increase the risk of landslide or erosion and in accordance with an approved geotechnical report.~~ (B)10) **The following vegetation removal activities:** **a. The removal of the noxious weed species designated by Washington State in Chapter 16-750 WAC or the local weed control authority, other invasive species with hand labor and light equipment, or with the use of only WA Dept. of Ecology-approved aquatic herbicides and, when necessary, avoidance of hazardous substances, prevention of soil compaction, and timing restrictions to protect fish and wildlife during sensitive periods;** **b. The removal of hazard trees from sensitive areas and buffers that are posing a threat to public safety, or an imminent risk of damage to a permanent structure with consultation from a certified arborist.** ~~Minor site investigative work necessary for land use submittals, such as surveys, soil logs, percolation tests, and other related activities, where such activities do not require construction of new roads, removal of native trees or shrubs, or displacement of more than five cubic yards of material.~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~Investigations involving displacement of more than five cubic yards of material, including geotechnical soil borings, groundwater monitoring wells, percolation tests, and similar activities, shall require submittal of specific plans and restoration plans. In every case, impacts to the sensitive area shall be minimized and disturbed areas shall be immediately restored.~~ (B)(11) ~~The application of herbicides, pesticides, organic or mineral-derived fertilizers, or other hazardous substances, if necessary; provided, that their use shall be conducted in accordance with applicable state and federal law.~~ **Minor site investigative work necessary for land use submittals, such as surveys, soil logs, percolation tests, and other related activities, where such activities do not require construction of new roads, removal of native trees or shrubs, or displacement of more than five cubic yards of material. Investigations involving displacement of more than five cubic yards of material, including geotechnical soil borings, groundwater monitoring wells, percolation tests, and similar activities, shall require submittal of specific plans and restoration plans. In every case, impacts to the sensitive area shall be minimized and disturbed areas shall be immediately restored.** (B)(12) ~~Activities undertaken to comply with a United States Environmental Protection Agency superfund-related order, or a Washington Department of Ecology order pursuant to the Model Toxics Control Act that specifically preempts local regulations in the findings of the order.~~ **The application of herbicides, pesticides, organic or mineral-derived fertilizers, or other hazardous substances, if necessary; provided; that their use shall be conducted in accordance with applicable state and federal law.** (B)(13) ~~Projects and facilities for restoration and enhancement of ecological functions of critical areas and related resources may be allowed within critical areas and buffers, upon approval of a restoration and mitigation plan in accordance with the provisions of this chapter, or for restoration and enhancement programs in an adopted shoreline restoration plan pursuant to Chapter 173-26 WAC, a watershed planning document prepared and adopted pursuant to Chapter 90.82 RCW, a watershed restoration project pursuant to~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~RCW 89.08.460, a salmonid recovery plan, the Salmon Recovery Funding Board habitat project list, or identified by the Washington Department of Fish and Wildlife as essential for fish and wildlife habitat enhancement pursuant to RCW 77.55.290.~~ **Activities undertaken to comply with a United States Environmental Protection Agency superfund-related order, or a Washington Department of Ecology order pursuant to the Model Toxics Control Act that specifically preempts local regulations in the findings of the order.** (B)(14) ~~The repair and maintenance of existing drainage ditches.~~ **Projects and facilities for restoration and enhancement of ecological functions of critical areas and related resources may be allowed within critical areas and buffers, upon approval of a restoration and mitigation plan in accordance with the provisions of this chapter, or for restoration and enhancement programs in an adopted shoreline restoration plan pursuant to Chapter 173-26 WAC, a watershed planning document prepared and adopted pursuant to Chapter 90.82 RCW, a watershed restoration project pursuant to RCW 89.08.460, a salmonid recovery plan, the Salmon Recovery Funding Board habitat project list, or identified by the Washington Department of Fish and Wildlife as essential for fish and wildlife habitat enhancement pursuant to RCW 77.55.290.** (B)(15) ~~The installation of individual service lines for agricultural purposes and to existing uses.~~ **The repair and maintenance of existing drainage ditches.** (B)(16) ~~Normal and routine activities conducted by a public agency to control mosquitoes and weeds~~. **The installation of individual service lines for agricultural purposes and to existing uses.** (B)(17) ~~Agricultural activities including farming, horticulture, normal maintenance and repair of irrigation delivery systems and drainage systems, ranching and grazing of animals and pest and weed control. This includes land lying idle under a government program, agricultural set-aside land and changes between agricultural activities.~~ **Normal and routine activities conducted by a public agency to control mosquitoes and weeds.**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		(B)(18) ~~Normal and routine maintenance of agricultural ponds, livestock watering ponds and fish ponds.~~ **Agricultural activities including farming, horticulture, normal maintenance and repair of irrigation delivery systems and drainage systems, ranching and grazing of animals, fence maintenance, and pest and weed control. This includes land lying idle under a government program, agricultural set-aside land, and changes between agricultural activities.** (B)(19) ~~The maintenance and repair of stormwater facilities under this chapter and designed in accordance with Chapter 13.16.~~ **Normal and routine maintenance of agricultural ponds, livestock watering ponds and fish ponds.** (B)(20) ~~Normal maintenance and repair of the concrete-lined Mill Creek channel within the city's jurisdiction from Rooks Park to Gose Street for flood control purposes.~~ **The maintenance and repair of stormwater facilities under this chapter and designed in accordance with Chapter 13.16.** (B)(21) ~~Normal dredging required to maintain ongoing water navigational facilities including boat and barge slips, docking facilities, entrance channels and agricultural irrigation facilities; provided, that other applicable permits are obtained.~~ **Normal maintenance and repair of the concrete-lined Mill Creek channel within the city's jurisdiction from Rooks Park to Gose Street for flood control purposes.** (B)(22) ~~Cases where a federal or state agency has jurisdictional control over a wetland and the director determines that those permit conditions would satisfy the requirements of this chapter.~~ **Normal dredging required to maintain ongoing water navigational facilities including boat and barge slips, docking facilities, entrance channels and agricultural irrigation facilities; provided that other applicable permits are obtained.** **(B)(23) Cases where a federal or state agency has jurisdictional control over a wetland and the director determines that those permit conditions would satisfy the requirements of this chapter.**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Chapter 21.04.090(B)(2-3) Critical Areas	Reasonable use.	B. Exception Request and Review Process. An application for a reasonable use exception shall be made to the city and shall include a critical area report, **prepared by a qualified professional**, including mitigation plan, if necessary, and any other related project documents, such as permit applications to other agencies, special studies, and environmental documents prepared pursuant to the State Environmental Policy Act (Chapter 43.21C RCW) (SEPA documents). The director shall determine whether an exception request shall be granted based on review of the submitted information, a site inspection, and the proposal's ability to comply with reasonable use exception criteria. The director shall approve with conditions or deny the request based on the proposal's ability to comply with all of the following reasonable use exception review criteria: 2. No other reasonable use of the property has less impact on the critical area **and the applicant demonstrates that other permitted uses in the areas that have less impact on the critical area and buffer are not technically feasible as an alternative.** 3. The proposed impact to the critical area is the minimum necessary to allow for reasonable economic use of the property; **and upon request, the director may require the applicant to provide a neighborhood analysis that evaluates the surrounding conditions in the immediate vicinity to verify that the applicant's request is consistent with the minimum necessary reasonable use criteria.**	State Mandated RCW 36.70A.172
Chapter 21.04.095 (E) Critical Areas	Critical area reports – General requirements.	**Critical area reports shall be valid for a period of five years. After such date, the Director shall determine whether a revision or additional assessment is necessary.**	State Mandated RCW 36.70A.172 and WDFW Comments
Chapter 21.04.105(C) Critical Areas	Mitigation requirements.	The director may approve off-site mitigation if the applicant demonstrates that no viable on-site mitigation opportunities exist. Compensatory mitigation proposed off-site **is required by state and/or federal permitting agencies, and/or**	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		shall be provided in the location that will provide the greatest ecological benefit and have the greatest likelihood of success. Preference will be given to off-site mitigation as close as possible to the impact area and within the same watershed sub-basin as the permitted alteration; provided**;** that off-site mitigation may occur within the city or within water resource inventory area (WRIA) 32 upon demonstration through a watershed- or landscape-based analysis that mitigation within an alternative sub-basin of the watershed would have greater ecological benefit. Off-site mitigation sites preference shall be given to sites and restoration activities identified in an adopted shoreline restoration plan pursuant to Chapter 173-26 WAC, a watershed planning document prepared and adopted pursuant to Chapter 90.82 RCW, a watershed restoration project pursuant to RCW 89.08.460, a salmonid recovery plan, the Salmon Recovery Funding Board habitat project list, or identified by the Washington Department of Fish and Wildlife as essential for fish and wildlife habitat enhancement pursuant to RCW 77.55.290.	
Chapter 21.04.115 (C)(1) and (4) and **(H**) Critical Areas	Mitigation plan requirements.	C. Detailed Construction Plans. The mitigation plan shall include written specifications and descriptions of the mitigation proposed, such as: 1. The proposed construction sequence, timing~~,~~ **of impact and mitigation activities,** and duration; 2. Grading and excavation details; 3. Erosion and sediment control features; 4. A vegetation planting plan specifying plant species, **including those species identified in Walla Walla County Conservation District Homeowner's Guide to Riparian Buffers**, quantities, locations, size, spacing, and density; and 5. Measures to protect and maintain plants until established. **H. Critical Area Tracts and Designations. A notice on title or critical area tract shall be used to delineate and protect those critical areas and buffers in development proposals for subdivisions, short subdivisions, or other affected lots as detailed under WWMC 21.04.125 at the discretion of the director.**	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Chapter 21.04.130(A) Critical Areas	Building setbacks**.**	Unless otherwise provided, buildings and other structures shall be set back a distance of **fifteen** ~~five~~ feet from the edges of all critical area buffers or from the edges of all critical areas, if no buffers are required. **Minor reduction of the standard building setback to a minimum of five feet may be permitted by the director if adequate protection of the critical area buffer will be maintained as documented by a qualified professional in a critical areas report.** The following may be allowed in the setback area: A. Landscaping **vegetation**;	State Mandated RCW 36.70A.172
Chapter 21.04.200(B) Critical Areas	Critical aquifer recharge areas – Designation.	Critical aquifer recharge areas (CARA) are those areas with a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030(~~2~~). CARA have prevailing geologic conditions associated with infiltration rates that create a high potential for contamination of ground water resources or contribute significantly to the replenishment of ground water. CARA in the city of Walla Walla are designated as follows: B. The ten-year time of travel as defined in the wellhead protection plans submitted by communities and water providers to the Department of Health ~~as of 2007~~. The city of Walla Walla maintains these groundwater capture zones. The CARA delineated by the ten-year capture zones ~~are~~ **is** defined in Critical Area Map ~~1~~ **in the Comprehensive Plan**. Table 1 lists the communities and water providers in the city of Walla Walla that have designated wellhead protection areas. Table 1 also lists the total area encompassed by the ten-year time of travel. The entire extent of the gravel aquifer as delineated in Critical Area Map ~~1~~ **in the Comprehensive Plan** is not defined as a CARA; however, it is an aquifer of significance/consideration. The city will encourage voluntary implementation of best management practices**, consistent with Critical Aquifer Recharge Areas Guidance (Ecology Publication # 05-10-028) current or as revised,** associated with development in this area.	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
21.04.210(A) Critical Areas	Mapping of critical aquifer recharge areas.	A. The approximate location and extent of critical aquifer recharge areas are shown on the following adopted critical areas map **in the Comprehensive Plan**: City of Walla Walla Critical Area Map ~~1~~: Critical Aquifer Recharge Areas.	Clarification
Chapter 21.04.220 Critical Areas	Activities allowed in critical aquifer recharge areas.	The following activities are allowed in critical aquifer recharge areas pursuant to Section 21.04.085, Allowed activities, **must be consistent with the Washington State Water Pollution Control Act (RCW 90.48)**, and do not require submission of a critical area report	State Mandated RCW 36.70A.172
Chapter 21.04.230(D)**(5)** Critical Areas	Critical area report – Additional requirements for critical aquifer recharge areas.	**5. Best Management Practices or Mitigation. The applicant must document implementation of presumptive best management practices, integrated pest management, or mitigation as applicable.**	State Mandated RCW 36.70A.172
Chapter 21.04.240(B) Critical Areas	Performance standards – General requirements.	The proposed activity must comply with the water source protection requirements and recommendations of the United States Environmental Protection Agency, Washington State Department of Ecology, Washington State Department of Health, and the ~~c~~**C**ity of Walla Walla ~~health department~~.	Clarification
Chapter 21.04.260**(G)** Critical Areas	Uses prohibited in critical aquifer recharge areas.	**G. Dry wells on sites used for vehicle repair and servicing or dry cleaners. Dry wells existing on the site prior to facility establishment must be abandoned using techniques approved by the state Department of Ecology prior to commencement of the proposed activity.**	State Mandated RCW 36.70A.172
Chapter 21.04.300(B(1)	Wetlands critical areas	1. Category I Wetlands. ~~Wetlands which are alkali wetlands, wetlands that are identified by scientists of the Washington Natural Heritage Program (DNR) as~~	State Mandated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Critical Areas	– Designation.	~~wetlands with high conservation value, bogs, mature old-growth forested wetlands over one-quarter acre with slow-growing trees, forests with stands of aspen, and wetlands~~ that perform many functions very well function at a very high level (scores twenty-two to twenty-seven points). They meet at least one of the following criteria: (a) represent a unique or rare wetland type; or (b) are more sensitive to disturbance than most wetlands; or (c) are relatively undisturbed and contain ecological attributes that are impossible to replace within a human lifetime; (d) provide a high level of functions (scores of twenty-two to twenty-seven points using the Eastside rating system); or (e) are documented wetlands of local significance. The city cannot afford the risk of any degradation to these wetlands because their functions and values are too difficult to replace. Generally, these wetlands are not common and make up a small percentage of the wetlands in the region.	RCW 36.70A.172
21.04.310 Critical Areas	Mapping of wetland areas.	A. The approximate location and extent of known wetlands are shown on the City of Walla Walla **Comprehensive Plan** Critical Area Map ~~2~~: Wetlands, or the latest revision of this map. This information is to be used as a guide for the city, project applicants and/or property owners, and may be updated as new information becomes available. In some instances (uncertified boundaries), it is a reference and does not provide a final critical area designation.	Clarification
Chapter 21.04.320(B)(3) Critical Areas	Critical area report – Additional requirements for wetland areas.	3. All shoreline areas, water features, flood-plains, and other critical areas, and related buffers within two hundred **fifty** feet of the project area.	State Mandated RCW 36.70A.172
Chapter 21.04.330(F) Critical Areas	Activities allowed in wetlands.	F. Enhancement of a wetland through the removal of nonnative invasive species. Weeding shall be restricted to hand removal and weed material shall be removed from the site. Bare areas that remain after weed removal shall be	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		revegetated with native shrubs and trees at natural densities. Some hand seeding may also be done over the bare areas with native ~~herb~~**plant**s.	
Chapter 21.04.340(C)(2) and (4) Critical Areas	Performance standards – General requirements.	2. Buffers shall not include areas that are functionally and effectively disconnected from the wetland by ~~a road or~~ **impervious surfaces,** other substantially developed surface**s** of sufficient width and with use characteristics such that buffer functions are not provided. **The director may approve modification of the standard buffer width to the edge of development, provided:** **a. The disconnected part of the buffer does not provide additional protection of the wetland; and** **b. The disconnected part of the buffer provides insignificant biological, geological, or hydrological buffer functions relating to the wetland; and** **c. If the resulting buffer distance is less than 75% of the standard or optional buffer for the applicable wetland category, no further reduction will be allowed.** **d. The legally established development includes impervious surfaces a minimum of 20 feet wide that completely isolates the project area from the critical area.** 4. Measurement of Wetland Buffers. All buffers shall be measured from the wetland boundary as surveyed in the field. **Wetland delineations will be documented on a ground-verified map using either professional surveying methods or an equivalent professional method using GPS with sub-meter accuracy.** The width of the wetland buffer shall be determined according to the wetland category and the proposed land use. The buffer for a wetland created, restored, or enhanced as compensation for wetland alterations shall be the same as the buffer required for the category of the created, restored, or enhanced wetland.	State Mandated RCW 36.70A.172
Chapter 21.04.344(B-D)	Performance standards –	The director shall have the authority to reduce the standard buffer widths identified in Section 21.04.340; **consistent with a reduction in the intensity of**	State Mandated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Critical Areas	Wetland buffer decrease.	**impacts from proposed land uses. The applied land use intensity buffer width may be reduced from high to moderate** provided, that the general standards for avoidance and minimization per Sections 21.04.110(A) and (B) shall apply; and provided further, that all of the following apply: B. ~~The buffer of a Category I or II wetland shall not be reduced to less than seventy-five percent of the required buffer or fifty feet, whichever is greater;~~ **The applicant implements all reasonable measures to reduce the adverse effects of adjacent land uses and ensure no net loss of buffer functions and values. The specific measures that shall be implemented include, but are not limited to, the following:** **1. Direct lights away from the wetland and buffer.** **2. Locate facilities that generate substantial noise (such as some manufacturing, industrial and recreational facilities) away from the wetland and buffer.** **3. Establish covenants limiting use of pesticides within two hundred feet of wetland.** **4. Implement integrated pest management programs.** **5. Integrate LID BMPs such as dispersion and downspout infiltration systems into the project design to infiltrate, filter, store, evaporate, and transpire stormwater runoff.** **6. Post signs at the outer edge of the critical area or buffer to clearly indicate the location of the critical area according to the direction of the city.** **7. Plant buffer with native vegetation appropriate for the region to create screens or barriers to noise, light, and human intrusion and discourage domestic animal intrusion.** **8. Use low impact development principles such as minimizing impervious surfaces, native vegetation loss, and stormwater runoff where appropriate.** **9. Establish a permanent conservation easement to protect the wetland and the associated buffer.**	RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		C.~~The buffer of a Category III or IV wetland shall not be reduced to less than seventy-five percent of the required buffer or twenty-five feet, whichever is greater;~~ **For wetlands that score moderate or high for habitat (6 points or more), the width of the buffer can be reduced if both of the following criteria are met:** **1. A relatively undisturbed, vegetated corridor at least 100 feet wide is protected between the wetland and any other priority habitats as defined by the Washington State Department of Fish and Wildlife.** **2. Measures to minimize the impacts of different land uses on wetlands, such as measures under WWMC 21.04.344(B), are applied**. D.~~ The applicant implements all reasonable measures to reduce the adverse effects of adjacent land uses and ensure no net loss of buffer functions and values. The specific measures that shall be implemented include, but are not limited to, the following:~~ ~~1. Direct lights away from the wetland and buffer.~~ ~~2. Locate facilities that generate substantial noise (such as some manufacturing, industrial and recreational facilities) away from the wetland and buffer.~~ ~~3. Establish covenants limiting use of pesticides within two hundred feet of wetland.~~ ~~4. Implement integrated pest management programs.~~ ~~5. Integrate LID BMPs such as dispersion and downspout infiltration systems into the project design to infiltrate, filter, store, evaporate, and transpire stormwater runoff.~~ ~~6. Post signs at the outer edge of the critical area or buffer to clearly indicate the location of the critical area according to the direction of the city.~~ ~~7. Plant buffer with native vegetation appropriate for the region to create screens or barriers to noise, light, and human intrusion and discourage domestic animal intrusion.~~ ~~8. Use low impact development principles such as minimizing impervious surfaces, native vegetation loss, and stormwater runoff where appropriate.~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~9. Establish a permanent conservation easement to protect the wetland and the associated buffer.~~ **For wetlands that score less than 6 points for habitat, the buffer width can be reduced to that required for moderate land-use impacts by applying measures to minimize the impacts of proposed land uses (WWMC 21.04.344(B).**	
Chapter 21.04.345 (A-C) Critical Areas	Performance standards – Buffer management plan.	~~In order to maintain effective buffer conditions, values and functions, a vegetation management plan shall be required for all buffer areas. Specific provisions to be addressed in the plan include:~~ ~~A. Maintaining adequate cover of native vegetation including trees and understory at densities provided in Table 8, Walla Walla County Conservation District native riparian vegetation planting guidelines;~~ ~~B. Establishing a plan for control of invasive weeds, and removal of existing invasive plant species;~~ ~~C. Incorporating a monitoring and maintenance plan for a period of at least five years, except this provision may be waived for isolated single-family residential lots.~~	Clarification
Chapter 21.04.346(B)(1) and (C)**(3)(a-h)** Critical Areas	Performance standards – Specific activities and uses.	(B)(1). Walkways and trails shall ~~not exceed five feet in width from shoulder to shoulder~~, shall meet **American with Disability Act, ADA accessibility standards and** the definition of a pervious surface**,** and require only limited excavation for foundation or stabilization; provided~~,~~ that those walkways and trails that are generally parallel to the perimeter of the wetland shall be located in the outer twenty-five percent of the buffer area; **(C)(3). A wetland or its buffer can be physically or hydrologically altered to meet the requirements of a Low Impact Development (LID) methodology or Flow Control BMP when the following criteria are met:** **a. The wetland is classified as a Category IV or a Category III wetland with a habitat score of 3-5 points.** **b. There will be no net loss of functions and values of the wetland.**	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		c. The wetland does not contain a breeding population of any native amphibian species. **d. The hydrologic functions of the wetland can be improved as outlined in questions 3, 4, and 5 of Chart 4 and questions 2, 3, and 4 of Chart 5 in Selecting Mitigation Sites Using a Watershed Approach, [Western Washington or Eastern Washington] (Ecology Publication [#09-06-032 or #10-06-007], or as revised); or the wetland is part of a restoration plan intended to achieve restoration goals identified in a shoreline master program or a local or regional watershed plan.** **e. The wetland lies in the natural routing of the runoff, and the discharge follows the natural routing.** **f. All regulations regarding stormwater and wetland management are followed, including but not limited to local and state wetland and stormwater codes, manuals, and permits.** **g. Lost existing functions and values are compensated.** **h. A site-specific characterization is performed to determine whether an LID BMP is feasible at the project site.**	
21.04.347 (A-E) Critical Areas	Performance standards – Mitigation requirements	A. Definitions of Types of Compensatory Mitigation. The ratios presented are based on the type of compensatory mitigation proposed (e.g., restoration, creation, and enhancement). In its Regulatory Guidance Letter 02-02, the U.S. Army Corps of Engineers provided definitions for these types of compensatory mitigation. For consistency, the authors of this document use the same definitions which are provided under "compensatory mitigation" in Section 21.04.020.	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes

Category of impacted wetland (based on score for function)	Re-establishment or creation	Rehabilitation	Preservation	Enhancement
Category I	4:1	8:1	16:1	16:1
Category II	3:1	6:1	12:1	12:1
Category III	2:1	4:1	8:1	8:1
Category IV	1.5:1	3:1	6:1	6:1

Notes:
1. Ratios for rehabilitation, preservation, and enhancement may be reduced when combined with 1:1 replacement through re-establishment or creation. See Table 6B-2 in Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance –Version 2 (Ecology et al., 2021 or as revised).
2. All proposed preservation sites need to meet the preservation criteria listed in Chapter 070.3.E of Appendix A, Sample Wetland Regulations.
3. The ratios are for permanent, direct impacts to wetlands. For recommended ratios for other types of impacts (e.g., long-term temporary, conversions), see Chapters 6B4.4 through 6B4.8 of Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance –Version 2 (Ecology et al., 2021 or as revised).
4. The category of impacted wetland is based on scores for functions. Compensation ratios generally do not apply when impacts involve a wetland whose category is based on special characteristics.

B. ~~The director shall have the authority to adjust these ratios when a combination of mitigation approaches is proposed. In such cases, the area of altered wetland shall be replaced at a one-to-one ratio through re-establishment or creation, and the remainder of the area needed to meet the ratio can be replaced by enhancement at a two-to-one ratio. For example, impacts to one acre of a Category II wetland requiring a three-to-one ratio for creation can be compensated by creating one acre and enhancing four acres~~

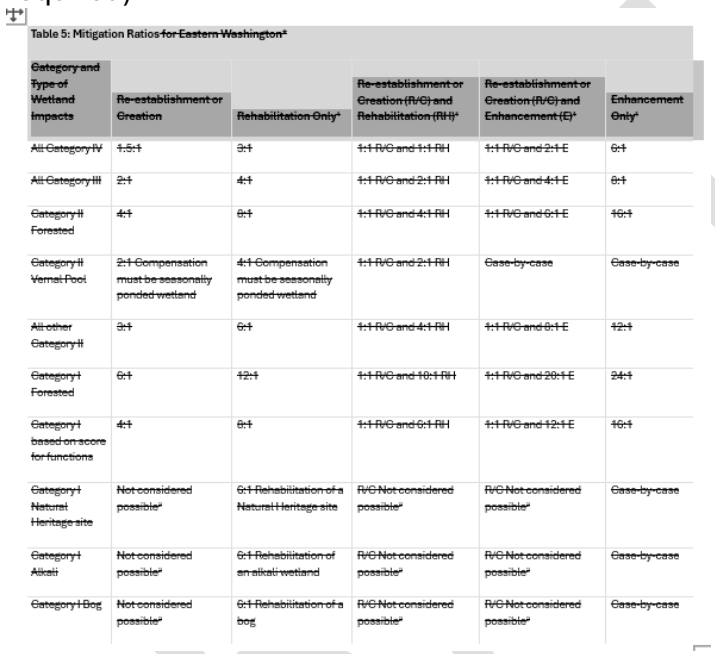
WWMC	Section	Proposed Amendment	Category and Notes
		(instead of the additional two acres of creation that would otherwise be required). 	

Table 5: Mitigation Ratios for Eastern Washington*

Category and Type of Wetland Impacts	Re-establishment or Creation	Rehabilitation Only[1]	Re-establishment or Creation (R/C) and Rehabilitation (RH)[1]	Re-establishment or Creation (R/C) and Enhancement (E)[1]	Enhancement Only[1]
All Category IV	1.5:1	3:1	1:1 R/C and 1:1 RH	1:1 R/C and 2:1 E	6:1
All Category III	2:1	4:1	1:1 R/C and 2:1 RH	1:1 R/C and 4:1 E	8:1
Category II Forested	4:1	8:1	1:1 R/C and 4:1 RH	1:1 R/C and 6:1 E	16:1
Category II Vernal Pool	2:1 Compensation must be seasonally ponded wetland	4:1 Compensation must be seasonally ponded wetland	1:1 R/C and 2:1 RH	Case-by-case	Case-by-case
All other Category II	3:1	6:1	1:1 R/C and 4:1 RH	1:1 R/C and 8:1 E	12:1
Category I Forested	6:1	12:1	1:1 R/C and 10:1 RH	1:1 R/C and 20:1 E	24:1
Category I based on score for functions	4:1	8:1	1:1 R/C and 6:1 RH	1:1 R/C and 12:1 E	16:1
Category I Natural Heritage site	Not considered possible[2]	6:1 Rehabilitation of a Natural Heritage site	R/C Not considered possible[2]	R/C Not considered possible[2]	Case-by-case
Category I Alkali	Not considered possible[2]	6:1 Rehabilitation of an alkali wetland	R/C Not considered possible[2]	R/C Not considered possible[2]	Case-by-case
Category I Bog	Not considered possible[2]	6:1 Rehabilitation of a bog	R/C Not considered possible[2]	R/C Not considered possible[2]	Case-by-case

* Mitigation ratios reference: Washington State Department of Ecology, U.S. Army Corps of Engineers Seattle District, and U.S. Environmental Protection Agency Region 10. March 2006. Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance (Version 1). Washington State Department of Ecology Publication No. 06-06-011a. Olympia, WA

1. These ratios are based on the assumption that the rehabilitation or enhancement actions implemented represent the average degree of improvement possible for the site. Proposals to implement more effective rehabilitation or enhancement actions may result in a lower ratio, while less effective actions may result in a higher ratio. The distinction between rehabilitation and enhancement is not clear-cut. Instead, rehabilitation and enhancement actions span a continuum. Proposals that fall within the gray area

WWMC	Section	Proposed Amendment	Category and Notes
		~~between rehabilitation and enhancement will result in a ratio that lies between the ratios for rehabilitation and the ratios for enhancement.~~ ~~2. Wetlands of high conservation value, alkali wetland, and bogs are considered irreplaceable wetlands because they perform some functions that cannot be replaced through compensatory mitigation. Impacts to such wetlands would therefore result in a net loss of some functions no matter what kind of compensation is proposed.~~ **Credit/Debit Method. To more fully protect functions and values, and as an alternative to the mitigation ratios found in the joint guidance "Wetland Mitigation in Washington State Parts I and II," detailed in Table 5 in subsection B of this section (Ecology Publication No. 06-06-011a-b, Olympia, WA, March, 2006), the administrator may allow mitigation based on the "credit/debit" method developed by the Department of Ecology in "Calculating Credits and Debits for Compensatory Mitigation in Wetlands of Eastern Washington: Final Report" (Ecology Publication No. 11-06-015, August 2012, or as revised).** C. ~~Credit/Debit Method. To more fully protect functions and values, and as an alternative to the mitigation ratios found in the joint guidance "Wetland Mitigation in Washington State Parts I and II," detailed in Table 5 in subsection B of this section (Ecology Publication No. 06-06-011a-b, Olympia, WA, March, 2006), the administrator may allow mitigation based on the "credit/debit" method developed by the Department of Ecology in "Calculating Credits and Debits for Compensatory Mitigation in Wetlands of Eastern Washington: Final Report" (Ecology Publication No. 11-06-015, August 2012, or as revised).~~ **Buffers. Replacement wetlands established pursuant to these mitigation provisions shall have adequate buffers to ensure their protection and sustainability. The buffer shall be based on the category and land-use intensity in Section 21.04.340(C); provided that the director shall have the authority to approve a smaller buffer when existing site constraints (such as a road) prohibit attainment of the standard buffer.** D. ~~Buffers. Replacement wetlands established pursuant to these mitigation provisions shall have adequate buffers to ensure their protection and~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~sustainability. The buffer shall be based on the category and land-use intensity in Section 21.04.340(C); provided, that the director shall have the authority to approve a smaller buffer when existing site constraints (such as a road) prohibit attainment of the standard buffer.~~ **Mitigation Maintenance and Monitoring. Mitigation areas will be maintained and monitored for a minimum of five years or a period necessary to establish that performance standards have been met after the mitigation has been completed. Annual maintenance and monitoring reports will be submitted to the city and, where applicable, the Department of Ecology, and shall include:** **1. Descriptive data for vegetation, soils, and hydrology;** **2. Itemized list of dead, dying, and replaced vegetation;** **3. Quantitative assessment of invasive species;** **4. Descriptive photographs;** **5. Statement of overall success of mitigation;** **6. Schedule of activities for the next year of maintenance and monitoring.** ~~E.Mitigation Maintenance and Monitoring. Mitigation areas will be maintained and monitored for a minimum of five years or a period necessary to establish that performance standards have been met after the mitigation has been completed. Annual maintenance and monitoring reports will be submitted to the city and, where applicable, the Department of Ecology, and shall include:~~ ~~1. Descriptive data for vegetation, soils, and hydrology;~~ ~~2. Itemized list of dead, dying, and replaced vegetation;~~ ~~3. Quantitative assessment of invasive species;~~ ~~4. Descriptive photographs;~~ ~~5. Statement of overall success of mitigation;~~ ~~6. Schedule of activities for the next year of maintenance and monitoring.~~	
Chapter 21.04.348(B)(1) Critical Areas	Performance standards – Specific	The rationale for site selection**, documenting how the watershed approach was applied consistent with Ecology publication #10-06-007, Selecting Wetland Mitigation Sites Using a Watershed Approach (Eastern Washington), current or as revised**;	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
	activities and uses.		
Chapter 21.04.400 Critical Areas	Mapping of frequently flooded areas.	~~21.04.400Mapping of frequently flooded areas.~~ ~~A. The approximate location and extent of frequently flooded areas are shown on the following adopted critical areas map: City of Walla Walla Critical Area Map 3: Frequently Flooded Areas. This map is based on data obtained from the Federal Emergency Management Agency Flood Insurance Rate Maps, December 1983, or as later revised.~~ ~~B. These maps are to be used as a guide for the city, project applicants, and/or property owners and may be continuously updated as new critical areas are identified. They are a reference and do not provide a final critical area designation.~~ ~~(Formerly 21.04.410; Ord. 2009-07 § 1 (part), 2009; Ord. 2015-12 § 1 (part), 2015)~~ **Frequently flooded areas - designation.** **Frequently flooded areas are designated in accordance with WAC 365-190-110. These areas include the 100-year floodplain designated by FEMA and the NFIP.**	State Mandated RCW 36.70A.172
Chapter 21.04.**410(A)** Critical Areas	**Mapping of frequently flooded areas.**	**The approximate location and extent of frequently flooded areas are shown in the Comprehensive Plan on the following adopted critical areas map: City of Walla Walla Critical Area Map: Frequently Flooded Areas. This map is based on data obtained from the Federal Emergency Management Agency Flood Insurance Rate Maps, December 1983, or as later revised.**	Clarification
Chapter 21.04.**420** Critical Areas	**Frequently flooded areas-regulation**	**Development in frequently flooded areas shall be subject to the provisions in WWMC Chapter 21.10 Floodplain Management.**	Clarification
Chapter 21.04.500(B)**(4),**(D) and (E)	Geologically hazardous	**(B)(4) The City may consult with the U.S. Department of Agriculture Natural Resources Conservation Service for data to help identify erosion hazard areas.**	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Critical Areas	areas – Designation	D. Seismic hazards shall be as identified in Washington State Department of Natural Resources seismic hazard and liquefaction susceptibility maps for eastern Washington and other geologic resources**. Seismic hazard areas are prone to ground settlement or subsidence, soil liquefaction, and surface faulting.** E. Other Hazard Areas. Geologically hazardous areas shall also include areas determined by the director **to be** those areas subject to severe risk of damage as a result of other geological events**,** including mass wasting, debris flows, rock falls, **mine hazards,** and differential settlement.	
21.04.510	Mapping of geologically hazardous areas.	A. The approximate location and extent of geologically hazardous areas containing known or suspected risk are shown **in the Comprehensive Plan** on the following adopted critical areas maps: City of Walla Walla Critical Area Map ~~4~~: Geologic Hazard Areas, or the latest revision of this map. The hazard areas outlined on these maps are based on the following data:	Clarification
Chapter 21.04.600(A)(1)(b), (C) Critical Areas	Fish and wildlife habitat conservation areas – Designation.	(A)(1)(b) State designated endangered, threatened, and sensitive species are those fish, wildlife and plant species native to the state of Washington identified by the state Department of Fish and Wildlife that are in danger of extinction, threatened to become endangered, vulnerable, or declining and are likely to become endangered or threatened in a significant portion of their range within the state without cooperative management or removal of threats. State designated endangered, threatened, and sensitive species are periodically recorded in WAC 232-12-014 (state endangered species), and WAC 232-12-011 (state threatened and sensitive species). The **Washington** ~~s~~**S**tate Department of Fish and Wildlife maintains the most current listing **(Priority Habitats and Species List, WDFW 2023, current or as amended),** and should be consulted ~~as necessary~~ for current listing status. C. The following is identified as an area of local importance: hawk habitat identified on Critical Area Map ~~6~~ **in the Comprehensive Plan**.	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
21.04.610 Critical Areas	Fish and wildlife habitat conservation areas – Mapping.	The approximate location and extent of conservation areas are shown on the critical area maps adopted by the city **in the Comprehensive Plan** (Critical Area Map ~~5~~: Fish and Wildlife Habitat Conservation Areas, or **the** latest version of this map), as most recently updated, and the following critical area maps hereby adopted:	Clarification
Chapter 21.04.620 (F)(1),(3) and (5) (G-K) Critical Areas	Fish and wildlife habitat conservation areas – Water bodies – Allowed uses.	F. Stream bank stabilization, ~~shoreline protection, and public or private launching ramps~~ may be permitted subject to all of the following standards: 1. Natural shoreline riparian processes will be maintained to the maximum extent practicable. The activity will not result in increased erosion and will not alter the size or distribution ~~of shoreline~~ or stream substrate, or eliminate or reduce sediment supply from feeder bluffs; 3. Nonstructural measures, such as placing or relocating the development further from the ~~shoreline~~ **stream,** planting vegetation, or installing on-site drainage improvements, are not feasible or not sufficient; 5. Hard bank armoring may occur only when the property contains an existing permanent structure(s) that is in danger from ~~shoreline~~ erosion caused by riverine processes and not erosion caused by upland conditions, such as the alteration of natural vegetation or drainage, and the armoring shall not increase erosion on adjacent properties and shall not eliminate or reduce sediment supply. G. New public flood protection measures and expansion of existing measures may be permitted; provided, that bioengineering or soft armoring techniques shall be used where feasible. Hard bank armoring may occur only in situations where soft approaches do not provide adequate protection, and shall be subject to requirements of the ~~shoreline master program, where applicable,~~ hydraulic project approval and other permits. H. **In-stream structures, such as, but not limited to, high flow bypasses, dams, and weirs, other than those regulated exclusively by the Federal Energy Regulatory Commission (FERC) shall be permitted only when multiple public benefits are provided, and ecological impacts are fully**	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		mitigated. ~~New docks shall be permitted only for public access, as an accessory to water-dependent uses or associated with a single-family residence:~~ 1. **In-stream facility locations shall avoid areas of high habitat value for aquatic organisms, specifically anadromous fish.** ~~To limit the effects on ecological functions, the number of docks should be limited and new subdivisions should employ shared moorage whenever feasible. Docks on shorelines of the state must comply with policies and regulations of the city of Walla Walla shoreline master program.~~ 2. **In-stream facilities shall be designed to produce the least feasible effect on fluvial processes and shall minimize change in gradient.** ~~Docks shall be located and designed to minimize adverse effects on ecological processes through location where they will not interfere with fluvial and limnal processes including gradient and substrate; recruitment of woody debris; and fish habitat, including that related to anadromous fish.~~ 3. **In-stream facilities shall provide mitigation of all impacts on aquatic species and habitat.** ~~Docks shall minimize reduction in ambient light level by limiting width to the minimum necessary and shall not exceed four feet in width, except where specific information on use patterns justifies a greater width. Materials that will allow light to pass through the deck may be required, including grating on walkways or gangplanks in nearshore areas.~~ 4. **In-stream facilities shall provide fish passage, in accordance with Chapter 77.57 RCW.** ~~Approaches shall utilize piers or other structures to span the entire upper foreshore to the point of intersection with stable upland soils and shall be designed to avoid interfering with stream processes.~~ 5. **A construction bond for one hundred fifty percent of the cost of the structure and all mitigation measures shall be filed before construction. A maintenance agreement shall specify responsibility for maintenance, a maintenance schedule as determined by the design engineer, annual**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		inspections by a civil engineer licensed in the State of Washington, and abandonment procedures including, where appropriate, provisions for site restoration. ~~Pile spacing shall be the maximum feasible to minimize shading and avoid a wall effect that would block or baffle currents, sediment movement or movement of aquatic life forms, or result in structure damage from driftwood impact or entrapment.~~ ~~6. Docks should be constructed of materials that will not adversely affect water quality or aquatic plants and animals in the long term.~~ I. ~~In-stream structures, such as, but not limited to, high flow bypasses, dams, and weirs, other than those regulated exclusively by the Federal Energy Regulatory Commission (FERC) shall be permitted only when the multiple public benefits are provided and ecological impacts are fully mitigated. Dams on shorelines of the state shall be regulated in accordance with the shoreline master program.~~ **Clearing and grading, when allowed as part of an authorized use or activity or as otherwise allowed in these standards, may be permitted; provided that the following shall apply:** 1. ~~In-stream facility locations shall avoid areas of high habitat value for aquatic organisms, specifically anadromous fish.~~ **Appropriate erosion and sediment control measures shall be used at all times. The soil duff layer shall remain undisturbed to the maximum extent possible.** 2. ~~In-stream facilities shall be designed to produce the least feasible effect on fluvial processes and shall minimize change in gradient.~~ **The moisture-holding capacity of the topsoil layer shall be maintained by minimizing soil compaction or reestablishing natural soil structure and infiltrative capacity on all areas of the project area not covered by impervious surfaces.** ~~3. In-stream facilities shall provide mitigation of all impacts on aquatic species and habitat.~~ ~~4. In-stream facilities shall provide fish passage, in accordance with Chapter 77.57 RCW.~~ ~~5. A construction bond for one hundred fifty percent of the cost of the structure and all mitigation measures shall be filed prior to construction and a~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~maintenance agreement shall specify responsibility for maintenance, shall incorporate the maintenance schedule specified by the design engineer, shall require annual inspections by a civil engineer licensed in the state of Washington and shall stipulate abandonment procedures which shall include, where appropriate, provisions for site restoration.~~ ~~J. Facilities permitted as shoreline-dependent or shoreline-oriented uses in accordance with the city shoreline master program may be located in water bodies and buffers; provided, that only those facilities that are water-dependent or water-oriented and facilities for necessary access may be located in water bodies and buffers; and provided, that the facility is located, designed, constructed and operated to minimize and, where possible, avoid critical area disturbance to the maximum extent feasible.~~ **Repairs to Existing On-Site Sewage Systems. Repairs to failing on-site sewage systems associated with an existing structure shall be accomplished by utilizing one of the following methods that results in the least impact:** **1. Connection to an available public sanitary sewer system;** **2. Replacement with a new on-site sewage system located in a portion of the site that has already been disturbed by development and is located landward as far as possible, provided the proposed sewage system is in compliance with the City of Walla Walla; or** **3. Repair to the existing on-site septic system.** ~~K. Clearing and grading, when allowed as part of an authorized use or activity or as otherwise allowed in these standards, may be permitted; provided, that the following shall apply:~~ ~~1. Appropriate erosion and sediment control measures shall be used at all times. The soil duff layer shall remain undisturbed to the maximum extent possible.~~ ~~2. The moisture-holding capacity of the topsoil layer shall be maintained by minimizing soil compaction or reestablishing natural soil structure and infiltrative capacity on all areas of the project area not covered by impervious surfaces.~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~L. Repairs to Existing On-Site Sewage Systems. Repairs to failing on-site sewage systems associated with an existing structure shall be accomplished by utilizing one of the following methods that results in the least impact:~~ ~~1. Connection to an available public sanitary sewer system;~~ ~~2. Replacement with a new on-site sewage system located in a portion of the site that has already been disturbed by development and is located landward as far as possible, provided the proposed sewage system is in compliance with city of Walla Walla environmental health department; or~~ ~~3. Repair to the existing on-site septic system.~~	
Chapter 21.04.630(B)(2) Critical Areas	Critical area report – Additional requirements for habitat conservation areas.	All habitat conservation areas and recommended buffers within two hundred **fifty** feet of the project area **or the extents of existing urban land use that functionally disconnect the site from habitat conservation areas;** and	State Mandated RCW 36.70A.172
Chapter 21.04.640(G)(3)(c) and (H)(3)(b) Critical Areas	Performance standards – General requirements.	(B)(2) Provide for a monitoring and maintenance plan for a period of at least five years, ~~except this provision may be waived for single-family residential lots~~. (H)(3)(b) The applicant shall be required to install a permanent **wildlife passable** fence around the habitat conservation area or buffer when domestic grazing animals are present or may be introduced on site.	State Mandated RCW 36.70A.172 and WDFW Comment
Chapter 21.04.650(A)(1)(a), (B)(C)(D)(2, 3,4) and 5)(a)(iii-**viii**), (6),(E) and (F) Critical Areas	Performance standards – Specific habitats.	**(A)(1)(a) WDFW-mapped species within the City include, but are not limited to, Bull trout, Chinook salmon, Steelhead, and Ferruginous hawk.** B. ~~Wetland Habitats. All proposed activities within or adjacent to habitat conservation areas containing wetlands shall, at a minimum, conform to the wetland development performance standards set forth in Section 21.04.300, in addition to meeting the habitat conservation area standards in this chapter.~~ **Priority Habitats and Species (PHS). Habitats and species on the Department of Fish and Wildlife PHS List**	State Mandated and Clarification RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		1. PHS mapped by the Department of Fish and Wildlife within the City includes but is not limited to shrubsteppe. **2. Whenever activities are proposed adjacent to a habitat conservation area with which a priority habitat or species has a primary association, such area shall be protected through the application of best management practices provided by the Department of Fish and Wildlife and documented in a critical area report prepared by a qualified professional and submitted to the City. Approval for alteration of land adjacent to the habitat conservation area or its buffer may also require consultation with the Department of Fish and Wildlife and the appropriate federal agency, if applicable.** C. ~~Riparian Habitat Areas. Unless otherwise allowed in this chapter, all structures and activities shall be located outside of the riparian habitat buffers.~~ **Wetland Habitats. All proposed activities within or adjacent to habitat conservation areas containing wetlands shall, at a minimum, conform to the wetland development performance standards set forth in Section 21.04.300, in addition to meeting the habitat conservation area standards in this chapter.** ~~1,Establishment of Riparian Habitat Buffers. Buffers shall be established for habitats that include aquatic systems.~~ ~~2. Standard Buffer Widths.~~ ~~a. A riparian habitat shall have at least the buffer width recommended in Table 6, unless a greater width is required pursuant to subsection (C)(4) of this section, or a lesser width is allowed pursuant to subsection (C)(6) of this section.~~ ~~b.Widths shall be measured outward, on the horizontal plane, from the ordinary high water mark or from the top of bank if the ordinary high water mark cannot be identified.~~ ~~c. The required buffer shall be extended to include any adjacent regulated wetland(s), landslide hazard areas and/or erosion hazard areas and required buffers, but shall not be extended across roads or other lawfully established structures or hardened surfaces that are functionally and effectively~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~disconnected from the stream.~~ ~~3. Buffers in Conjunction with Other Critical Areas. Where other critical areas defined in this chapter fall within the water body buffer, the buffer area shall be the most expansive of the buffers applicable to any applicable critical area.~~ D. ~~Anadromous Fish~~. **Riparian Habitat Areas. Unless otherwise allowed in this chapter, all structures and activities shall be located outside of the riparian habitat buffers.** 1. ~~All activities, uses, and alterations proposed to be located in water bodies used by anadromous fish or in areas that affect such water bodies shall give special consideration to the preservation and enhancement of anadromous fish habitat, including, but not limited to, adhering to the following standards:~~ ~~a. Activities shall be timed to occur only during the allowable work window as designated by the Washington Department of Fish and Wildlife for the applicable species;~~ ~~b. An alternative alignment or location for the activity is not feasible;~~ ~~c. The activity is designed so that it will not degrade the functions or values of the fish habitat or other critical areas;~~ ~~d. Shoreline erosion control measures shall be designed to use bioengineering methods or soft armoring techniques, according to an approved critical area report; and~~ ~~e. Any impacts to the functions or values of the habitat conservation area are mitigated in accordance with an approved critical area report.~~ **Establishment of Riparian Habitat Buffers. Buffers shall be established for habitats that include aquatic systems.** 2. ~~Structures that prevent the migration of salmonids shall not be allowed in the portion of water bodies currently or historically used by anadromous fish. Fish bypass facilities shall be provided that allow the upstream migration of adult fish and shall prevent fry and juveniles migrating downstream from being trapped or harmed.~~ **Standard Buffer Widths.**	

DRAFT

<table>
<tr><th>WWMC</th><th>Section</th><th>Proposed Amendment</th><th>Category and Notes</th></tr>
<tr><td></td><td></td><td>
a. A riparian habitat shall have at least the buffer width recommended in Table 6, unless a greater width is required pursuant to subsection (D)(4) of this section.
b. Buffer measurements: Widths shall be measured outward, on the horizontal plane, from the ordinary high-water mark or from the top of bank if the ordinary high-water mark cannot be identified or the channel migration zone, whichever is greater.
i. Where a stream exits a culvert, the open stream buffer width shall be measured perpendicular to the culvert opening.
c. Functionally disconnected buffers: Where impervious surfaces or other lawfully established structures functionally and effectively disconnect the riparian buffer from the stream, the Department director may approve a complete or partial buffer modification of the standard width to exclude non-functional areas.
3.<s>Fills, when authorized by the locally adopted shoreline management program, shall not adversely impact anadromous fish or their habitat or shall mitigate any unavoidable impacts and shall only be allowed for a water-dependent use.</s> Buffers in Conjunction with Other Critical Areas. Where other critical areas defined in this chapter fall within the water body buffer, the buffer area shall be the most expansive of the buffers applicable to any applicable critical area.
<table>
<tr><th colspan="3">Table 6: Minimum Riparian Buffer Widths for Watercourses within the City of Walla Walla</th></tr>
<tr><th>River</th><th>Minimum Riparian Buffer Width (per side)[1]</th><th>Other Measures Recommended for Protection</th></tr>
<tr><td>Mill Creek</td><td>See SMP</td><td>See SMP</td></tr>
<tr><td>Creeks: Yellowhawk, Russell, Reser,</td><td>100 Feet</td><td>No additional surface discharges of</td></tr>
</table>
</td><td></td></tr>
</table>

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes

Caldwell, Stone, Garrison, Bryant, Titus, and others within city limits/UGA including intermittent open channels between piped sections.		**untreated runoff, restore degraded parts of the buffer, and maintain connections to other habitat areas.**

Notes: 1. In stream segments where the **Conservation Reserve Enhancement Program** (CREP) buffers are established, CREP buffers become the minimum streamside buffer width

~~Table 6: Recommended Minimum Riparian Buffer Widths for Waterways within the City of Walla Walla~~

~~Waterway Category~~	~~River Reach Included~~	~~Existing Conditions/Targeted Functions~~	~~Minimum Streamside Buffer Width (per side)[‡]~~
~~6a~~	~~Mill Creek from Gose Street to Bennington Lake dam diversion~~	~~-Flood channel~~ ~~-No riparian vegetation allowed within the channel~~ ~~-Trees outside the concrete channel section with potential to shade the channel should remain~~	~~35 feet – See SMP~~
~~6b~~	~~Yellowhawk Creek – Russell Creek to Mill Creek~~	~~-Summer steelhead migration, limited rearing habitat and/or EDT priority protection reach~~ ~~-LWD recruitment~~ ~~-Shade~~ ~~-Existing riparian average = 31 ft~~ ~~-Meet CREP minimum~~ ~~-Control sediment, nutrients, and stormwater runoff~~	~~50 feet~~
	~~Russell Creek – Dipping Road to Yellowhawk~~	~~-Influence on downstream habitat~~ ~~-Existing riparian average = 21 ft~~ ~~-Meet CREP minimum~~ ~~-Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~

WWMC	Section	Proposed Amendment				Category and Notes
			~~Reser Creek – Wilbur Avenue to Russell Creek~~	~~-Influence on downstream habitat -Existing riparian average = 23 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
			~~Caldwell Creek – Headwaters to Yellowhawk~~	~~-Influence on downstream habitat -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
		~~6b~~	~~Stone Creek – Headwaters to Teal Street~~	~~-Influence on downstream habitat -Existing riparian average = 20 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
			~~Garrison Creek – Yellowhawk to Lions Park (excluding wetland)~~	~~-Influence on downstream habitat -Existing riparian average = 24 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff -Wildlife habitat~~	~~35 feet~~	
			~~Bryant Creek – Sprague Avenue to Fort Walla Walla Park~~	~~-Influence on downstream habitat -Existing riparian average = 14 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
			~~Titus Creek – Blackberry Lane to Mill Creek by community college~~	~~-Influence on downstream habitat -Existing riparian average = 25 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
			~~All other creeks within city limits/UGA – Intermittent open channels~~	~~-Influence on downstream habitat -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	

WWMC	Section	Proposed Amendment	Category and Notes
		~~with piped sections~~ (5)(iv). ~~The total area of the buffer after averaging is equal to the area required without averaging and all increases in buffer dimension for averaging are generally parallel to the wetland edge;~~ **Stormwater management applies the City of Walla Walla Stormater Design Standards Handbook, current or as amended, as necessary to maintain water quality;** v. ~~The buffer at its narrowest point is never less than seventy-five percent of the standard buffer width;~~ **The total area of the buffer after averaging is equal to the area required without averaging and all increases in buffer dimension for averaging are generally parallel to the wetland edge;** vi. ~~The slopes adjacent to the stream within the buffer area are stable and the gradient does not exceed thirty percent.~~ **The buffer at its narrowest point is never less than seventy-five percent of the standard buffer width;** **vii. The slopes adjacent to the stream within the buffer area are stable; and the gradient does not exceed thirty percent.** **viii. The averaged buffer line is recorded in a notice on title consistent with WWMC 21.04.125.** ~~6. Decreased Buffer Widths. The director shall have the authority to reduce buffer widths on a case-by-case basis; provided, that the general standards for avoidance and minimization per Sections 21.04.110(A) and (B) shall apply, and when the applicant demonstrates to the satisfaction of the director that all of the following criteria are met:~~ ~~a. The buffer reduction shall not adversely affect the habitat functions and values of the adjacent habitat conservation area or other critical area.~~ ~~b. The slopes adjacent to the habitat conservation area within the buffer area are stable and the gradient does not exceed thirty percent.~~ ~~c. The buffer shall not be reduced to less than seventy-five percent of the standard buffer as defined in this section. A thirty-five-foot buffer cannot be decreased. Table 7 identifies potential buffer reductions with accompanying riparian habitat enhancement (see subsection D of this section).~~	

WWMC	Section	Proposed Amendment	Category and Notes

~~Table 7: Modified Buffer Widths with Approved Habitat Enhancement/Water Quality Treatment~~

~~No Habitat Enhancement~~	~~Modified Buffer Width with Approved Enhancement/Treatment~~
~~100'~~	~~75'~~
~~75'~~	~~56'~~
~~50'~~	~~38'~~
~~35'~~	~~35'~~

~~d. Habitat enhancement plans prepared by a qualified professional must be provided to the city identifying existing conditions, and how the enhancement plan will improve riparian functions over existing conditions. A five-year monitoring plan must be included. The plan must also address how land outside a reduced buffer would protect surface water quality. Habitat enhancement plans must be consistent with riparian native vegetation planting guides developed by the city of Walla Walla conservation district, as provided in Table 8.~~

~~Table 8: Walla Walla County Conservation District Suggested Native Plants by Precipitation and Riparian Zone~~

~~County Area~~	~~Zone #1 – Generally 0' – 35'~~	~~Zone #2 – Generally 35' – 75'~~	~~Zone #3 – Generally 75' and greater~~
~~Central Walla Walla County: Lowden-Walla Walla 10" – 15" precipitation zone~~	~~Black Cottonwood – moist soils, silts, slightly alkaline soils (5' – 20' from shoreline) Water Birch – moist soils, silts, pH~~	~~Black Hawthorn – pH neutral to slightly alkaline silts and soils (25' – 40' off shoreline) Ponderosa Pine – well drained soils,~~	~~Smooth Sumac – well drained soils, silts and loess, pH neutral to slightly alkaline (25' – 100' off shoreline) Buffalo Berry – well drained soils,~~

WWMC	Section	Proposed Amendment				Category and Notes
			~~neutral soils (3' – 12' off shoreline)~~ ~~Thin-leaf Alder – moist soils, pH neutral to slightly acidic silts and loess (3' – 15' off shoreline)~~ ~~White Alder – moist soils, pH neutral to slightly acidic silts, cobble (1' – 15' off shoreline)~~ ~~Coyote Willow – moist soils, pH neutral silts and clays (3' – 15' off shoreline)~~ ~~Peach-leaf Willow – moist soils, pH neutral to slightly alkaline (5' – 25' off the shoreline)~~ ~~Red-osier Dogwood – moist to well drained soils, pH neutral to slightly alkaline (2' – 25' off the shoreline)~~	~~dry sites (25' – 50' from shoreline)~~ ~~Mock-orange – well drained soils, slightly acidic (15' – 35' off shoreline)~~ ~~Chokecherry – moist-dry well drained soils, pH neutral to slightly acidic soils (5' – 25' off shoreline)~~ ~~Peach-leaf Willow – moist soils, pH neutral to slightly alkaline (5' – 25' off the shoreline)~~ ~~Smooth Sumac – well drained soils, silts and loess, pH neutral to slightly alkaline (25' – 100' off shoreline)~~ ~~Blue Elderberry – well drained soils, pH neutral to slightly alkaline (15' – 50' off the shoreline)~~ ~~Buffalo Berry – well drained soils,~~	~~slightly alkaline (25' – 100'+ off the shoreline)~~ ~~Antelope-brush (Bitterbrush) – well drained soils, pH neutral to slightly acidic~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~Antelope-brush (Bitterbrush) – well drained soils, pH neutral to slightly acidic~~ ~~slightly alkaline (25' – 100'+ off the shoreline) Antelope-brush (Bitterbrush) – well drained soils, pH neutral to slightly acidic~~ E. ~~Wetland Habitats. All proposed activities within or adjacent to habitat conservation areas containing wetlands shall conform to the wetland development performance standards set forth in Sections 21.04.300 through 21.04.350. If nonwetlands habitat and wetlands are present at the same location, the provisions of Sections 21.04.600 through 21.04.674 or Sections 21.04.300 through 21.04.350, whichever provide greater protection to the habitat, apply.~~ **Anadromous Fish.** **1. All activities, uses, and alterations proposed to be located in water bodies used by anadromous fish or in areas that affect such water bodies shall give special consideration to the preservation and enhancement of anadromous fish habitat, including, but not limited to, adhering to the following standards:** **a. Activities shall be timed to occur only during the allowable work window as designated by the Washington Department of Fish and Wildlife for the applicable species;** **b. An alternative alignment or location for the activity is not feasible;** **c. The activity is designed so that it will not degrade the functions or values of the fish habitat or other critical areas;** **d. Shoreline erosion control measures shall be designed to use bioengineering methods or soft armoring techniques, according to an approved critical area report; and**	

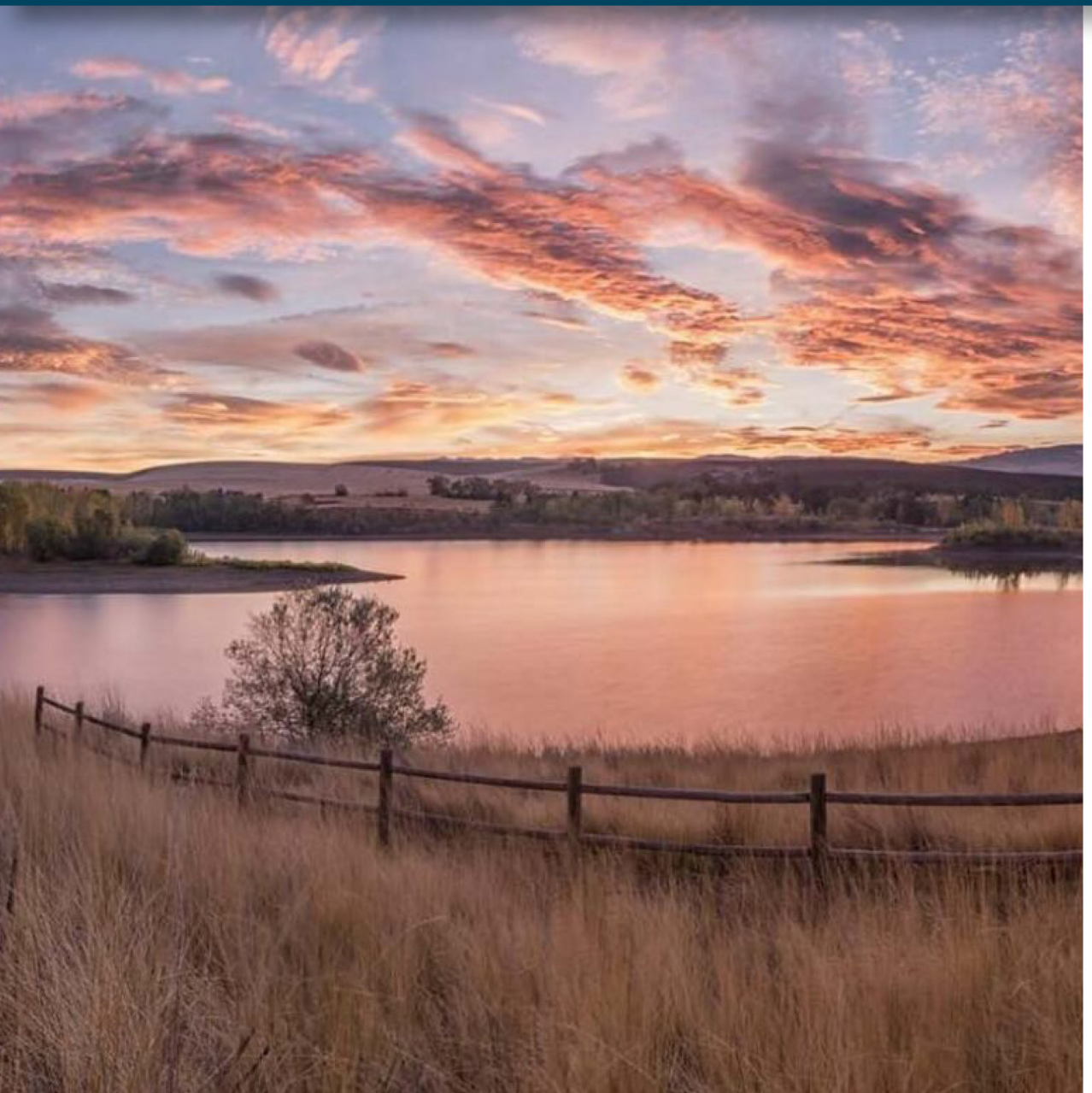
DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		e. Any impacts to the functions or values of the habitat conservation area are mitigated in accordance with an approved critical area report. **2. Structures that prevent the migration of salmonids shall not be allowed in the portion of water bodies currently or historically used by anadromous fish. Fish bypass facilities shall be provided that allow the upstream migration of adult fish and shall prevent fry and juveniles migrating downstream from being trapped or harmed.** **3. Fills, when authorized by the locally adopted shoreline management program, shall not adversely impact anadromous fish or their habitat or shall mitigate any unavoidable impacts and shall only be allowed for a water-dependent use.** **F. Wetland Habitats. All proposed activities within or adjacent to habitat conservation areas containing wetlands shall conform to the wetland development performance standards set forth in** **Sections 21.04.300 through 21.04.350. If non-wetlands habitat and wetlands are present at the same location, the provisions of** **Sections 21.04.600 through 21.04.674 or** **Sections 21.04.300 through 21.04.350, whichever provide greater protection to the habitat, apply.**	
Chapter 21.04.660**(D)** Critical Areas	Performance standards – Subdivisions.	**Development projects must be located to preserve or achieve contiguous wildlife habitat corridors to minimize the isolating effects of development on habitat areas.**	State Mandated RCW 36.70A.172
Chapter 21.04.670(**C**) Critical Areas	Fish and wildlife habitat conservation areas – Piped streams.	**Daylighting. Opening up piped stream segments to restore a more natural condition with riparian functions means removing a stream from a culvert through a critical areas report (WWMC 21.04.095) and stream daylighting plan. Buffer widths for daylit stream segments will be determined on a case-by-case basis based on a site-specific analysis of water quality, riparian functions, and overall improvements to ecological functions.**	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Chapter 21.04.700 Critical Areas	Landfill vicinity development standards.	~~All enclosed structures, requiring a building permit, within one thousand feet of a sanitary landfill or former landfill site/parcel must be protected from potential landfill gas migration. The method for ensuring a structure's protection from landfill gas shall be addressed in a report submitted by a licensed professional engineer, at the cost of the developer, to the city of Walla Walla for review. The report shall contain a description of the investigation and recommendation(s) for preventing the accumulation of explosive concentrations of landfill gas within or under enclosed portions of the proposed building or structure. Any changes to the design shall be documented in writing and stamped by the landfill gas design engineer and the contractor shall provide as-built drawings to the city documenting the changes.~~	Clarification Moved

DRAFT



City of Walla Walla

Critical Areas Ordinance (CAO) Update

City Council Workshop

September 21, 2026

FACET

FACET

Nell Lund, PWS

Principal, Senior Ecologist



Critical Areas

Cities and counties in Washington state are required to designate critical areas and adopt development regulations to protect them.
(WAC 365-195-485)

Critical Areas *(cont.)*

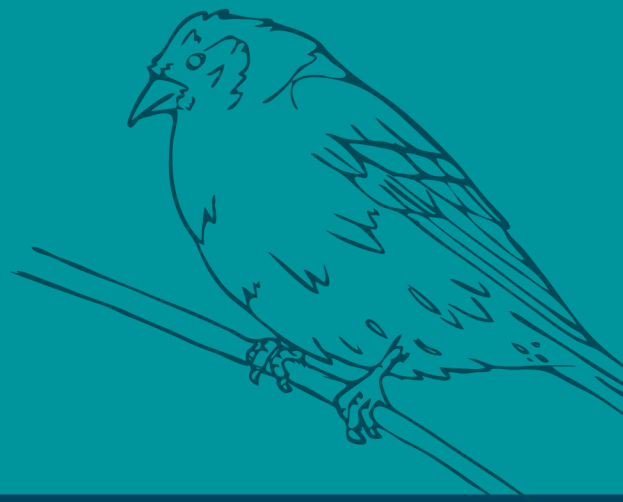
Critical areas include the following areas and ecosystems:

- **Wetlands**
- **Critical Aquifer Recharge Areas (CARA)**
- **Fish and Wildlife Habitat Conservation Areas (FWHCA)**
- **Frequently Flooded Areas (FFA)**
- **Geologically Hazardous Areas**



Growth Management Act Mandate

RCW 36.70A.172.
Critical areas–
Designation and protection–
Best available science to be used.



Growth Management Act Mandate

(1) In designating and protecting critical areas under this chapter, counties and cities shall include the best available science in developing policies and development regulations to protect the functions and values of critical areas. In addition, counties and cities shall give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries.

What is Best Available Science?

- **Best Available Science (BAS) is the best science that is available. It is produced through a valid scientific process.**
- **Reviewing BAS allows local jurisdictions to develop a science-based regulatory approach without having to conduct new scientific studies.**

Criteria for Including BAS



(WAC 365-195-900)

Through 925 defines BAS and requirements for jurisdictions to include the BAS in the Comprehensive Plan CAO period updates.

Criteria for Including BAS *(cont.)*

Demonstrate inclusion of BAS in policies and regulations:

- **Protect functions and values of critical areas**
- **Include relevant BAS in decision-making**
- **Identify and document any non-scientific information and rationale for incorporating in the update. Identify and resulting potential risks to critical area functions and values and the measures to limit those risks.**



Science and Planning

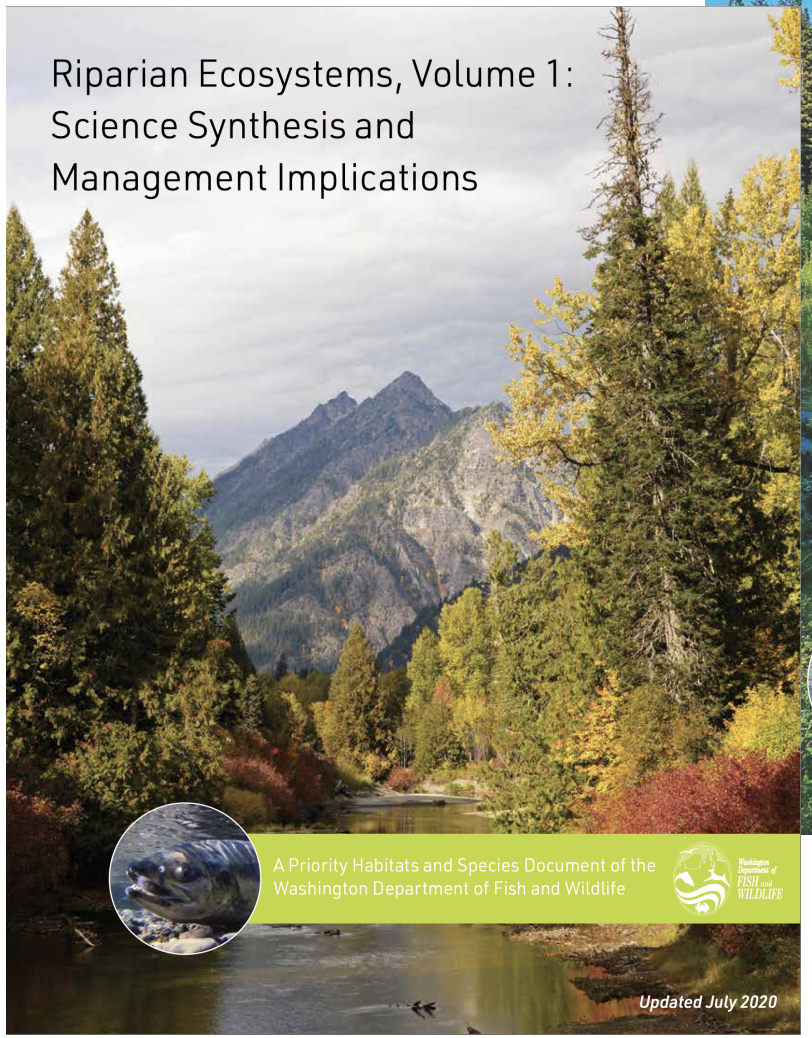
- **BAS informs planning decisions.** Science helps us understand and consider how land use decisions affect critical areas within the City.
- **BAS provides a framework** for managing critical areas in a systematic manner that addresses functions and values while considering practical implementation.
- **The City must balance BAS** with other substantive goals and mandates of the GMA.

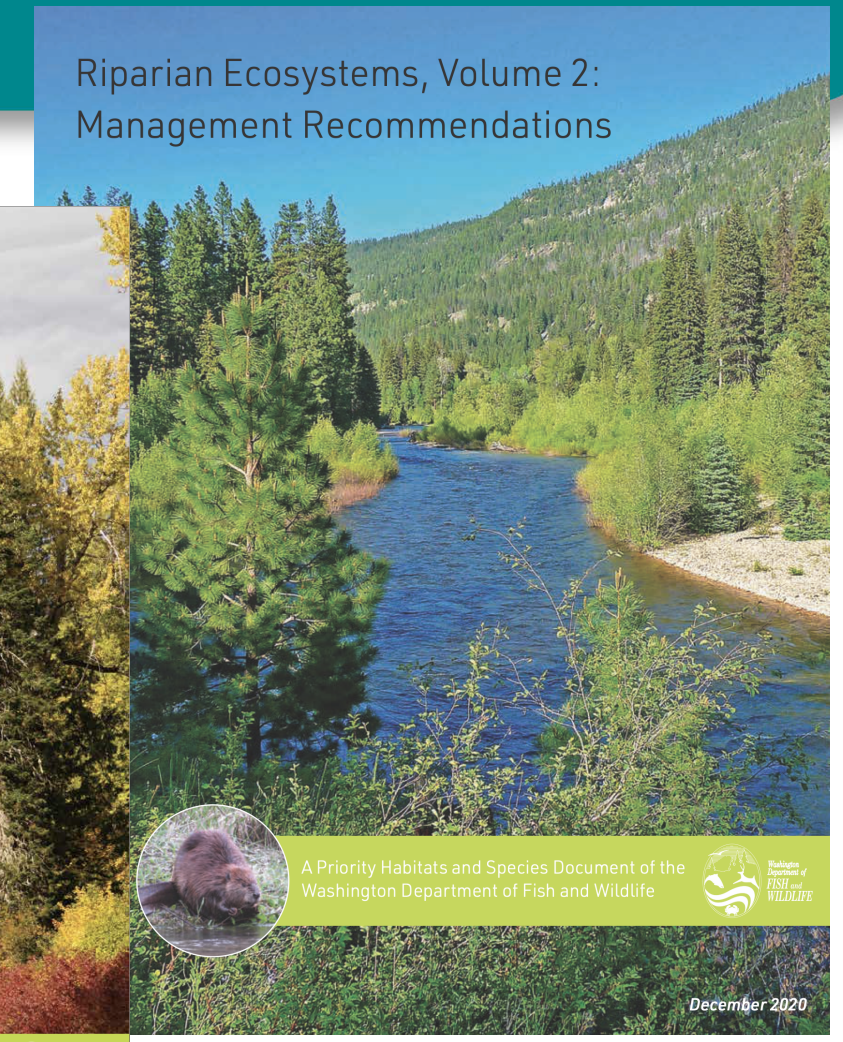
CAO Update Process

- BAS Review
- Gap Analysis
- Draft Code Update
- Engagement: Planning Commission, City Council, the Public
- Final draft CAO
- Adoption by City Council



Riparian Ecosystems



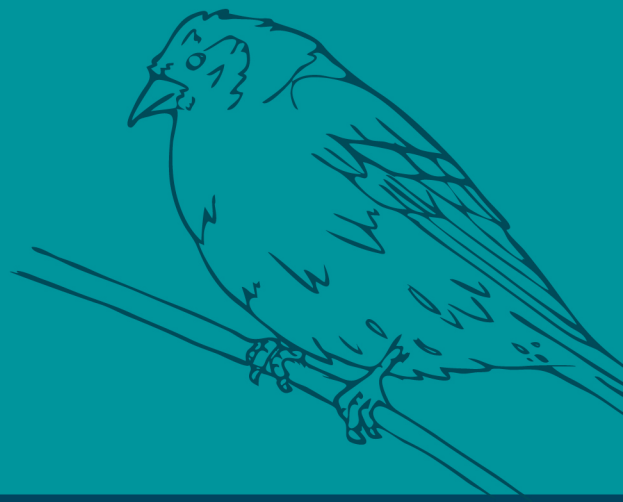


Riparian Habitat Areas in Walla Walla

City of Walla Walla is a Dryland Ecosystem.

WDFW Recommends:

- **100-ft minimum for water quality**
- **Preserve extent of intact riparian vegetation**



City Stream Analysis

Riparian Habitat.

Results:

- **43.2 stream miles**
- **Approximately 30% of streams with impervious surfaces/ disconnected from buffer**
- **Approximately 70% are currently vegetated**



Overview of Changes

Simplified where feasible

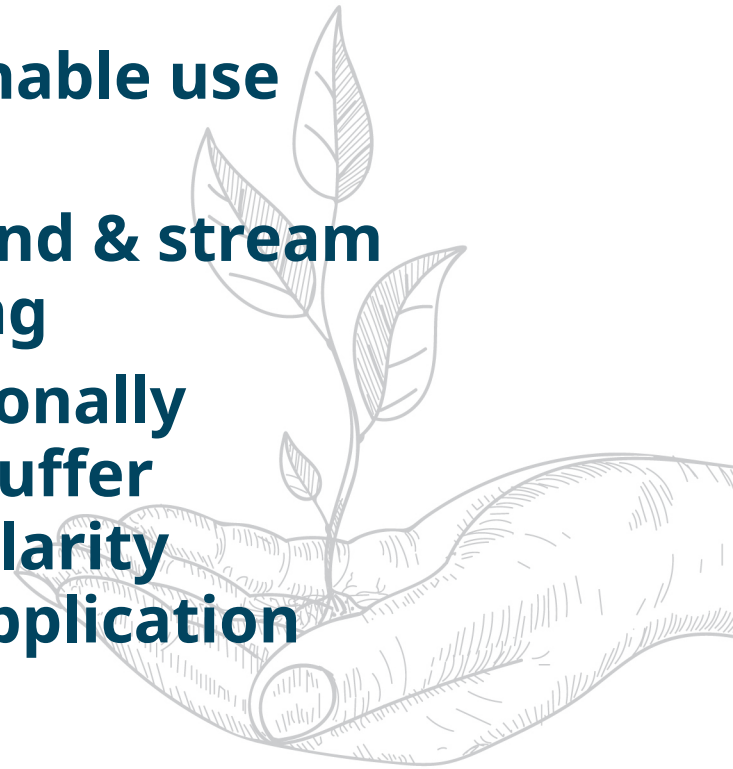
- Remove SMP regulations from the CAO
- Minor edits to improve clarity and consistency

WAC Alignment

- Definition updates
- New code references to the WAC

Added Flexibility

- Fencing as allowed activities
- Clarified reasonable use review process
- Retained wetland & stream buffer averaging
- Updated functionally disconnected buffer provisions for clarity and practical application



Overview of Changes*(cont.)*

Incorporate BAS

- New language to ensure reasonable use applications are consistent with zoning and adhere to mitigation sequencing
- Update mitigation plan requirements
- Update building setbacks to align with purpose and intent
- Added reference to current publications
- Updated Riparian Habitat Area regulations based on BAS




Questions?

City of Walla Walla
Development Services

2026 Draft Critical Areas Ordinance (CAO) Amendments
Level V Review Staff Report
File# PLN5-26-0001

I. GENERAL INFORMATION:

Application Date: June 29, 2026

Public Hearing Date: September 14, 2026

Applicant: City of Walla Walla Development Services
55 E Moore Street, Walla Walla, WA 99362

Amendment Description:
Amendments to the Critical Areas Ordinance, Walla Walla Municipal Code (WWMC) Chapter 21.04, to implement the Walla Walla Comprehensive Plan 2046. The proposed code amendments would apply citywide. New sections are bolded. Under the Washington State Growth Management Act (GMA), the City of Walla Walla must incorporate "best available science" (BAS) when developing policies and regulations to protect the functions and values of critical areas. Additionally, "special consideration" must be given to conservation, or protection measures to preserve or enhance anadromous fisheries, or species that hatch in fresh water, migrate to the ocean to grow as adults, and return to fresh water to spawn. Amendments to the following Municipal Code sections include:

Title 21: Environment

Code Section	Amendment Summary	Category
Chapter 21.04 Critical Areas		
21.04.005(B) Purpose	Adds clarification relating to no net loss of ecological functions and values of critical areas.	State Mandated RCW 36.70A.172
21.04.015 Applicability	Removes outdated Figure 1, which identified how critical areas review was incorporated into the application process for the underlying permit.	Outdated
21.04.020 Definitions	Updates, removes, or adds several definitions per state law.	State Mandated and Clarification

Code Section	Amendment Summary	Category
		RCW 36.70A.172 and WDFW Comments
21.04.035(A) Critical area maps	Renames the “development services” department to the “community development” department and removes outdated numbering of maps.	Outdated
21.04.060(4)(a) Permit processing	Minor clarification.	Clarification
21.04.085(B) (2-3) and (7-**23**) Allowed Activities	Clarifies the use and installation of fences in critical areas buffers and adds clarification regarding the removal of noxious weed species.	State Mandated RCW 36.70A.172 and WDFW Comments
21.04.090(B) (2-3) Reasonable use	Adds clarification relating to application requirements for a reasonable use exception.	State Mandated RCW 36.70A.172
21.04.095 (E) Critical area reports – General requirements	Adds clarification that critical area reports shall be valid for five years.	State Mandated RCW 36.70A.172 and WDFW Comments
21.04.105(C) Mitigation requirements	Provides clarification regarding compensatory off-site mitigation requirements.	State Mandated RCW 36.70A.172
21.04.115(C)(1) and (4) and (H) Mitigation plan requirements	Adds clarification relating to vegetation planting plans and critical area tracts and designations.	State Mandated RCW 36.70A.172
21.04.130(A) Building setbacks	Increases the building setback from critical area buffers from five feet to 15-feet.	State Mandated RCW 36.70A.172
21.04.200(B) Critical aquifer recharge areas – Designation.	Adds clarification relating to Washington State Department of Ecology guidance.	State Mandated RCW 36.70A.172
21.04.210(A) Mapping of critical aquifer recharge areas	Clarifies the location of the critical aquifer recharge areas map.	Clarification

Code Section	Amendment Summary	Category
21.04.220 Activities allowed in critical aquifer recharge areas.	Adds clarification relating to the Washington State Water Pollution Control Act.	State Mandated RCW 36.70A.172
21.04.230(D)(5) Critical area report – Additional requirements for critical aquifer recharge areas.	Adds clarification relating to best management practices or mitigation.	State Mandated RCW 36.70A.172 New
21.04.240(B) Performance standards – General requirements	Minor clarification relating to the City.	Clarification
21.04.260(G) Uses prohibited in critical aquifer recharge areas.	Adds a new section relating to dry wells used for vehicle repair and servicing or dry cleaners being prohibited in critical aquifer recharge areas.	State Mandated RCW 36.70A.172 New
21.04.300(B)(1) Wetlands critical areas – Designation	Clarification regarding Category I wetlands.	State Mandated RCW 36.70A.172
21.04.310 Mapping of wetland areas	Clarification regarding the Comprehensive Plan critical areas map.	Clarification
21.04.320(B)(3) Critical area report – Additional requirements for wetland areas	Clarifies that areas within 250 feet of the project area shall be addressed in a critical area report for wetlands.	State Mandated RCW 36.70A.172
21.04.330(F) Activities allowed in wetlands	Language change from “native herbs” to “native plants”.	Clarification
21.04.340(C)(2) and (4) Performance standards – General requirements	Adds and clarifies standards for disconnected buffers, or areas where an existing man-made structure is within the buffer zone. Allowances for modifying the standard buffer width are proposed, when certain conditions are met.	State Mandated RCW 36.70A.172

Code Section	Amendment Summary	Category
21.04.344(B-D) Performance standards – wetland buffer decrease	Adds and clarifies allowances for reductions in the standard buffer widths.	State Mandated RCW 36.70A.172
21.04.345(A-C) Performance standards – Buffer management plan.	Section removed for clarification.	Clarification
21.04.346(B)(1) and (C)**(3)(a-h)** Performance standards – specific activities and uses	Clarification relating to walkways and trails meeting the Americans with Disabilities Act (ADA) accessibility standards. New section regarding Low Impact Development (LID) and Flow Control best management practices.	State Mandated RCW 36.70A.172
21.04.347 (A-E) Performance standards – Mitigation requirements	Updates ratios for compensatory mitigation.	Outdated
21.04.348(B)(1) Performance standards – specific activities and uses.	Adds clarification regarding the watershed approach and consistency with Ecology publications.	State Mandated RCW 36.70A.172
21.04.400 Mapping of frequently flooded areas	Updates information regarding mapping and designation of frequently flooded areas.	State Mandated RCW 36.70A.172
21.04.**410(A) Mapping of frequently flooded areas**	Adds information regarding critical areas maps and their data source.	Clarification New
21.04.**420 Frequently flooded areas – regulation**	Adds clarification regarding the requirements for development in frequently flooded areas.	Clarification New
21.04.500(B)**(4)**; (D); (E) Geologically hazardous areas – designation	Adds clarification relating to geologically hazardous areas, including erosion hazard areas, seismic hazard areas, and mine hazards.	State Mandated RCW 36.70A.172

Code Section	Amendment Summary	Category
21.04.510 Mapping of geologically hazardous areas	Clarification relating to the Comprehensive Plan.	Clarification
21.04.600(A)(1)(b); (C) Fish and wildlife habitat conservation areas – Designation	Updates information relating to the Priority Habitats and Species List.	Clarification
21.04.610 Fish and wildlife habitat conservation areas – Mapping	Clarification relating to the Comprehensive Plan.	Clarification
21.04.620(F)(1); (3) and (5) (G-K) Fish and wildlife habitat conservation areas – Water bodies – Allowed uses.	Adds clarification relating to the requirements for in-stream structures such as dams and weirs.	Clarification
21.04.630(B)(2) Critical area report – Additional requirements for habitat conservation areas	Clarifies that areas to be addressed in the critical areas report shall be areas within 250 feet of the project area.	State Mandated RCW 36.70A.172
21.04.640(G)(3)(c) and (H)(3)(b) Performance standards – General requirements	Clarifies requirements relating to monitoring and maintenance plans and wildlife passable fencing around habitat conservation areas.	State Mandated RCW 36.70A.172 and WDFW comment
21.04.650(A)(1)(a); (B)(C)(D)(2-5)(a)(iii-**viii**); (6); (E-F) Performance standards – Specific habitats	Adds clarification relating to Washington State Department of Fish and Wildlife (WDFW) Priority Habitats and Species lists; clarifies requirements for wetland habitats and riparian habitat areas, including provisions for riparian habitat buffers. Proposes an increase to 100 feet for riparian buffers in the City. Adds standards for	State Mandated and Clarification RCW 36.70A.172

Code Section	Amendment Summary	Category
	water bodies used by anadromous fish.	
21.04.660**(D)** Performance standards – Subdivisions	Adds a requirement relating to development projects and wildlife habitat corridors.	State Mandated RCW 36.70A.172
21.04.670**(C)** Fish and wildlife habitat conservation areas – Piped streams	Adds clarification relating to the daylighting of piped streams.	State Mandated RCW 36.70A.172
21.04.700 Landfill vicinity development standards	Relocates this section to Title 20 Zoning.	Clarification Moved

II. SEPA STATUS:

The Notice of Application and Washington State Environmental Policy Act (SEPA) checklist was circulated to the SEPA distribution list and Washington State Department of Ecology SEPA register on August 18, 2026.

The City of Walla Walla Development Services has determined that this proposal is unlikely to have a significant adverse impact on the environment. An environmental impact statement (EIS) is not required under RCW 43.21C.030(2)(c). Staff reviewed the following: Submitted SEPA Checklist, dated June 29, 2026, and the existing environmental documents: Walla Walla Comprehensive Plan Final Environmental Impact Statement (FEIS), issued May 22, 2018, and Walla Walla Comprehensive Plan - Walla Walla 2040, Ordinance 2018-15, adopted June 13, 2018.

Pursuant to WAC 197-11-600(4)(c) and the addendum procedures in WAC 197-11-625, the City is issuing this Addendum to the 2018 FEIS. This Addendum provides additional information and analysis based on the June 29, 2026, Environmental Checklist. The information presented does not substantially change the analysis of probable significant adverse impacts or the range of alternatives considered in the 2018 FEIS. The original FEIS remains valid and is not modified or replaced by this Addendum.

III. FINDINGS OF FACT:

1. In accordance with Walla Walla Municipal Code (WWMC) Section 20.02.130, the Development Services staff and the Planning Commission review the WWMC throughout the year to ensure consistency with newly passed Washington State legislation, to clarify confusing sections that Development Services staff have observed to be difficult to administer, or to amend and

remove outdated language or land uses. The Zoning Code is thoroughly examined as part of the Planning Commission's regular work program, in coordination with the required periodic update of the Comprehensive Plan.

2. The City hired a consultant, Facet, to support the 2026 critical areas ordinance (CAO) periodic update. City staff kicked off the project with Facet in fall 2025 and began initial discussions and review of the draft critical area ordinance amendments.

3. Draft critical areas ordinance amendments were presented to the Planning Commission at the August 3, 2026, workshop.

4. The formal critical areas ordinance amendments were initiated (application submitted) on June 29, 2026. The 60-day notice was submitted to the Washington State Department of Commerce on August 4, 2026, and the submittal receipt was received on August 4, 2026.

5. Zoning code text amendments are a Level V review under Walla Walla Municipal Code (WWMC) Chapter 20.28, which requires the Planning Commission to hold a public hearing and make a recommendation to the City Council. The City Council is the decision authority.

6. A Notice of Application/ Notice of Public Hearing was published in the Union Bulletin newspaper on August 18, 2026, and posted on the City of Walla Walla website on August 18, 2026, as required by WWMC 20.14.065.

7. **Public Comments:** Two agency comments from the Washington State Department of Fish and Wildlife (WDFW) and the Department of Natural Resources (DNR) and one public comment have been received.

8. WWMC Chapter 20.48, Amendments, outlines the requirements for processing amendments as follows:

   20.48.020 Who may initiate.
   A. Amendments may be initiated by:
   1. The City Council;
   2. The City Manager;
   3. The Planning Commission;
   4. The Zoning Administrator;
   5. Any person requesting amendment to the text of this Code;
   6. Any property owner or contract purchaser or authorized agent requesting a rezone of his property; or
   7. Any property owner(s) requesting annexation to the City.

   20.48.030 Procedure.
   C. The City Council is responsible for the approval or denial of a rezone or text amendment. When considering a rezone request or a text amendment, the City Council will act on the request at a public meeting upon the hearing record of the initial reviewing body.

20.48.045 Review criteria for prezones, area-wide rezones, and text amendments.

The decision on a prezone, area-wide rezone, or text amendment shall be based on a legislative finding upon whether or not the proposal is consistent with and implements the Walla Walla Comprehensive Plan.

20.48.050 Record of amendments.

All amendments to the zone code will be recorded and indexed in the Development Services Department according to Section 20.14.100 of this code.

9. The proposed code amendments are supported by the City of Walla Walla Comprehensive Plan as identified in the conclusions of law section of this staff report as required by RCW 36.70A.130(1)(d), which reads in part: "Any amendment of or revision to development regulations shall be consistent with and implement the comprehensive plan."

10. Pursuant to WAC 197-11-600(4)(c) and the addendum procedures in WAC 197-11-625, the City is issuing this Addendum to the 2018 FEIS. This Addendum provides additional information and analysis based on the June 29, 2026, Environmental Checklist. The information presented does not substantially change the analysis of probable significant adverse impacts or the range of alternatives considered in the 2018 FEIS. The original FEIS remains valid and is not modified or replaced by this Addendum.

11. The Planning Commission is scheduled to conduct a Public Hearing on September 14, 2026.

IV. CONCLUSIONS OF LAW:

1. Pursuant to Walla Walla Municipal Code Chapter 20.48 Amendments, the following applies:

20.48.020 Who may initiate.

A. Amendments may be initiated by:
1. The City Council;
2. The City Manager;
3. The Planning Commission;
4. The Zoning Administrator;
5. Any person requesting an amendment to the text of this Code;
6. Any property owner or contract purchaser or authorized agent requesting a rezone of his property; or
7. Any property owner(s) requesting annexation to the City.

20.48.030 Procedure.

C. The City Council is responsible for the approval or denial of a rezone or text amendment. When considering a rezone request or a text amendment, the City Council will act on the request at a public meeting upon the hearing record of the initial reviewing body.

20.48.045 Review criteria prezones, area-wide rezones, and text amendments.
The decision on a prezone, area wide rezone, or text amendment shall be based on a legislative finding upon whether or not the proposal is consistent with and implements the Walla Walla Comprehensive Plan.

20.48.050 Record of amendments.
All amendments to the zone code will be recorded and indexed in the Development Services Department according to Section 20.14.100 of the Walla Walla Municipal Code.

Staff analysis of how the proposed code amendments meet the requirements of WWMC Chapter 20.48:

1. **Procedural Elements-**
   The proposed code amendments were initiated by the Development Services Department (Zoning Administrator) to revise and update sections of the code to improve clarity and usability, to align with recently passed State legislation, and to remove and update outdated language.

   The review by the Planning Commission was conducted at the regularly scheduled work session on August 3, 2026.

   A notice of application and notice of public hearing for the Planning Commission Public Hearing on September 14, 2026, was published in the Union Bulletin on August 18, 2026, and posted on the City's website on August 18, 2026. The public comment period concluded on September 4, 2026, for inclusion in the staff report for the Planning Commission.

   Two agency comments from the Washington State Department of Fish and Wildlife (WDFW) and the Department of Natural Resources (DNR) and one public comment have been received.

   The Planning Commission shall conduct a Public Hearing and make a recommendation to the City Council.

   The review criterion for municipal code text amendments is that the amendments are consistent with and implement the Walla Walla Comprehensive Plan – Walla Walla 2046. Staff will outline how the proposed code amendments are consistent with the Comprehensive Plan in the next conclusion analysis below.

Staff finds that the proposed code amendments meet the requirements of WWMC Chapter 20.48 Amendments based on the above staff analysis.

2. **Walla Walla Comprehensive Plan -**
   The proposed code amendments are supported by the Walla Walla Comprehensive Plan – Walla Walla 2046 Goals and Policies, as follows:

   Environment and Natural Resources (ENR) Goal 1: Water, air, and soil resources in Walla Walla are protected.

   ENR Policy 1.3: Identify and protect critical areas, and keep the City's Critical Areas Ordinance updated, in accordance with the Periodic Update Cycle.

ENR Goal 4: The integrity of Walla Walla's riparian ecosystem is protected by avoiding development and other land use activities within Riparian Management Zones (RMZs).

ENR Policy 4.1: Take measures to safeguard existing wetlands to prevent continual loss and degradation.

ENR Policy 5.1: Ensure that buffers are adequately defined, regulated, and controlled to limit the disturbance of vegetation and disruption of ecological function.

Climate Resilience (CR) Policy 1.4: Address climate change impacts (such as increased flooding, reduced winter streamflow, extreme heat risks, heightened wildfire threats, and broader ecosystem vulnerabilities), in future planning, design, and management of critical infrastructure, services, and natural resources.

CR Policy 4.1: Prioritize the protection and restoration of critical habitats such as floodplains, wetlands, and riparian ecosystems and other critical areas to reduce the severity of climate impacts, support long-term ecosystem health, and improve climate adaptability.

CR Policy 4.2: Continue to support fish and habitat recovery efforts to improve the climate resilience of streams and watersheds.

CR Policy 4.3: Coordinate climate resilience efforts in future updates of other city plans, including the Shoreline Master Program and critical areas regulations, through conservation area designations, buffers, and the development of open space corridors.

Staff analysis of how the proposed critical areas ordinance amendments align with the Comprehensive Plan:

The proposed 2026 periodic critical areas ordinance amendments fall into the categories of outdated, clarification, and state mandated. The majority of the code amendments relate to a state mandate under RCW (Revised Code of Washington) 36.70A.172. This RCW requires "best available science" (BAS) to be incorporated when developing policies and regulations to protect the functions and values of critical areas. The associated code amendments are aligned with the Comprehensive Plan Environment and Natural Resources (ENR) Policy 1.3 and Climate Resilience (CR) Policy 4.1.

The above legislation also includes new requirements related to preserving or enhancing anadromous fisheries, which are species that hatch in fresh water, migrate to the ocean to grow as adults, and return to fresh water to spawn, such as salmon. To this end, the riparian buffer zones on either side of the City's creeks and streams are proposed to increase from 35 or 50 feet, depending on the waterway, to 100 feet. These code amendments are supported by and aligned with Comprehensive Plan ENR Goal 4 and CR Policies 4.2 and 4.3.

Code amendments are proposed relating to disconnected buffers, or areas where an existing man-made structure is within the buffer zone. Allowances for modifying the standard buffer width are proposed when certain conditions are met. Comprehensive Plan ENR Policy 5.1 supports these code amendments.

As noted above, comments were received from WDFW, and changes were made to reflect the agency's comments. These code changes include adding clarification to the definition of "mitigation"; adding a section regarding the removal of noxious weed species; adding a new section specifying that critical area reports are valid for five years; removing the exception for single-family residential lots to provide monitoring and maintenance plans; and clarifying that fencing around habitat conservation areas or buffers shall be wildlife-passable fencing.

Staff reviewed the existing Municipal Code for inconsistencies, lack of clarity and usability, and places where the existing code was out of alignment with recently passed state legislation.

3. **Growth Management Act -**

The Growth Management Act (GMA) RCW 36.70A.020 goals that apply to the proposed Municipal Code Text Amendments are as follows:

Goal 1 Urban Growth. Encourage development in urban areas where adequate public facilities and services exist or can be provided in an efficient manner.

Goal 6 Property Rights. Private property shall not be taken for public use without just compensation having been made. The property rights of landowners shall be protected from arbitrary and discriminatory actions.

Goal 7 Permits. Applications for both state and local government permits should be processed in a timely and fair manner to ensure predictability.

Goal 9 Open Space and Recreation. Retain open space and green space, enhance recreational opportunities, enhance fish and wildlife habitat, increase access to natural resource lands and water, and develop parks and recreation facilities.

Goal 10 Environment. Protect and enhance the environment and enhance the state's high quality of life, including air and water quality, and the availability of water.

Goal 11 Citizen Participation and Coordination. Encourage the involvement of citizens in the planning process and ensure coordination between communities and jurisdictions to reconcile conflicts.

The public hearing notice was posted on August 18, 2026, and published on August 18, 2026, advertising the Planning Commission's public hearing on September 14, 2026, and soliciting comments from the public.

The intent is to take public input and feedback and bring forth the proposed amendments in this legislative process. Staff concludes that the proposed text amendments will implement the goals and policies of the City of Walla Walla Comprehensive Plan 2046 and of the Growth Management Act.

V. STAFF RECOMMENDATION

Staff recommend the Planning Commission recommend approval to the Walla Walla City Council for the Walla Walla Critical Areas Ordinance Amendments to Title 21 Environment.

Prepared by Lisa Wasson-Seilo, Planner: Lisa Wasson-Seilo

VI. EXHIBITS

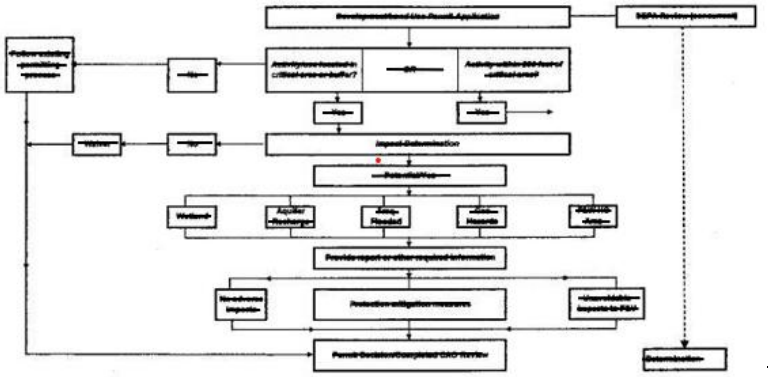
1. Draft Critical Areas Ordinance Amendments Table for Application and Public Comment — September 14, 2026
2. SEPA Checklist — June 29, 2026
3. SEPA Addendum to the 2018 FEIS — August 17, 2026
4. Planning Commission Workshop Draft Minutes — August 3, 2026
5. WA Department of Commerce Submittal Receipt — August 4, 2026
6. Notice of Application/ Notice of Public Hearing — August 18, 2026
7. Public Comment – Department of Natural Resources — August 7, 2026
8. Public Comment – Howard Boggs — August 26, 2026
9. Public Comment – Department of Fish and Wildlife — August 28, 2026

2026 Draft Critical Areas Code (CAO) Amendments Table

Planning Commission Public Hearing – September 14, 2026

KEY:
BOLD (NEW)
STRIKEOUT (PROPOSED DELETION)

CATEGORIES: OUTDATED, CLARIFICATION, STATE MANDATED

WWMC	Section	Proposed Amendment	Category and Notes
Title 21: Environment			
Chapter 21.04.005 (B) Critical Areas	Purpose	B. This chapter is to implement the goals, policies, guidelines, and requirements of the city of Walla Walla ("city") urban area comprehensive plan and the Growth Management Act. **Development regulations must protect all functions and values of critical areas to ensure no net loss of ecological functions and values. The city must give special consideration to conservation and protection measures necessary to preserve or enhance anadromous fisheries (WAC 365-190-080).**	State Mandated RCW 36.70A.172
21.04.015 Critical Areas	Applicability	~~Figure 1~~ 	Outdated

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Chapter 21.04.020 Critical Areas	Definitions	"Best available science" means current scientific information used in the process to designate, protect, or restore critical areas that is derived from a valid scientific process as defined by WAC 365-195-900 through 365-195-925. Sources of best available science are included in ~~"Citations of Recommended Sources of Best Available Science for Designating and Protecting Critical Areas" published by the state Office of Community Development.~~ **The Washington State Department of Commerce's Critical Areas Handbook; A Handbook for Reviewing Critical Areas Regulations.** "Critical aquifer recharge areas" means areas designated by WAC 365-190~~-080(2)~~**100** ~~that are determined to have a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030(2).~~ **and are areas with geologic conditions associated with critical recharging of aquifers used for potable water, including areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water, or is susceptible to reduced recharge**. "Erosion hazard areas" ~~means at least~~ **are** those areas ~~identified by the~~ **containing soils which, according to the** United States Department of Agriculture Natural Resources Conservation Service ~~as having a~~ **Soil Survey Program**, **may experience significant erosion, including** severe rill and inter-rill erosion hazard. **Erosion hazard areas also include channel migration zones in WAC 365-190-030.** **"Frequently flooded areas" as defined in WAC 365-190-030 means lands in the flood plain subject to at least a one percent or greater chance of flooding in any given year, or within areas subject to flooding due to high groundwater. These areas include, but are not limited to, streams, rivers, lakes, wetlands, and areas where high groundwater forms ponds on the ground surface.**	State Mandated and Clarification RCW 36.70A.172 And WDFD Comments

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		"Groundwater" means water in a saturated zone or stratum beneath the surface of land or a surface water body**;** ~~.~~ **whatever may be the geological formation or structure in which such water stands or flows, percolates or otherwise moves as defined in WAC 173-100-040.** “Habitats of Local Importance.” These areas include a seasonal range or habitat element with which a given species has a primary association and which, if altered, may reduce the likelihood that the species will maintain and reproduce over the long term. These might include areas of high relative density or species richness, breeding habitat, winter range, and movement corridors. These might also include habitats that are ~~of~~ limited **in** availability or high vulnerab~~ility~~**le** to **change** ~~alterations~~, such as cliffs, talus, and wetlands **as defined in** ~~(~~WAC 365-190-030.~~)~~ "Hazard areas" means areas designated as frequently flooded areas or geologically hazardous areas due to potential for erosion, landslide, seismic activity, extreme slopes, or other geological condition**s**. "Landslide hazard areas" ~~means~~ **as defined in WAC 365-190-120, includes** areas ~~that are potentially~~ subject to **landslides based on** ~~risk of mass movement due to~~ a combination of geologic ~~landslide resulting from a combination of geologic~~, topographic, and hydrologic factors. The**y**~~se~~ include areas ~~are typically~~ susceptible to landslides because of a combination of ~~factors including:~~ bedrock, soil, slope gradient, slope aspect, ~~geologic~~ structure, **hydrology** ~~ground water,~~ or other factors**, and include, at a minimum, the following:** **1. Areas of historic failures, such as:** **a. Those areas delineated by the United States Department of Agriculture Natural Resources Conservation Service as having a significant limitation for building site development;** **b. Areas designated as quaternary slumps, earthflows, mudflows, lahars,**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		or landslides on maps published by the United States Geological Survey or Washington Department of Natural Resources. **2. Areas with all three of the following characteristics:** **a. Slopes steeper than 15 percent;** **b. Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and** **c. Springs or groundwater seepage.** **3. Areas that have shown movement during the Holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of this epoch;** **4. Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;** **5. Slopes having gradients steeper than 80 percent subject to rockfall during seismic shaking;** **6. Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action, including stream channel migration zones;** **7. Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding;** **8. Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of bedrock. A slope is delineated by establishing its toe and top and measured by averaging the inclination over at least 10 feet of vertical relief.** "Mitigation" means avoiding, minimizing or compensating for adverse critical areas impacts **and** • ***Occurs at the same time as, or in advance of, a project's planned environmental impacts;*** • ***Is located in a site either on, near, or distant from the project's impacts; and***	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		• ***provides either the same or different biological functions and values as the functions and values impacted by the project. (RCW 90.74.010)*** Mitigation, in the following order of preference, is: 1. Avoiding the impact altogether by not taking a certain action or parts of an action; 2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps, such as project redesign, relocation, or timing, to avoid or reduce impacts; 3. Rectifying the impact to wetlands, critical aquifer recharge areas, and habitat conservation areas by repairing, rehabilitating or restoring the affected environment to the conditions existing at the time of the initiation of the project; 4. Minimizing or eliminating the hazard by restoring or stabilizing the hazard area through engineered or other methods; 5. Reducing or eliminating the impact or hazard over time by preservation and maintenance operations during the life of the action; 6. Compensating for the impact to wetlands, critical aquifer recharge areas, and habitat or critical areas by replacing, enhancing, or providing substitute resources or environments; and 7. Monitoring the hazard or other required mitigation and taking remedial action when necessary. Mitigation for individual actions may include a combination of the above measures. "On-site mitigation" means on or adjacent to the project impact site or in the same **watershed,** ~~stream reach,~~ based on resource needs. ~~"Shorelands or shoreland areas"~~ ~~means those lands extending landward for two hundred feet in all directions as measured on a horizontal plane from the ordinary high water mark; floodways and contiguous floodplain areas landward two hundred feet from such floodways; and all wetlands and river deltas associated with the streams and~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~lakes which are subject to the provisions of the City of Walla Walla Shoreline Master Program; the same to be designated as to location by the Department of Ecology.~~ ~~"Shorelines"~~ ~~means all of the water areas of the state as defined in RCW 90.58.030, including reservoirs and their associated shorelands, together with the lands underlying them except:~~ ~~1. Shorelines of statewide significance;~~ ~~2. Shorelines on segments of streams upstream of a point where the mean annual flow is twenty cubic feet per second or less and the wetlands associated with such upstream segments; and~~ ~~3. Shorelines on lakes less than twenty acres in size and wetlands associated with such small lakes.~~ ~~"Shorelines of statewide significance"~~ ~~means those areas defined in RCW 90.58.030(2)(e).~~ ~~"Shorelines of the state"~~ ~~means the total of all shorelines, as defined in RCW 90.58.030(2)(d), and shorelines of statewide significance within the state, as defined in RCW 90.58.030(2)(c).~~ "Water typing system" means waters classified according to WAC 222-16-030~~,~~ ~~including the following:~~**.** 1.~~"Type S Water"means all waters, within their bankfull width, inventoried as shorelines of the state under Chapter 90.58 RCW and the rules promulgated pursuant to Chapter 90.58 RCW including periodically inundated areas of their associated wetlands.~~ **For purposes of this definition:** **a. "Dwelling unit"** **means a home, apartment, residential condominium unit or mobile home, serving as the principal place of residence.** **b. "Camping unit"**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		means an area intended and used for: **i. Overnight camping or picnicking by the public, containing at least a fireplace, picnic table and access to water and sanitary facilities; or** **ii. A permanent home or condominium unit or mobile home not qualifying as a dwelling unit because of part-time occupancy.** **c. "Public accommodation facility"** **means a business establishment open to and licensed to serve the public, such as a restaurant, tavern, motel or hotel.** **d. "Natural waters"** **only excludes water conveyance systems which are artificially constructed and actively maintained for irrigation.** **e. "Seasonal low flow" and "seasonal low water"** **mean the conditions of the seven-day, two-year low water situation, as measured or estimated by accepted hydrologic techniques recognized by the department.** **f. "Channel width and gradient"** **means a measurement over a representative section of at least five hundred linear feet with at least ten evenly spaced measurement points along the normal stream channel but excluding unusually wide areas of negligible gradient such as marshy or swampy areas, beaver ponds and impoundments. Channel gradient may be determined utilizing stream profiles plotted from United States Geological Survey topographic maps (see board manual section 23).** **g. "Intermittent streams"** **means those segments of streams that normally go dry.** **h. "Fish habitat"** **means habitat which is used by any fish at any life stage at any time of the year, including potential habitat likely to be used by fish which could be recovered by restoration or management, and includes off-channel habitat.** ~~2, "Type F Water"means segments of natural waters, other than Type S Waters, which are within the bankfull widths of defined channels and periodically~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~inundated areas of their associated wetlands, or within lakes, ponds, or impoundments having a surface area of one-half acre or greater at seasonal low water and which in any case contain fish habitat or are described by one of the following four categories:~~ ~~a. Waters which are diverted for domestic use by more than ten residential or camping units or by a public accommodation facility licensed to serve more than ten persons, where such diversion is determined by the department to be a valid appropriation of water and the only practical water source for such users. Such waters shall be considered to be Type F Water upstream from the point of such diversion for one thousand five hundred feet or until the drainage area is reduced by fifty percent, whichever is less;~~ ~~b. Waters which are diverted for use by federal, state, tribal or private fish hatcheries. Such waters shall be considered Type F Water upstream from the point of diversion for one thousand five hundred feet, including tributaries if highly significant for protection of downstream water quality. The department may allow additional harvest beyond the requirements of Type F Water designation, provided the department determines after a landowner-requested on-site assessment by the Department of Fish and Wildlife, Department of Ecology, the affected tribes and interested parties that:~~ ~~i. The management practices proposed by the landowner will adequately protect water quality for the fish hatchery; and~~ ~~ii. Such additional harvest meets the requirements of the water type designation that would apply in the absence of the hatchery;~~ ~~c. Waters which are within a federal, state, local, or private campground having more than ten camping units; provided, that the water shall not be considered to enter a campground until it reaches the boundary of the park lands available for public use and comes within one hundred feet of a camping unit, trail or other park improvement;~~ ~~d. Riverine ponds, wall-based channels, and other channel features that are used by fish for off-channel habitat. These areas are critical to the maintenance~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~of optimum survival of fish. This habitat shall be identified based on the following criteria:~~ ~~i. The site must be connected to a fish habitat stream and accessible during some period of the year; and~~ ~~ii. The off-channel water must be accessible to fish.~~ ~~3. "Type Np Water"means all segments of natural waters within the bankfull width of defined channels that are perennial non-fish-habitat streams. Perennial streams are flowing waters that do not go dry any time of a year of normal rainfall and include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow.~~ ~~4. "Type Ns Water"means all segments of natural waters within the bankfull width of the defined channels that are not Type S, F, or Np Waters. These are seasonal, non-fish-habitat streams in which surface flow is not present for at least some portion of a year of normal rainfall and are not located downstream from any stream reach that is a Type Np Water. Type Ns Waters must be physically connected by an above-ground channel system to Type S, F, or Np Waters.~~ "Wetland category" means wetlands that are categorized into Category I, II, III or IV based upon the categorization procedures in the Washington State Wetland Rating System for Eastern Washington **2014 update**, as amended (Hruby T. 20~~0~~**1**4). "Wetlands" **as defined by WAC 365-190-030** means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from non-wetland areas to mitigate the conversion of wetlands. ~~For identifying and delineating a wetland, local government shall use the approved federal delineation manual and regional supplement, as amended.~~	
21.04.035(A) Critical Areas	Critical area maps.	A. The approximate location and extent of critical areas will be displayed on various inventory maps available at the city **community** development ~~services~~ department or online. These maps will be updated as inventories are completed in compliance with the requirements of the Growth Management Act, and additional maps may be added as appropriate. These **Comprehensive Plan** maps include: 1. City of Walla Walla Critical Area Map ~~1~~: Critical Aquifer Recharge Areas; 2. City of Walla Walla Critical Area Map ~~2.~~ Wetlands; 3. City of Walla Walla Critical Area Map ~~3~~: Frequently Flooded Areas; 4. City of Walla Walla Critical Area Map ~~4~~: Geologically Hazard Areas; 5. City of Walla Walla Critical Area Map~~-5~~: Fish and Wildlife Habitat Conservation Areas;	Clarification
Chapter 21.04.060(4)(a) Critical Areas	Permit processing.	Field markings are intended to prevent disturbance of critical areas and buffers and may include ~~such~~ items such as temporary fences;	Clarification
Chapter 21.04.085(B)(2-3, 7-23) Critical Areas	Allowed activities.	The following developments, activities, and associated uses are allowed in critical areas, and do not require approval or submission of a critical area report, provided they are consistent with the provisions of other local, state, and federal laws and requirements. Activities may intrude into the critical area or required buffer **provided such activities are otherwise consistent with this chapter and other applicable regulations. The director may apply conditions to an underlying permit or approval to ensure that the activities are consistent with the provisions of this chapter,** ~~subject to any listed conditions, related permits,~~ and in conformance with other portions of the	State Mandated RCW 36.70A.172 and WDFW Comments

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		Walla Walla Municipal Code and applicable state or federal law or regulation. **Any proposal to modify a critical area or its buffer must demonstrate compliance with mitigation sequencing under WWMC 21.04.110.** (B)(2) Maintenance, operation and/or repair of existing rights-of-way, trails, roads, utilities, **fences,** buildings and other facilities within critical areas and buffers; provided, that the activity does not further alter, impact, or encroach upon the sensitive area or buffer or further affect the functions of sensitive areas, and there is no increased risk to life or property as a result of the proposed operation, maintenance, or repair; and provided further, that: (B)(3) Maintenance of existing, lawfully established landscap**eing ~~ing~~ features** and gardens within a regulated critical area or its buffer, including but not limited to **maintaining fences, trellises, pathways and patio,** mowing lawns, weeding, removal of noxious and invasive species, harvesting and replanting of garden crops, pruning and planting native vegetation, pruning of existing ornamental vegetation to maintain the condition and appearance of such areas as they existed prior to adoption of this code; provided, that native growth protection areas, mitigation sites, or other areas protected via conservation easements or similar restrictive covenants are not covered by this exception. (B)(7) ~~Low-impact activities such as hiking, canoeing, nature study, photography, fishing, education or scientific research.~~ **Replacement modification, installation, or construction of fences; provided, wildlife passage is considered where feasible, and no fill or discharge occurs outside the existing improved area and with appropriate best management practices to control erosion, sedimentation and other potential impacts. Excluded is work within a water body or wetland, including but not limited to fence posts.**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		(B)(8) **Low-impact activities such as hiking, canoeing, nature study, photography, fishing, education or scientific research.** ~~Public and private pedestrian trails, provided they are subject to the following:~~ ~~a. The trail surface shall not exceed five feet in width;~~ ~~b. The trail surface shall consist of gravel, a pervious surface or a boardwalk;~~ ~~c. The trail shall meet all other city requirements including water quality standards;~~ ~~d. Sensitive area and/or buffer widths shall be increased, where possible, equal to the width of the trail corridor, including disturbed areas; and~~ ~~e. Trails proposed to be located in landslide or erosion hazard areas shall be constructed in a manner that does not increase the risk of landslide or erosion and in accordance with an approved geotechnical report. Low-impact activities such as hiking, canoeing, nature study, photography, fishing, education or scientific research.~~ (B)(9) **Public and private pedestrian trails, provided they are subject to the following:** **a. The trail surface shall not exceed five feet in width;** **b. The trail surface shall consist of gravel, a pervious surface or a boardwalk;** **c. The trail shall meet all other city requirements including water quality standards;** **d. Sensitive area and/or buffer widths shall be increased, where possible, equal to the width of the trail corridor, including disturbed areas; and** **e. Trails proposed to be located in landslide or erosion hazard areas shall be constructed in a manner that does not increase the risk of landslide or erosion and in accordance with an approved geotechnical report.** ~~The following vegetation removal activities:~~ ~~a. The removal of the noxious weed species designated by Washington State in Chapter 16-750 WAC or the local weed control authority with hand labor and light equipment, or other invasive species;~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~b. The removal of hazard trees from sensitive areas and buffers that are posing a threat to public safety, or an imminent risk of damage to a permanent structure with consultation from a certified arborist.~~ ~~Public and private pedestrian trails, provided they are subject to the following:~~ ~~a. The trail surface shall not exceed five feet in width;~~ ~~b. The trail surface shall consist of gravel, a pervious surface or a boardwalk;~~ ~~c. The trail shall meet all other city requirements including water quality standards;~~ ~~d. Sensitive area and/or buffer widths shall be increased, where possible, equal to the width of the trail corridor, including disturbed areas; and~~ ~~e. Trails proposed to be located in landslide or erosion hazard areas shall be constructed in a manner that does not increase the risk of landslide or erosion and in accordance with an approved geotechnical report.~~ (B)10) **The following vegetation removal activities:** **a. The removal of the noxious weed species designated by Washington State in Chapter 16-750 WAC or the local weed control authority, other invasive species with hand labor and light equipment, or with the use of only WA Dept. of Ecology-approved aquatic herbicides and, when necessary, avoidance of hazardous substances, prevention of soil compaction, and timing restrictions to protect fish and wildlife during sensitive periods;** **b. The removal of hazard trees from sensitive areas and buffers that are posing a threat to public safety, or an imminent risk of damage to a permanent structure with consultation from a certified arborist.** ~~Minor site investigative work necessary for land use submittals, such as surveys, soil logs, percolation tests, and other related activities, where such activities do not require construction of new roads, removal of native trees or shrubs, or displacement of more than five cubic yards of material.~~ ~~Investigations involving displacement of more than five cubic yards of material, including geotechnical soil borings, groundwater monitoring wells, percolation tests, and similar activities, shall require submittal of specific plans and~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~restoration plans. In every case, impacts to the sensitive area shall be minimized and disturbed areas shall be immediately restored.~~ (B)(11) ~~The application of herbicides, pesticides, organic or mineral-derived fertilizers, or other hazardous substances, if necessary; provided, that their use shall be conducted in accordance with applicable state and federal law.~~ **Minor site investigative work necessary for land use submittals, such as surveys, soil logs, percolation tests, and other related activities, where such activities do not require construction of new roads, removal of native trees or shrubs, or displacement of more than five cubic yards of material. Investigations involving displacement of more than five cubic yards of material, including geotechnical soil borings, groundwater monitoring wells, percolation tests, and similar activities, shall require submittal of specific plans and restoration plans. In every case, impacts to the sensitive area shall be minimized and disturbed areas shall be immediately restored.** (B)(12) ~~Activities undertaken to comply with a United States Environmental Protection Agency superfund-related order, or a Washington Department of Ecology order pursuant to the Model Toxics Control Act that specifically preempts local regulations in the findings of the order.~~ **The application of herbicides, pesticides, organic or mineral-derived fertilizers, or other hazardous substances, if necessary; provided; that their use shall be conducted in accordance with applicable state and federal law.** (B)(13) ~~Projects and facilities for restoration and enhancement of ecological functions of critical areas and related resources may be allowed within critical areas and buffers, upon approval of a restoration and mitigation plan in accordance with the provisions of this chapter, or for restoration and enhancement programs in an adopted shoreline restoration plan pursuant to Chapter 173-26 WAC, a watershed planning document prepared and adopted pursuant to Chapter 90.82 RCW, a watershed restoration project pursuant to RCW 89.08.460, a salmonid recovery plan, the Salmon Recovery Funding Board habitat project list, or identified by the Washington Department of Fish and Wildlife as essential for fish and wildlife habitat enhancement pursuant to~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~RCW 77.55.290.~~ **Activities undertaken to comply with a United States Environmental Protection Agency superfund-related order, or a Washington Department of Ecology order pursuant to the Model Toxics Control Act that specifically preempts local regulations in the findings of the order.** (B)(14) ~~The repair and maintenance of existing drainage ditches.~~ **Projects and facilities for restoration and enhancement of ecological functions of critical areas and related resources may be allowed within critical areas and buffers, upon approval of a restoration and mitigation plan in accordance with the provisions of this chapter, or for restoration and enhancement programs in an adopted shoreline restoration plan pursuant to Chapter 173-26 WAC, a watershed planning document prepared and adopted pursuant to Chapter 90.82 RCW, a watershed restoration project pursuant to RCW 89.08.460, a salmonid recovery plan, the Salmon Recovery Funding Board habitat project list, or identified by the Washington Department of Fish and Wildlife as essential for fish and wildlife habitat enhancement pursuant to RCW 77.55.290.** (B)(15) ~~The installation of individual service lines for agricultural purposes and to existing uses.~~ **The repair and maintenance of existing drainage ditches.** (B)(16) ~~Normal and routine activities conducted by a public agency to control mosquitoes and weeds~~. **The installation of individual service lines for agricultural purposes and to existing uses.** (B)(17) ~~Agricultural activities including farming, horticulture, normal maintenance and repair of irrigation delivery systems and drainage systems, ranching and grazing of animals and pest and weed control. This includes land lying idle under a government program, agricultural set-aside land and changes between agricultural activities.~~ **Normal and routine activities conducted by a public agency to control mosquitoes and weeds.** (B)(18) ~~Normal and routine maintenance of agricultural ponds, livestock watering ponds and fish ponds.~~ **Agricultural activities including farming, horticulture, normal maintenance and repair of irrigation delivery systems**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		and drainage systems, ranching and grazing of animals, fence maintenance, and pest and weed control. This includes land lying idle under a government program, agricultural set-aside land, and changes between agricultural activities. (B)(19) ~~The maintenance and repair of stormwater facilities under this chapter and designed in accordance with Chapter 13.16.~~ **Normal and routine maintenance of agricultural ponds, livestock watering ponds and fish ponds.** (B)(20) ~~Normal maintenance and repair of the concrete-lined Mill Creek channel within the city's jurisdiction from Rooks Park to Gose Street for flood control purposes.~~ **The maintenance and repair of stormwater facilities under this chapter and designed in accordance with Chapter 13.16.** (B)(21) ~~Normal dredging required to maintain ongoing water navigational facilities including boat and barge slips, docking facilities, entrance channels and agricuttural irrigation facilities; provided, that other applicable permits are obtained.~~ **Normal maintenance and repair of the concrete-lined Mill Creek channel within the city's jurisdiction from Rooks Park to Gose Street for flood control purposes.** (B)(22) ~~Cases where a federal or state agency has jurisdictional control over a wetland and the director determines that those permit conditions would satisfy the requirements of this chapter.~~ **Normal dredging required to maintain ongoing water navigational facilities including boat and barge slips, docking facilities, entrance channels and agricultural irrigation facilities; provided that other applicable permits are obtained.** **(B)(23) Cases where a federal or state agency has jurisdictional control over a wetland and the director determines that those permit conditions would satisfy the requirements of this chapter.**	
Chapter 21.04.090(B)(2-3) Critical Areas	Reasonable use.	B. Exception Request and Review Process. An application for a reasonable use exception shall be made to the city and shall include a critical area report, **prepared by a qualified professional**, including mitigation plan, if necessary,	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		and any other related project documents, such as permit applications to other agencies, special studies, and environmental documents prepared pursuant to the State Environmental Policy Act (Chapter 43.21C RCW) (SEPA documents). The director shall determine whether an exception request shall be granted based on review of the submitted information, a site inspection, and the proposal's ability to comply with reasonable use exception criteria. The director shall approve with conditions or deny the request based on the proposal's ability to comply with all of the following reasonable use exception review criteria: 2. No other reasonable use of the property has less impact on the critical area **and the applicant demonstrates that other permitted uses in the areas that have less impact on the critical area and buffer are not technically feasible as an alternative.** 3. The proposed impact to the critical area is the minimum necessary to allow for reasonable economic use of the property; **and upon request, the director may require the applicant to provide a neighborhood analysis that evaluates the surrounding conditions in the immediate vicinity to verify that the applicant's request is consistent with the minimum necessary reasonable use criteria.**	
Chapter 21.04.095 (E) Critical Areas	Critical area reports – General requirements.	**Critical area reports shall be valid for a period of five years. After such date, the Director shall determine whether a revision or additional assessment is necessary.**	State Mandated RCW 36.70A.172 and WDFW Comments
Chapter 21.04.105(C) Critical Areas	Mitigation requirements.	The director may approve off-site mitigation if the applicant demonstrates that no viable on-site mitigation opportunities exist. Compensatory mitigation proposed off-site **is required by state and/or federal permitting agencies, and/or** shall be provided in the location that will provide the greatest ecological benefit and have the greatest likelihood of success. Preference will be given to off-site mitigation as close as possible to the impact area and within the same	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		watershed sub-basin as the permitted alteration; provided**;** that off-site mitigation may occur within the city or within water resource inventory area (WRIA) 32 upon demonstration through a watershed- or landscape-based analysis that mitigation within an alternative sub-basin of the watershed would have greater ecological benefit. Off-site mitigation sites preference shall be given to sites and restoration activities identified in an adopted shoreline restoration plan pursuant to Chapter 173-26 WAC, a watershed planning document prepared and adopted pursuant to Chapter 90.82 RCW, a watershed restoration project pursuant to RCW 89.08.460, a salmonid recovery plan, the Salmon Recovery Funding Board habitat project list, or identified by the Washington Department of Fish and Wildlife as essential for fish and wildlife habitat enhancement pursuant to RCW 77.55.290.	
Chapter 21.04.115 (C)(1) and (4) and **(H**) Critical Areas	Mitigation plan requirements.	C. Detailed Construction Plans. The mitigation plan shall include written specifications and descriptions of the mitigation proposed, such as: 1. The proposed construction sequence, timing~~,~~ **of impact and mitigation activities,** and duration; 2. Grading and excavation details; 3. Erosion and sediment control features; 4. A vegetation planting plan specifying plant species, **including those species identified in Walla Walla County Conservation District Homeowner's Guide to Riparian Buffers**, quantities, locations, size, spacing, and density; and 5. Measures to protect and maintain plants until established. **H. Critical Area Tracts and Designations. A notice on title or critical area tract shall be used to delineate and protect those critical areas and buffers in development proposals for subdivisions, short subdivisions, or other affected lots as detailed under WWMC 21.04.125 at the discretion of the director.**	State Mandated RCW 36.70A.172
Chapter 21.04.130(A) Critical Areas	Building setbacks**.**	Unless otherwise provided, buildings and other structures shall be set back a distance of **fifteen** ~~five~~ feet from the edges of all critical area buffers or from the edges of all critical areas, if no buffers are required. **Minor reduction of the**	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		standard building setback to a minimum of five feet may be permitted by the director if adequate protection of the critical area buffer will be maintained as documented by a qualified professional in a critical areas report. The following may be allowed in the setback area: A. Landscaping **vegetation**;	
Chapter 21.04.200(B) Critical Areas	Critical aquifer recharge areas – Designation.	Critical aquifer recharge areas (CARA) are those areas with a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030(~~2~~). CARA have prevailing geologic conditions associated with infiltration rates that create a high potential for contamination of ground water resources or contribute significantly to the replenishment of ground water. CARA in the city of Walla Walla are designated as follows: B. The ten-year time of travel as defined in the wellhead protection plans submitted by communities and water providers to the Department of Health ~~as of 2007~~. The city of Walla Walla maintains these groundwater capture zones. The CARA delineated by the ten-year capture zones ~~are~~ **is** defined in Critical Area Map ~~1~~ **in the Comprehensive Plan**. Table 1 lists the communities and water providers in the city of Walla Walla that have designated wellhead protection areas. Table 1 also lists the total area encompassed by the ten-year time of travel. The entire extent of the gravel aquifer as delineated in Critical Area Map ~~1~~ **in the Comprehensive Plan** is not defined as a CARA; however, it is an aquifer of significance/consideration. The city will encourage voluntary implementation of best management practices**, consistent with Critical Aquifer Recharge Areas Guidance (Ecology Publication # 05-10-028) current or as revised,** associated with development in this area.	State Mandated RCW 36.70A.172
21.04.210(A) Critical Areas	Mapping of critical aquifer	A. The approximate location and extent of critical aquifer recharge areas are shown on the following adopted critical areas map **in the Comprehensive Plan**: City of Walla Walla Critical Area Map ~~1~~: Critical Aquifer Recharge Areas.	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
	recharge areas.		
Chapter 21.04.220 Critical Areas	Activities allowed in critical aquifer recharge areas.	The following activities are allowed in critical aquifer recharge areas pursuant to Section 21.04.085, Allowed activities, **must be consistent with the Washington State Water Pollution Control Act (RCW 90.48)**, and do not require submission of a critical area report	State Mandated RCW 36.70A.172
Chapter 21.04.230(D)**(5)** Critical Areas	Critical area report – Additional requirements for critical aquifer recharge areas.	**5. Best Management Practices or Mitigation. The applicant must document implementation of presumptive best management practices, integrated pest management, or mitigation as applicable.**	State Mandated RCW 36.70A.172
Chapter 21.04.240(B) Critical Areas	Performance standards – General requirements.	The proposed activity must comply with the water source protection requirements and recommendations of the United States Environmental Protection Agency, Washington State Department of Ecology, Washington State Department of Health, and the ~~c~~**C**ity of Walla Walla ~~health department~~.	Clarification
Chapter 21.04.260**(G)** Critical Areas	Uses prohibited in critical aquifer recharge areas.	**G. Dry wells on sites used for vehicle repair and servicing or dry cleaners. Dry wells existing on the site prior to facility establishment must be abandoned using techniques approved by the state Department of Ecology prior to commencement of the proposed activity.**	State Mandated RCW 36.70A.172
Chapter 21.04.300(B(1) Critical Areas	Wetlands critical areas – Designation.	1. Category I Wetlands. ~~Wetlands which are alkali wetlands, wetlands that are identified by scientists of the Washington Natural Heritage Program (DNR) as wetlands with high conservation value, bogs, mature old-growth forested wetlands over one-quarter acre with slow-growing trees, forests with stands of aspen, and wetlands~~ that perform many functions very well function at a very	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		high level (scores twenty-two to twenty-seven points). They meet at least one of the following criteria: (a) represent a unique or rare wetland type; or (b) are more sensitive to disturbance than most wetlands; or (c) are relatively undisturbed and contain ecological attributes that are impossible to replace within a human lifetime; (d) provide a high level of functions (scores of twenty-two to twenty-seven points using the Eastside rating system); or (e) are documented wetlands of local significance. The city cannot afford the risk of any degradation to these wetlands because their functions and values are too difficult to replace. Generally, these wetlands are not common and make up a small percentage of the wetlands in the region.	
21.04.310 Critical Areas	Mapping of wetland areas.	A. The approximate location and extent of known wetlands are shown on the City of Walla Walla **Comprehensive Plan** Critical Area Map ~~2~~: Wetlands, or the latest revision of this map. This information is to be used as a guide for the city, project applicants and/or property owners, and may be updated as new information becomes available. In some instances (uncertified boundaries), it is a reference and does not provide a final critical area designation.	Clarification
Chapter 21.04.320(B)(3) Critical Areas	Critical area report – Additional requirements for wetland areas.	3. All shoreline areas, water features, flood-plains, and other critical areas, and related buffers within two hundred **fifty** feet of the project area.	State Mandated RCW 36.70A.172
Chapter 21.04.330(F) Critical Areas	Activities allowed in wetlands.	F. Enhancement of a wetland through the removal of nonnative invasive species. Weeding shall be restricted to hand removal and weed material shall be removed from the site. Bare areas that remain after weed removal shall be revegetated with native shrubs and trees at natural densities. Some hand seeding may also be done over the bare areas with native ~~herb~~**plant**s.	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Chapter 21.04.340(C)(2) and (4) Critical Areas	Performance standards – General requirements.	2. Buffers shall not include areas that are functionally and effectively disconnected from the wetland by ~~a road or~~ **impervious surfaces,** other substantially developed surface**s** of sufficient width and with use characteristics such that buffer functions are not provided. **The director may approve modification of the standard buffer width to the edge of development, provided:** **a. The disconnected part of the buffer does not provide additional protection of the wetland; and** **b. The disconnected part of the buffer provides insignificant biological, geological, or hydrological buffer functions relating to the wetland; and** **c. If the resulting buffer distance is less than 75% of the standard or optional buffer for the applicable wetland category, no further reduction will be allowed.** **d. The legally established development includes impervious surfaces a minimum of 20 feet wide that completely isolates the project area from the critical area.** 4. Measurement of Wetland Buffers. All buffers shall be measured from the wetland boundary as surveyed in the field. **Wetland delineations will be documented on a ground-verified map using either professional surveying methods or an equivalent professional method using GPS with sub-meter accuracy.** The width of the wetland buffer shall be determined according to the wetland category and the proposed land use. The buffer for a wetland created, restored, or enhanced as compensation for wetland alterations shall be the same as the buffer required for the category of the created, restored, or enhanced wetland.	State Mandated RCW 36.70A.172
Chapter 21.04.344(B-D) Critical Areas	Performance standards – Wetland buffer decrease.	The director shall have the authority to reduce the standard buffer widths identified in Section 21.04.340; **consistent with a reduction in the intensity of impacts from proposed land uses. The applied land use intensity buffer width may be reduced from high to moderate** provided, that the general standards for avoidance and minimization per	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		Sections 21.04.110(A) and (B) shall apply; and provided further, that all of the following apply: B. ~~The buffer of a Category I or II wetland shall not be reduced to less than seventy-five percent of the required buffer or fifty feet, whichever is greater;~~ **The applicant implements all reasonable measures to reduce the adverse effects of adjacent land uses and ensure no net loss of buffer functions and values. The specific measures that shall be implemented include, but are not limited to, the following:** **1. Direct lights away from the wetland and buffer.** **2. Locate facilities that generate substantial noise (such as some manufacturing, industrial and recreational facilities) away from the wetland and buffer.** **3. Establish covenants limiting use of pesticides within two hundred feet of wetland.** **4. Implement integrated pest management programs.** **5. Integrate LID BMPs such as dispersion and downspout infiltration systems into the project design to infiltrate, filter, store, evaporate, and transpire stormwater runoff.** **6. Post signs at the outer edge of the critical area or buffer to clearly indicate the location of the critical area according to the direction of the city.** **7. Plant buffer with native vegetation appropriate for the region to create screens or barriers to noise, light, and human intrusion and discourage domestic animal intrusion.** **8. Use low impact development principles such as minimizing impervious surfaces, native vegetation loss, and stormwater runoff where appropriate.** **9. Establish a permanent conservation easement to protect the wetland and the associated buffer.** C. ~~The buffer of a Category III or IV wetland shall not be reduced to less than seventy-five percent of the required buffer or twenty-five feet, whichever is greater;~~ **For wetlands that score moderate or high for habitat (6 points or**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		more), the width of the buffer can be reduced if both of the following criteria are met: **1. A relatively undisturbed, vegetated corridor at least 100 feet wide is protected between the wetland and any other priority habitats as defined by the Washington State Department of Fish and Wildlife.** **2. Measures to minimize the impacts of different land uses on wetlands, such as measures under WWMC 21.04.344(B), are applied**. D. ~~The applicant implements all reasonable measures to reduce the adverse effects of adjacent land uses and ensure no net loss of buffer functions and values. The specific measures that shall be implemented include, but are not limited to, the following:~~ ~~1. Direct lights away from the wetland and buffer.~~ ~~2. Locate facilities that generate substantial noise (such as some manufacturing, industrial and recreational facilities) away from the wetland and buffer.~~ ~~3. Establish covenants limiting use of pesticides within two hundred feet of wetland.~~ ~~4. Implement integrated pest management programs.~~ ~~5. Integrate LID BMPs such as dispersion and downspout infiltration systems into the project design to infiltrate, filter, store, evaporate, and transpire stormwater runoff.~~ ~~6. Post signs at the outer edge of the critical area or buffer to clearly indicate the location of the critical area according to the direction of the city.~~ ~~7. Plant buffer with native vegetation appropriate for the region to create screens or barriers to noise, light, and human intrusion and discourage domestic animal intrusion.~~ ~~8. Use low impact development principles such as minimizing impervious surfaces, native vegetation loss, and stormwater runoff where appropriate.~~ ~~9. Establish a permanent conservation easement to protect the wetland and the associated buffer.~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		For wetlands that score less than 6 points for habitat, the buffer width can be reduced to that required for moderate land-use impacts by applying measures to minimize the impacts of proposed land uses (WWMC 21.04.344(B).	
Chapter 21.04.345 (A-C) Critical Areas	Performance standards – Buffer management plan.	~~In order to maintain effective buffer conditions, values and functions, a vegetation management plan shall be required for all buffer areas. Specific provisions to be addressed in the plan include:~~ ~~A. Maintaining adequate cover of native vegetation including trees and understory at densities provided in Table 8, Walla Walla County Conservation District native riparian vegetation planting guidelines;~~ ~~B. Establishing a plan for control of invasive weeds, and removal of existing invasive plant species;~~ ~~C. Incorporating a monitoring and maintenance plan for a period of at least five years, except this provision may be waived for isolated single-family residential lots.~~	Clarification
Chapter 21.04.346(B)(1) and (C)**(3)(a-h)** Critical Areas	Performance standards – Specific activities and uses.	(B)(1). Walkways and trails shall ~~not exceed five feet in width from shoulder to shoulder~~, shall meet **American with Disability Act, ADA accessibility standards and** the definition of a pervious surface**,** and require only limited excavation for foundation or stabilization; provided~~,~~ that those walkways and trails that are generally parallel to the perimeter of the wetland shall be located in the outer twenty-five percent of the buffer area; **(C)(3). A wetland or its buffer can be physically or hydrologically altered to meet the requirements of a Low Impact Development (LID) methodology or Flow Control BMP when the following criteria are met:** **a. The wetland is classified as a Category IV or a Category III wetland with a habitat score of 3-5 points.** **b. There will be no net loss of functions and values of the wetland.** **c. The wetland does not contain a breeding population of any native amphibian species.**	State Mandated RCW 36.70A.172

DRAFT

<table>
<tr><th>WWMC</th><th>Section</th><th>Proposed Amendment</th><th>Category and Notes</th></tr>
<tr><td></td><td></td><td>d. The hydrologic functions of the wetland can be improved as outlined in questions 3, 4, and 5 of Chart 4 and questions 2, 3, and 4 of Chart 5 in Selecting Mitigation Sites Using a Watershed Approach, [Western Washington or Eastern Washington] (Ecology Publication [#09-06-032 or #10-06-007], or as revised); or the wetland is part of a restoration plan intended to achieve restoration goals identified in a shoreline master program or a local or regional watershed plan.
e. The wetland lies in the natural routing of the runoff, and the discharge follows the natural routing.
f. All regulations regarding stormwater and wetland management are followed, including but not limited to local and state wetland and stormwater codes, manuals, and permits.
g. Lost existing functions and values are compensated.
h. A site-specific characterization is performed to determine whether an LID BMP is feasible at the project site.</td><td></td></tr>
<tr><td>21.04.347 (A-E) Critical Areas</td><td>Performance standards – Mitigation requirements</td><td>A. Definitions of Types of Compensatory Mitigation. The ratios presented are based on the type of compensatory mitigation proposed (e.g., restoration, creation, and enhancement). In its Regulatory Guidance Letter 02-02, the U.S. Army Corps of Engineers provided definitions for these types of compensatory mitigation. For consistency, the authors of this document use the same definitions which are provided under "compensatory mitigation" in Section 21.04.020.
<table>
<tr><th>Category of impacted wetland (based on score for function)</th><th>Re-establishment or creation</th><th>Rehabilitation</th><th>Preservation</th><th>Enhancement</th></tr>
<tr><td>Category I</td><td>4:1</td><td>8:1</td><td>16:1</td><td>16:1</td></tr>
<tr><td>Category II</td><td>3:1</td><td>6:1</td><td>12:1</td><td>12:1</td></tr>
<tr><td>Category III</td><td>2:1</td><td>4:1</td><td>8:1</td><td>8:1</td></tr>
<tr><td>Category IV</td><td>1.5:1</td><td>3:1</td><td>6:1</td><td>6:1</td></tr>
</table></td><td>Outdated</td></tr>
</table>

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		Notes: **1. Ratios for rehabilitation, preservation, and enhancement may be reduced when combined with 1:1 replacement through re-establishment or creation. See Table 6B-2 in Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance –Version 2 (Ecology et al., 2021 or as revised).** **2. All proposed preservation sites need to meet the preservation criteria listed in Chapter 070.3.E of Appendix A, Sample Wetland Regulations.** **3. The ratios are for permanent, direct impacts to wetlands. For recommended ratios for other types of impacts (e.g., long-term temporary, conversions), see Chapters 6B4.4 through 6B4.8 of Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance –Version 2 (Ecology et al., 2021 or as revised).** **4. The category of impacted wetland is based on scores for functions. Compensation ratios generally do not apply when impacts involve a wetland whose category is based on special characteristics.** B. ~~The director shall have the authority to adjust these ratios when a combination of mitigation approaches is proposed. In such cases, the area of altered wetland shall be replaced at a one-to-one ratio through re-establishment or creation, and the remainder of the area needed to meet the ratio can be replaced by enhancement at a two-to-one ratio. For example, impacts to one acre of a Category II wetland requiring a three-to-one ratio for creation can be compensated by creating one acre and enhancing four acres (instead of the additional two acres of creation that would otherwise be required).~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes

Table 5: Mitigation Ratios for Eastern Washington*

Category and Type of Wetland Impacts	Re-establishment or Creation	Rehabilitation Only*	Re-establishment or Creation (R/C) and Rehabilitation (RH)*	Re-establishment or Creation (R/C) and Enhancement (E)*	Enhancement Only*
All Category IV	1.5:1	3:1	1:1 R/C and 1:1 RH	1:1 R/C and 2:1 E	6:1
All Category III	2:1	4:1	1:1 R/C and 2:1 RH	1:1 R/C and 4:1 E	8:1
Category II Forested	4:1	8:1	1:1 R/C and 4:1 RH	1:1 R/C and 8:1 E	16:1
Category II Vernal Pool	2:1 Compensation must be seasonally ponded wetland	4:1 Compensation must be seasonally ponded wetland	1:1 R/C and 2:1 RH	Case-by-case	Case-by-case
All other Category II	3:1	6:1	1:1 R/C and 4:1 RH	1:1 R/C and 8:1 E	12:1
Category I Forested	6:1	12:1	1:1 R/C and 10:1 RH	1:1 R/C and 20:1 E	24:1
Category I based on score for functions	4:1	8:1	1:1 R/C and 6:1 RH	1:1 R/C and 12:1 E	16:1
Category I Natural Heritage site	Not considered possible#	6:1 Rehabilitation of a Natural Heritage site	R/C Not considered possible#	R/C Not considered possible#	Case-by-case
Category I Alkali	Not considered possible#	6:1 Rehabilitation of an alkali wetland	R/C Not considered possible#	R/C Not considered possible#	Case-by-case
Category I Bog	Not considered possible#	6:1 Rehabilitation of a bog	R/C Not considered possible#	R/C Not considered possible#	Case-by-case

* Mitigation ratios reference: Washington State Department of Ecology, U.S. Army Corps of Engineers Seattle District, and U.S. Environmental Protection Agency Region 10. March 2006. Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance (Version 1). Washington State Department of Ecology Publication No. 06-06-011a. Olympia, WA

1. These ratios are based on the assumption that the rehabilitation or enhancement actions implemented represent the average degree of improvement possible for the site. Proposals to implement more effective rehabilitation or enhancement actions may result in a lower ratio, while less effective actions may result in a higher ratio. The distinction between rehabilitation and enhancement is not clear-cut. Instead, rehabilitation and enhancement actions span a continuum. Proposals that fall within the gray area between rehabilitation and enhancement will result in a ratio that lies between the ratios for rehabilitation and the ratios for enhancement.

WWMC	Section	Proposed Amendment	Category and Notes
		~~2. Wetlands of high conservation value, alkali wetland, and bogs are considered irreplaceable wetlands because they perform some functions that cannot be replaced through compensatory mitigation. Impacts to such wetlands would therefore result in a net loss of some functions no matter what kind of compensation is proposed.~~ **Credit/Debit Method. To more fully protect functions and values, and as an alternative to the mitigation ratios found in the joint guidance "Wetland Mitigation in Washington State Parts I and II," detailed in Table 5 in subsection B of this section (Ecology Publication No. 06-06-011a-b, Olympia, WA, March, 2006), the administrator may allow mitigation based on the "credit/debit" method developed by the Department of Ecology in "Calculating Credits and Debits for Compensatory Mitigation in Wetlands of Eastern Washington: Final Report" (Ecology Publication No. 11-06-015, August 2012, or as revised).** C. ~~Credit/Debit Method. To more fully protect functions and values, and as an alternative to the mitigation ratios found in the joint guidance "Wetland Mitigation in Washington State Parts I and II," detailed in Table 5 in subsection B of this section (Ecology Publication No. 06-06-011a-b, Olympia, WA, March, 2006), the administrator may allow mitigation based on the "credit/debit" method developed by the Department of Ecology in "Calculating Credits and Debits for Compensatory Mitigation in Wetlands of Eastern Washington: Final Report" (Ecology Publication No. 11-06-015, August 2012, or as revised).~~ **Buffers. Replacement wetlands established pursuant to these mitigation provisions shall have adequate buffers to ensure their protection and sustainability. The buffer shall be based on the category and land-use intensity in Section 21.04.340(C); provided that the director shall have the authority to approve a smaller buffer when existing site constraints (such as a road) prohibit attainment of the standard buffer.** D. ~~Buffers. Replacement wetlands established pursuant to these mitigation provisions shall have adequate buffers to ensure their protection and sustainability. The buffer shall be based on the category and land-use intensity in Section 21.04.340(C); provided, that the director shall have the authority to~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~approve a smaller buffer when existing site constraints (such as a road) prohibit attainment of the standard buffer.~~ **Mitigation Maintenance and Monitoring. Mitigation areas will be maintained and monitored for a minimum of five years or a period necessary to establish that performance standards have been met after the mitigation has been completed. Annual maintenance and monitoring reports will be submitted to the city and, where applicable, the Department of Ecology, and shall include:** **1. Descriptive data for vegetation, soils, and hydrology;** **2. Itemized list of dead, dying, and replaced vegetation;** **3. Quantitative assessment of invasive species;** **4. Descriptive photographs;** **5. Statement of overall success of mitigation;** **6. Schedule of activities for the next year of maintenance and monitoring.** ~~E.Mitigation Maintenance and Monitoring. Mitigation areas will be maintained and monitored for a minimum of five years or a period necessary to establish that performance standards have been met after the mitigation has been completed. Annual maintenance and monitoring reports will be submitted to the city and, where applicable, the Department of Ecology, and shall include:~~ ~~1. Descriptive data for vegetation, soils, and hydrology;~~ ~~2. Itemized list of dead, dying, and replaced vegetation;~~ ~~3. Quantitative assessment of invasive species;~~ ~~4. Descriptive photographs;~~ ~~5. Statement of overall success of mitigation;~~ ~~6. Schedule of activities for the next year of maintenance and monitoring.~~	
Chapter 21.04.348(B)(1) Critical Areas	Performance standards – Specific activities and uses.	The rationale for site selection**, documenting how the watershed approach was applied consistent with Ecology publication #10-06-007, Selecting Wetland Mitigation Sites Using a Watershed Approach (Eastern Washington), current or as revised**;	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
Chapter 21.04.400 Critical Areas	Mapping of frequently flooded areas.	~~21.04.400Mapping of frequently flooded areas.~~ ~~A. The approximate location and extent of frequently flooded areas are shown on the following adopted critical areas map: City of Walla Walla Critical Area Map 3: Frequently Flooded Areas. This map is based on data obtained from the Federal Emergency Management Agency Flood Insurance Rate Maps, December 1983, or as later revised.~~ ~~B. These maps are to be used as a guide for the city, project applicants, and/or property owners and may be continuously updated as new critical areas are identified. They are a reference and do not provide a final critical area designation.~~ ~~(Formerly 21.04.410; Ord. 2009-07 § 1 (part), 2009; Ord. 2015-12 § 1 (part), 2015)~~ **Frequently flooded areas - designation.** **Frequently flooded areas are designated in accordance with WAC 365-190-110. These areas include the 100-year floodplain designated by FEMA and the NFIP.**	State Mandated RCW 36.70A.172
Chapter 21.04.**410(A)** Critical Areas	**Mapping of frequently flooded areas.**	**The approximate location and extent of frequently flooded areas are shown in the Comprehensive Plan on the following adopted critical areas map: City of Walla Walla Critical Area Map: Frequently Flooded Areas. This map is based on data obtained from the Federal Emergency Management Agency Flood Insurance Rate Maps, December 1983, or as later revised.**	Clarification
Chapter 21.04.**420** Critical Areas	**Frequently flooded areas-regulation**	**Development in frequently flooded areas shall be subject to the provisions in WWMC Chapter 21.10 Floodplain Management.**	Clarification
Chapter 21.04.500(B)**(4),**(D) and (E) Critical Areas	Geologically hazardous areas – Designation	**(B)(4) The City may consult with the U.S. Department of Agriculture Natural Resources Conservation Service for data to help identify erosion hazard areas.** D. Seismic hazards shall be as identified in Washington State Department of Natural Resources seismic hazard and liquefaction susceptibility maps for	State Mandated RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		eastern Washington and other geologic resources**. Seismic hazard areas are prone to ground settlement or subsidence, soil liquefaction, and surface faulting.** E. Other Hazard Areas. Geologically hazardous areas shall also include areas determined by the director **to be** those areas subject to severe risk of damage as a result of other geological events**,** including mass wasting, debris flows, rock falls, **mine hazards,** and differential settlement.	
21.04.510	Mapping of geologically hazardous areas.	A. The approximate location and extent of geologically hazardous areas containing known or suspected risk are shown **in the Comprehensive Plan** on the following adopted critical areas maps: City of Walla Walla Critical Area Map ~~4~~: Geologic Hazard Areas, or the latest revision of this map. The hazard areas outlined on these maps are based on the following data:	Clarification
Chapter 21.04.600(A)(1)(b), (C) Critical Areas	Fish and wildlife habitat conservation areas – Designation.	(A)(1)(b) State designated endangered, threatened, and sensitive species are those fish, wildlife and plant species native to the state of Washington identified by the state Department of Fish and Wildlife that are in danger of extinction, threatened to become endangered, vulnerable, or declining and are likely to become endangered or threatened in a significant portion of their range within the state without cooperative management or removal of threats. State designated endangered, threatened, and sensitive species are periodically recorded in WAC 232-12-014 (state endangered species), and WAC 232-12-011 (state threatened and sensitive species). The **Washington** ~~s~~**S**tate Department of Fish and Wildlife maintains the most current listing **(Priority Habitats and Species List, WDFW 2023, current or as amended),** and should be consulted ~~as necessary~~ for current listing status. C. The following is identified as an area of local importance: hawk habitat identified on Critical Area Map ~~6~~ **in the Comprehensive Plan**.	Clarification
21.04.610 Critical Areas	Fish and wildlife habitat	The approximate location and extent of conservation areas are shown on the critical area maps adopted by the city **in the Comprehensive Plan** (Critical Area Map ~~5~~: Fish and Wildlife Habitat Conservation Areas, or **the** latest version of this	Clarification

WWMC	Section	Proposed Amendment	Category and Notes
	conservation areas – Mapping.	map), as most recently updated, and the following critical area maps hereby adopted:	
Chapter 21.04.620 (F)(1),(3) and (5) (G-K) Critical Areas	Fish and wildlife habitat conservation areas – Water bodies – Allowed uses.	F. Stream bank stabilization, ~~shoreline protection, and public or private launching ramps~~ may be permitted subject to all of the following standards: 1. Natural shoreline riparian processes will be maintained to the maximum extent practicable. The activity will not result in increased erosion and will not alter the size or distribution ~~of shoreline~~ or stream substrate, or eliminate or reduce sediment supply from feeder bluffs; 3. Nonstructural measures, such as placing or relocating the development further from the ~~shoreline~~ **stream,** planting vegetation, or installing on-site drainage improvements, are not feasible or not sufficient; 5. Hard bank armoring may occur only when the property contains an existing permanent structure(s) that is in danger from ~~shoreline~~ erosion caused by riverine processes and not erosion caused by upland conditions, such as the alteration of natural vegetation or drainage, and the armoring shall not increase erosion on adjacent properties and shall not eliminate or reduce sediment supply. G. New public flood protection measures and expansion of existing measures may be permitted; provided, that bioengineering or soft armoring techniques shall be used where feasible. Hard bank armoring may occur only in situations where soft approaches do not provide adequate protection, and shall be subject to requirements of the ~~shoreline master program, where applicable,~~ hydraulic project approval and other permits. H. **In-stream structures, such as, but not limited to, high flow bypasses, dams, and weirs, other than those regulated exclusively by the Federal Energy Regulatory Commission (FERC) shall be permitted only when multiple public benefits are provided, and ecological impacts are fully mitigated.** ~~New docks shall be permitted only for public access, as an accessory to water-dependent uses or associated with a single-family residence:~~	Clarification

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		1. **In-stream facility locations shall avoid areas of high habitat value for aquatic organisms, specifically anadromous fish.** ~~To limit the effects on ecological functions, the number of docks should be limited and new subdivisions should employ shared moorage whenever feasible. Docks on shorelines of the state must comply with policies and regulations of the city of Walla Walla shoreline master program.~~ 2. **In-stream facilities shall be designed to produce the least feasible effect on fluvial processes and shall minimize change in gradient.** ~~Docks shall be located and designed to minimize adverse effects on ecological processes through location where they will not interfere with fluvial and limnal processes including gradient and substrate; recruitment of woody debris; and fish habitat, including that related to anadromous fish.~~ 3. **In-stream facilities shall provide mitigation of all impacts on aquatic species and habitat.** ~~Docks shall minimize reduction in ambient light level by limiting width to the minimum necessary and shall not exceed four feet in width, except where specific information on use patterns justifies a greater width. Materials that will allow light to pass through the deck may be required, including grating on walkways or gangplanks in nearshore areas.~~ 4. **In-stream facilities shall provide fish passage, in accordance with Chapter 77.57 RCW.** ~~Approaches shall utilize piers or other structures to span the entire upper foreshore to the point of intersection with stable upland soils and shall be designed to avoid interfering with stream processes.~~ 5. **A construction bond for one hundred fifty percent of the cost of the structure and all mitigation measures shall be filed before construction. A maintenance agreement shall specify responsibility for maintenance, a maintenance schedule as determined by the design engineer, annual inspections by a civil engineer licensed in the State of Washington, and abandonment procedures including, where appropriate, provisions for site restoration.** ~~Pile spacing shall be the maximum feasible to minimize shading~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~and avoid a wall effect that would block or baffle currents, sediment movement or movement of aquatic life forms, or result in structure damage from driftwood impact or entrapment.~~ ~~6. Docks should be constructed of materials that will not adversely affect water quality or aquatic plants and animals in the long term.~~ l. ~~In-stream structures, such as, but not limited to, high flow bypasses, dams, and weirs, other than those regulated exclusively by the Federal Energy Regulatory Commission (FERC) shall be permitted only when the multiple public benefits are provided and ecological impacts are fully mitigated. Dams on shorelines of the state shall be regulated in accordance with the shoreline master program.~~ **Clearing and grading, when allowed as part of an authorized use or activity or as otherwise allowed in these standards, may be permitted; provided that the following shall apply:** 1. ~~In-stream facility locations shall avoid areas of high habitat value for aquatic organisms, specifically anadromous fish.~~ **Appropriate erosion and sediment control measures shall be used at all times. The soil duff layer shall remain undisturbed to the maximum extent possible.** 2. ~~In-stream facilities shall be designed to produce the least feasible effect on fluvial processes and shall minimize change in gradient.~~ **The moisture-holding capacity of the topsoil layer shall be maintained by minimizing soil compaction or reestablishing natural soil structure and infiltrative capacity on all areas of the project area not covered by impervious surfaces.** ~~3. In-stream facilities shall provide mitigation of all impacts on aquatic species and habitat.~~ ~~4. In-stream facilities shall provide fish passage, in accordance with Chapter 77.57 RCW.~~ ~~5. A construction bond for one hundred fifty percent of the cost of the structure and all mitigation measures shall be filed prior to construction and a maintenance agreement shall specify responsibility for maintenance, shall incorporate the maintenance schedule specified by the design engineer, shall require annual inspections by a civil engineer licensed in the state of~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~Washington and shall stipulate abandonment procedures which shall include, where appropriate, provisions for site restoration.~~ J.~~ Facilities permitted as shoreline-dependent or shoreline-oriented uses in accordance with the city shoreline master program may be located in water bodies and buffers; provided, that only those facilities that are water-dependent or water-oriented and facilities for necessary access may be located in water bodies and buffers; and provided, that the facility is located, designed, constructed and operated to minimize and, where possible, avoid critical area disturbance to the maximum extent feasible.~~ **Repairs to Existing On-Site Sewage Systems. Repairs to failing on-site sewage systems associated with an existing structure shall be accomplished by utilizing one of the following methods that results in the least impact:** **1. Connection to an available public sanitary sewer system;** **2. Replacement with a new on-site sewage system located in a portion of the site that has already been disturbed by development and is located landward as far as possible, provided the proposed sewage system is in compliance with the City of Walla Walla; or** **3. Repair to the existing on-site septic system.** ~~K. Clearing and grading, when allowed as part of an authorized use or activity or as otherwise allowed in these standards, may be permitted; provided, that the following shall apply:~~ ~~1. Appropriate erosion and sediment control measures shall be used at all times. The soil duff layer shall remain undisturbed to the maximum extent possible.~~ ~~2. The moisture-holding capacity of the topsoil layer shall be maintained by minimizing soil compaction or reestablishing natural soil structure and infiltrative capacity on all areas of the project area not covered by impervious surfaces.~~ ~~L. Repairs to Existing On-Site Sewage Systems. Repairs to failing on-site sewage systems associated with an existing structure shall be accomplished by utilizing one of the following methods that results in the least impact:~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~1. Connection to an available public sanitary sewer system;~~ ~~2. Replacement with a new on-site sewage system located in a portion of the site that has already been disturbed by development and is located landward as far as possible, provided the proposed sewage system is in compliance with city of Walla Walla environmental health department; or~~ ~~3. Repair to the existing on-site septic system.~~	
Chapter 21.04.630(B)(2) Critical Areas	Critical area report – Additional requirements for habitat conservation areas.	All habitat conservation areas and recommended buffers within two hundred **fifty** feet of the project area **or the extents of existing urban land use that functionally disconnect the site from habitat conservation areas;** and	State Mandated RCW 36.70A.172
Chapter 21.04.640(G)(3)(c) and (H)(3)(b) Critical Areas	Performance standards – General requirements.	(B)(2) Provide for a monitoring and maintenance plan for a period of at least five years, ~~except this provision may be waived for single-family residential lots~~. (H)(3)(b) The applicant shall be required to install a permanent **wildlife passable** fence around the habitat conservation area or buffer when domestic grazing animals are present or may be introduced on site.	State Mandated RCW 36.70A.172 and WDFW Comment
Chapter 21.04.650(A)(1)(a), (B)(C)(D)(2, 3,4) and 5)(a)(iii-**viii**), (6),(E) and (F) Critical Areas	Performance standards – Specific habitats.	**(A)(1)(a) WDFW-mapped species within the City include, but are not limited to, Bull trout, Chinook salmon, Steelhead, and Ferruginous hawk.** B. ~~Wetland Habitats. All proposed activities within or adjacent to habitat conservation areas containing wetlands shall, at a minimum, conform to the wetland development performance standards set forth in Section 21.04.300, in addition to meeting the habitat conservation area standards in this chapter.~~ **Priority Habitats and Species (PHS). Habitats and species on the Department of Fish and Wildlife PHS List** **1. PHS mapped by the Department of Fish and Wildlife within the City includes but is not limited to shrubsteppe.** **2. Whenever activities are proposed adjacent to a habitat conservation area**	State Mandated and Clarification RCW 36.70A.172

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		with which a priority habitat or species has a primary association, such area shall be protected through the application of best management practices provided by the Department of Fish and Wildlife and documented in a critical area report prepared by a qualified professional and submitted to the City. Approval for alteration of land adjacent to the habitat conservation area or its buffer may also require consultation with the Department of Fish and Wildlife and the appropriate federal agency, if applicable. C. ~~Riparian Habitat Areas. Unless otherwise allowed in this chapter, all structures and activities shall be located outside of the riparian habitat buffers.~~ **Wetland Habitats. All proposed activities within or adjacent to habitat conservation areas containing wetlands shall, at a minimum, conform to the wetland development performance standards set forth in Section 21.04.300, in addition to meeting the habitat conservation area standards in this chapter.** 1~~,Establishment of Riparian Habitat Buffers. Buffers shall be established for habitats that include aquatic systems.~~ ~~2. Standard Buffer Widths.~~ ~~a. A riparian habitat shall have at least the buffer width recommended in Table 6, unless a greater width is required pursuant to subsection (C)(4) of this section, or a lesser width is allowed pursuant to subsection (C)(6) of this section.~~ ~~b.Widths shall be measured outward, on the horizontal plane, from the ordinary high water mark or from the top of bank if the ordinary high water mark cannot be identified.~~ ~~c. The required buffer shall be extended to include any adjacent regulated wetland(s), landslide hazard areas and/or erosion hazard areas and required buffers, but shall not be extended across roads or other lawfully established structures or hardened surfaces that are functionally and effectively disconnected from the stream.~~ ~~3. Buffers in Conjunction with Other Critical Areas. Where other critical areas defined in this chapter fall within the water body buffer, the buffer area shall be~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~the most expansive of the buffers applicable to any applicable critical area.~~ D. ~~Anadromous Fish~~. **Riparian Habitat Areas. Unless otherwise allowed in this chapter, all structures and activities shall be located outside of the riparian habitat buffers.** 1. ~~All activities, uses, and alterations proposed to be located in water bodies used by anadromous fish or in areas that affect such water bodies shall give special consideration to the preservation and enhancement of anadromous fish habitat, including, but not limited to, adhering to the following standards:~~ ~~a. Activities shall be timed to occur only during the allowable work window as designated by the Washington Department of Fish and Wildlife for the applicable species;~~ ~~b. An alternative alignment or location for the activity is not feasible;~~ ~~c. The activity is designed so that it will not degrade the functions or values of the fish habitat or other critical areas;~~ ~~d. Shoreline erosion control measures shall be designed to use bioengineering methods or soft armoring techniques, according to an approved critical area report; and~~ ~~e. Any impacts to the functions or values of the habitat conservation area are mitigated in accordance with an approved critical area report.~~ **Establishment of Riparian Habitat Buffers. Buffers shall be established for habitats that include aquatic systems.** 2. ~~Structures that prevent the migration of salmonids shall not be allowed in the portion of water bodies currently or historically used by anadromous fish. Fish bypass facilities shall be provided that allow the upstream migration of adult fish and shall prevent fry and juveniles migrating downstream from being trapped or harmed.~~ **Standard Buffer Widths.** **a. A riparian habitat shall have at least the buffer width recommended in Table 6, unless a greater width is required pursuant to subsection (D)(4) of this section.** **b. Buffer measurements: Widths shall be measured outward, on the horizontal plane, from the ordinary high-water mark or from the top of bank**	

DRAFT

<table>
<tr><th>WWMC</th><th>Section</th><th>Proposed Amendment</th><th>Category and Notes</th></tr>
<tr><td></td><td></td><td>
if the ordinary high-water mark cannot be identified or the channel migration zone, whichever is greater.
i. Where a stream exits a culvert, the open stream buffer width shall be measured perpendicular to the culvert opening.
c. Functionally disconnected buffers: Where impervious surfaces or other lawfully established structures functionally and effectively disconnect the riparian buffer from the stream, the Department director may approve a complete or partial buffer modification of the standard width to exclude non-functional areas.
3.<s>Fills, when authorized by the locally adopted shoreline management program, shall not adversely impact anadromous fish or their habitat or shall mitigate any unavoidable impacts and shall only be allowed for a water-dependent use.</s> Buffers in Conjunction with Other Critical Areas. Where other critical areas defined in this chapter fall within the water body buffer, the buffer area shall be the most expansive of the buffers applicable to any applicable critical area.
<table>
<tr><th colspan="3">Table 6: Minimum Riparian Buffer Widths for Watercourses within the City of Walla Walla</th></tr>
<tr><th>River</th><th>Minimum Riparian Buffer Width (per side)[1]</th><th>Other Measures Recommended for Protection</th></tr>
<tr><td>Mill Creek</td><td>See SMP</td><td>See SMP</td></tr>
<tr><td>Creeks: Yellowhawk, Russell, Reser, Caldwell, Stone, Garrison, Bryant, Titus, and others within</td><td>100 Feet</td><td>No additional surface discharges of untreated runoff, restore degraded parts of the buffer, and maintain</td></tr>
</table>
</td><td></td></tr>
</table>

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes

city limits/UGA including intermittent open channels between piped sections.		**connections to other habitat areas.**

Notes: 1. In stream segments where the **Conservation Reserve Enhancement Program** (CREP) buffers are established, CREP buffers become the minimum streamside buffer width

~~Table 6: Recommended Minimum Riparian Buffer Widths for Waterways within the City of Walla Walla~~

~~Waterway Category~~	~~River Reach Included~~	~~Existing Conditions/Targeted Functions~~	~~Minimum Streamside Buffer Width (per side)[4]~~
~~6a~~	~~Mill Creek from Gose Street to Bennington Lake dam diversion~~	~~-Flood channel -No riparian vegetation allowed within the channel -Trees outside the concrete channel section with potential to shade the channel should remain~~	~~35 feet – See SMP~~
~~6b~~	~~Yellowhawk Creek – Russell Creek to Mill Creek~~	~~-Summer steelhead migration, limited rearing habitat and/or EDT priority protection reach -LWD recruitment -Shade -Existing riparian average = 31 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~50 feet~~
	~~Russell Creek – Dipping Road to Yellowhawk~~	~~-Influence on downstream habitat -Existing riparian average = 21 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~
	~~Reser Creek – Wilbur Avenue to Russell Creek~~	~~-Influence on downstream habitat -Existing riparian average = 23 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~

WWMC	Section	Proposed Amendment				Category and Notes
			~~Caldwell Creek – Headwaters to Yellowhawk~~	~~-Influence on downstream habitat -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
		~~6b~~	~~Stone Creek – Headwaters to Teal Street~~	~~-Influence on downstream habitat -Existing riparian average = 20 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
			~~Garrison Creek – Yellowhawk to Lions Park (excluding wetland)~~	~~-Influence on downstream habitat -Existing riparian average = 24 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff -Wildlife habitat~~	~~35 feet~~	
			~~Bryant Creek – Sprague Avenue to Fort Walla Walla Park~~	~~-Influence on downstream habitat -Existing riparian average = 14 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
			~~Titus Creek – Blackberry Lane to Mill Creek by community college~~	~~-Influence on downstream habitat -Existing riparian average = 25 ft -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
			~~All other creeks within city limits/UGA – Intermittent open channels with piped sections~~	~~-Influence on downstream habitat -Meet CREP minimum -Control sediment, nutrients, and stormwater runoff~~	~~35 feet~~	
		(5)(iv). ~~The total area of the buffer after averaging is equal to the area required without averaging and all increases in buffer dimension for averaging are generally parallel to the wetland edge;~~ **Stormwater**				

WWMC	Section	Proposed Amendment	Category and Notes
		management applies the City of Walla Walla Stormater Design Standards Handbook, current or as amended, as necessary to maintain water quality; v. ~~The buffer at its narrowest point is never less than seventy-five percent of the standard buffer width;~~ **The total area of the buffer after averaging is equal to the area required without averaging and all increases in buffer dimension for averaging are generally parallel to the wetland edge;** vi. ~~The slopes adjacent to the stream within the buffer area are stable and the gradient does not exceed thirty percent.~~ **The buffer at its narrowest point is never less than seventy-five percent of the standard buffer width;** **vii. The slopes adjacent to the stream within the buffer area are stable; and the gradient does not exceed thirty percent.** **viii. The averaged buffer line is recorded in a notice on title consistent with WWMC 21.04.125.** ~~6. Decreased Buffer Widths. The director shall have the authority to reduce buffer widths on a case-by-case basis; provided, that the general standards for avoidance and minimization per Sections 21.04.110(A) and (B) shall apply, and when the applicant demonstrates to the satisfaction of the director that all of the following criteria are met:~~ ~~a. The buffer reduction shall not adversely affect the habitat functions and values of the adjacent habitat conservation area or other critical area.~~ ~~b. The slopes adjacent to the habitat conservation area within the buffer area are stable and the gradient does not exceed thirty percent.~~ ~~c. The buffer shall not be reduced to less than seventy-five percent of the standard buffer as defined in this section. A thirty-five-foot buffer cannot be decreased. Table 7 identifies potential buffer reductions with accompanying riparian habitat enhancement (see subsection D of this section).~~	

WWMC	Section	Proposed Amendment	Category and Notes

~~Table 7: Modified Buffer Widths with Approved Habitat Enhancement/Water Quality Treatment~~

~~No Habitat Enhancement~~	~~Modified Buffer Width with Approved Enhancement/Treatment~~
~~100'~~	~~75'~~
~~75'~~	~~56'~~
~~50'~~	~~38'~~
~~35'~~	~~35'~~

~~d. Habitat enhancement plans prepared by a qualified professional must be provided to the city identifying existing conditions, and how the enhancement plan will improve riparian functions over existing conditions. A five-year monitoring plan must be included. The plan must also address how land outside a reduced buffer would protect surface water quality. Habitat enhancement plans must be consistent with riparian native vegetation planting guides developed by the city of Walla Walla conservation district, as provided in Table 8.~~

~~Table 8: Walla Walla County Conservation District Suggested Native Plants by Precipitation and Riparian Zone~~

~~County Area~~	~~Zone #1 – Generally 0' – 35'~~	~~Zone #2 – Generally 35' – 75'~~	~~Zone #3 – Generally 75' and greater~~
~~Central Walla Walla County: Lowden-Walla Walla 10" – 15" precipitation zone~~	~~Black Cottonwood – moist soils, silts, slightly alkaline soils (5' – 20' from shoreline)~~ ~~Water Birch – moist soils, silts, pH neutral soils (3' – 12' off shoreline)~~	~~Black Hawthorn – pH neutral to slightly alkaline silts and soils (25' – 40' off shoreline)~~ ~~Ponderosa Pine – well drained soils, dry sites (25' – 50' from shoreline)~~	~~Smooth Sumac – well drained soils, silts and loess, pH neutral to slightly alkaline (25' – 100' off shoreline)~~ ~~Buffalo Berry – well drained soils, slightly alkaline (25'~~

WWMC	Section	Proposed Amendment				Category and Notes
			~~Thin-leaf Alder – moist soils, pH neutral to slightly acidic silts and loess (3' – 15' off shoreline)~~ ~~White Alder – moist soils, pH neutral to slightly acidic silts, cobble (1' – 15' off shoreline)~~ ~~Coyote Willow – moist soils, pH neutral silts and clays (3' – 15' off shoreline)~~ ~~Peach-leaf Willow – moist soils, pH neutral to slightly alkaline (5' – 25' off the shoreline)~~ ~~Red-osier Dogwood – moist to well drained soils, pH neutral to slightly alkaline (2' – 25' off the shoreline)~~ ~~Antelope-brush (Bitterbrush) – well drained soils, pH~~	~~Mock-orange – well drained soils, slightly acidic (15' – 35' off shoreline)~~ ~~Chokecherry – moist-dry well drained soils, pH neutral to slightly acidic soils (5' – 25' off shoreline)~~ ~~Peach-leaf Willow – moist soils, pH neutral to slightly alkaline (5' – 25' off the shoreline)~~ ~~Smooth Sumac – well drained soils, silts and loess, pH neutral to slightly alkaline (25' – 100' off shoreline)~~ ~~Blue Elderberry – well drained soils, pH neutral to slightly alkaline (15' – 50' off the shoreline)~~ ~~Buffalo Berry – well drained soils, slightly alkaline (25'~~	~~– 100'+ off the shoreline)~~ ~~Antelope-brush (Bitterbrush) – well drained soils, pH neutral to slightly acidic~~	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		~~neutral to slightly acidic~~ ~~= 100'+ off the shoreline)~~ ~~Antelope-brush (Bitterbrush) – well drained soils, pH neutral to slightly acidic~~ E. ~~Wetland Habitats. All proposed activities within or adjacent to habitat conservation areas containing wetlands shall conform to the wetland development performance standards set forth in Sections 21.04.300 through 21.04.350. If nonwetlands habitat and wetlands are present at the same location, the provisions of Sections 21.04.600 through 21.04.674 or Sections 21.04.300 through 21.04.350, whichever provide greater protection to the habitat, apply~~. **Anadromous Fish.** **1. All activities, uses, and alterations proposed to be located in water bodies used by anadromous fish or in areas that affect such water bodies shall give special consideration to the preservation and enhancement of anadromous fish habitat, including, but not limited to, adhering to the following standards:** **a. Activities shall be timed to occur only during the allowable work window as designated by the Washington Department of Fish and Wildlife for the applicable species;** **b. An alternative alignment or location for the activity is not feasible;** **c. The activity is designed so that it will not degrade the functions or values of the fish habitat or other critical areas;** **d. Shoreline erosion control measures shall be designed to use bioengineering methods or soft armoring techniques, according to an approved critical area report; and** **e. Any impacts to the functions or values of the habitat conservation area are mitigated in accordance with an approved critical area report.**	

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
		2. Structures that prevent the migration of salmonids shall not be allowed in the portion of water bodies currently or historically used by anadromous fish. Fish bypass facilities shall be provided that allow the upstream migration of adult fish and shall prevent fry and juveniles migrating downstream from being trapped or harmed. **3. Fills, when authorized by the locally adopted shoreline management program, shall not adversely impact anadromous fish or their habitat or shall mitigate any unavoidable impacts and shall only be allowed for a water-dependent use.** **F. Wetland Habitats. All proposed activities within or adjacent to habitat conservation areas containing wetlands shall conform to the wetland development performance standards set forth in** **Sections 21.04.300 through 21.04.350. If non-wetlands habitat and wetlands are present at the same location, the provisions of** **Sections 21.04.600 through 21.04.674 or** **Sections 21.04.300 through 21.04.350, whichever provide greater protection to the habitat, apply.**	
Chapter 21.04.660**(D)** Critical Areas	Performance standards – Subdivisions.	**Development projects must be located to preserve or achieve contiguous wildlife habitat corridors to minimize the isolating effects of development on habitat areas.**	State Mandated RCW 36.70A.172
Chapter 21.04.670(**C)** Critical Areas	Fish and wildlife habitat conservation areas – Piped streams.	**Daylighting. Opening up piped stream segments to restore a more natural condition with riparian functions means removing a stream from a culvert through a critical areas report (WWMC 21.04.095) and stream daylighting plan. Buffer widths for daylit stream segments will be determined on a case-by-case basis based on a site-specific analysis of water quality, riparian functions, and overall improvements to ecological functions.**	State Mandated RCW 36.70A.172
Chapter 21.04.700 Critical Areas	Landfill vicinity	~~All enclosed structures, requiring a building permit, within one thousand feet of a sanitary landfill or former landfill site/parcel must be protected from potential landfill gas migration. The method for ensuring a structure's protection from~~	Clarification Moved

DRAFT

WWMC	Section	Proposed Amendment	Category and Notes
	development standards.	~~landfill gas shall be addressed in a report submitted by a licensed professional engineer, at the cost of the developer, to the city of Walla Walla for review. The report shall contain a description of the investigation and recommendation(s) for preventing the accumulation of explosive concentrations of landfill gas within or under enclosed portions of the proposed building or structure. Any changes to the design shall be documented in writing and stamped by the landfill gas design engineer and the contractor shall provide as-built drawings to the city documenting the changes.~~	

DRAFT

SEPA[1] Environmental Checklist

Purpose of checklist

Governmental agencies use this checklist to help determine whether the environmental impacts of your proposal are significant. This information is also helpful to determine if available avoidance, minimization, or compensatory mitigation measures will address the probable significant impacts or if an environmental impact statement will be prepared to further analyze the proposal.

Instructions for applicants

This environmental checklist asks you to describe some basic information about your proposal. Please answer each question accurately and carefully, to the best of your knowledge. You may need to consult with an agency specialist or private consultant for some questions. **You may use "not applicable" or "does not apply" only when you can explain why it does not apply and not when the answer is unknown.** You may also attach or incorporate by reference additional studies reports. Complete and accurate answers to these questions often avoid delays with the SEPA process as well as later in the decision-making process.

The checklist questions apply to **all parts of your proposal**, even if you plan to do them over a period of time or on different parcels of land. Attach any additional information that will help describe your proposal or its environmental effects. The agency to which you submit this checklist may ask you to explain your answers or provide additional information reasonably related to determining if there may be significant adverse impact.

Instructions for lead agencies

Please adjust the format of this template as needed. Additional information may be necessary to evaluate the existing environment, all interrelated aspects of the proposal and an analysis of adverse impacts. The checklist is considered the first but not necessarily the only source of information needed to make an adequate threshold determination. Once a threshold determination is made, the lead agency is responsible for the completeness and accuracy of the checklist and other supporting documents.

Use of checklist for nonproject proposals

For nonproject proposals (such as ordinances, regulations, plans and programs), complete the applicable parts of sections A and B, plus the Supplemental Sheet for Nonproject Actions (Part D). Please completely answer all questions that apply and note that the words "project," "applicant," and "property or site" should be read as "proposal," "proponent," and "affected geographic area," respectively. The lead agency may exclude (for non-projects) questions in "Part B: Environmental Elements" that do not contribute meaningfully to the analysis of the proposal.

[1] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/Checklist-guidance

A. Background

Find help answering background questions[2]

1. **Name of proposed project, if applicable:**
   Critical Area Ordinance (CAO) code amendments
2. **Name of applicant:**
   City of Walla Walla c/o Jon Maland, Senior Planner
3. **Address and phone number of applicant and contact person:**
   15 North 3rd Avenue, Walla Walla, WA 99362. (509) 524-4710
4. **Date checklist prepared:**
   06/29/2026
5. **Agency requesting checklist:**
   City of Walla Walla
6. **Proposed timing of schedule (including phasing, if applicable):**
   To be determined; adoption tentatively scheduled for October/ November 2026
7. **Do you have any plans for future additions, expansion, or further activity related to or connected with this proposal? If yes, explain.**
   No - non-project action. Any future projects that result from this code change will be evaluated under SEPA guidelines at that time, as appropriate.
8. **List any environmental information you know about that has been prepared, or will be prepared, directly related to this proposal.**
   The 2018 Walla Walla Comprehensive Plan, and Final Environmental Impact Statement, issued May 22, 2018.
9. **Do you know whether applications are pending for governmental approvals of other proposals directly affecting the property covered by your proposal? If yes, explain.**
   No specific property or parcel is covered by this non-project/ non-site-specific action.
10. **List any government approvals or permits that will be needed for your proposal, if known.**
    Washington State Department of Commerce review for code changes is required.
11. **Give brief, complete description of your proposal, including the proposed uses and the size of the project and site. There are several questions later in this checklist that ask you to describe certain aspects of your proposal. You do not need to repeat those answers on this page. (Lead agencies may modify this form to include additional specific information on project description.)**
    Critical Area Ordinance (CAO) code amendments
12. **Location of the proposal. Give sufficient information for a person to understand the precise location of your proposed project, including a street address, if any, and section,**

[2]

township, and range, if known. If a proposal would occur over a range of area, provide the range or boundaries of the site(s). Provide a legal description, site plan, vicinity map, and topographic map, if reasonably available. While you should submit any plans required by the agency, you are not required to duplicate maps or detailed plans submitted with any permit applications related to this checklist.

No specific site - city wide.

B. Environmental Elements

1. Earth

Find help answering earth questions[3]

a. General description of the site:

The Municipal Code amendments/update is not site specific.

Circle or highlight one: Flat, rolling, hilly, steep slopes, mountainous, other:

The City of Walla Walla is generally flat with a gradual slope that is higher in the east and lower in the west portions of the city.

b. What is the steepest slope on the site (approximate percent slope)?

Non-Project action. Review of potential steep slopes will be conducted on a site-by-site basis at the time of development proposal.

c. What general types of soils are found on the site (for example, clay, sand, gravel, peat, muck)? If you know the classification of agricultural soils, specify them, and note any agricultural land of long-term commercial significance and whether the proposal results in removing any of these soils.

Walla Walla largely has Yakima series soils, loams that are well drained.

d. Are there surface indications or history of unstable soils in the immediate vicinity? If so, describe.

Walla Walla generally has a high to moderate liquefaction potential.

e. Describe the purpose, type, total area, and approximate quantities and total affected area of any filling, excavation, and grading proposed. Indicate source of fill.

N/A non-project action. Review of potential filling, excavation, and grading will occur at permit submittal.

f. Could erosion occur because of clearing, construction, or use? If so, generally describe.

N/A non-project action - not specific to one parcel.

g. About what percent of the site will be covered with impervious surfaces after project construction (for example, asphalt or buildings)?

N/A - non-project action - not specific to one parcel.

[3] https://ecology.wa.gov/regulations-permits/sepa/environmental-review/sepa-guidance/sepa-checklist-guidance/sepa-checklist-section-b-environmental-elements/environmental-elements-earth

h. Proposed measures to reduce or control erosion, or other impacts to the earth, if any.

N/A - non project action.

2. Air

Find help answering air questions[4]

a. What types of emissions to the air would result from the proposal during construction, operation, and maintenance when the project is completed? If any, generally describe and give approximate quantities if known.

N/A - non project/ non site-specific action.

b. Are there any off-site sources of emissions or odor that may affect your proposal? If so, generally describe.

N/A - non project/ non site-specific action.

c. Proposed measures to reduce or control emissions or other impacts to air, if any:

N/A - non project/ non site-specific action.

3. Water

Find help answering water questions[5]

a. Surface:

Find help answering surface water questions[6]

1. **Is there any surface water body on or in the immediate vicinity of the site (including year-round and seasonal streams, saltwater, lakes, ponds, wetlands)? If yes, describe type and provide names. If appropriate, state what stream or river it flows into.**

   Walla Walla has many year-round streams throughout the city, including Mill Creek, Yellowhawk Creek, Stone Creek, Garrison Creek, and others.

2. **Will the project require any work over, in, or adjacent to (within 200 feet) the described waters? If yes, please describe and attach available plans.**

   No - non-site-specific action.

3. **Estimate the amount of fill and dredge material that would be placed in or removed from surface water or wetlands and indicate the area of the site that would be affected. Indicate the source of fill material.**

   N/A, Any fill or dredge would be subject to project specific review.

[4] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-Air
[5] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-3-Water
[6] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-3-Water/Environmental-elements-Surface-water

4. **Will the proposal require surface water withdrawals or diversions? Give a general description, purpose, and approximate quantities if known.**

   No - non project action.

5. **Does the proposal lie within a 100-year floodplain? If so, note location on the site plan.**

   Some portions of the southern end of Walla Walla are within a 100-year floodplain for Russell Creek.

6. **Does the proposal involve any discharges of waste materials to surface waters? If so, describe the type of waste and anticipated volume of discharge.**

   No - non project action.

b. Ground:

Find help answering ground water questions[7]

1. **Will groundwater be withdrawn from a well for drinking water or other purposes? If so, give a general description of the well, proposed uses and approximate quantities withdrawn from the well. Will water be discharged to groundwater? Give a general description, purpose, and approximate quantities if known.**

   No – non-project action. Any water used within the city for any projects that might stem from this code update would use City Water, not wells.

2. **Describe waste material that will be discharged into the ground from septic tanks or other sources, if any (domestic sewage; industrial, containing the following chemicals…; agricultural; etc.). Describe the general size of the system, the number of such systems, the number of houses to be served (if applicable), or the number of animals or humans the system(s) are expected to serve.**

   None, non-project action. Any waste material that would be a result of any project from this code change would be required to use the City's municipal wastewater system.

c. Water Runoff (including stormwater):

1. **Describe the source of runoff (including storm water) and method of collection and disposal, if any (include quantities, if known). Where will this water flow? Will this water flow into other waters? If so, describe.**

   Not applicable - non-project action.

2. **Could waste materials enter ground or surface waters? If so, generally describe.**

   No – non-project action.

3. **Does the proposal alter or otherwise affect drainage patterns in the vicinity of the site? If so, describe.**

   No. Any projects that might result from the code change would be required to handle their own stormwater impacts on the site.

[7] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-3-Water/Environmental-elements-Groundwater

d. **Proposed measures to reduce or control surface, ground, and runoff water, and drainage pattern impacts, if any:**

Any project resulting from the code change would be subject to the City of Walla Walla stormwater code and the Eastern Washington Stormwater Manual.

4. Plants

Find help answering plants questions

a. **Check the types of vegetation found on the site:** Non-site specific action

- ☐ **deciduous tree: alder, maple, aspen, other**
- ☐ **evergreen tree: fir, cedar, pine, other**
- ☐ **shrubs**
- ☐ **grass**
- ☐ **pasture**
- ☐ **crop or grain**
- ☐ **orchards, vineyards, or other permanent crops.**
- ☐ **wet soil plants: cattail, buttercup, bullrush, skunk cabbage, other**
- ☐ **water plants: water lily, eelgrass, milfoil, other**
- ☐ **other types of vegetation**

b. **What kind and amount of vegetation will be removed or altered?**

None, non-project action

c. **List threatened and endangered species known to be on or near the site.**

Not applicable - non project action

d. **Proposed landscaping, use of native plants, or other measures to preserve or enhance vegetation on the site, if any.**

Not applicable - non project action

e. **List all noxious weeds and invasive species known to be on or near the site.**

Not applicable - non project action

5. Animals

Find help answering animal questions[8]

a. **List any birds and other animals that have been observed on or near the site or are known to be on or near the site.**

Examples include:

[8] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-5-Animals

Non-site specific action/ project

- **Birds: hawk, heron, eagle, songbirds, other:**
- **Mammals: deer, bear, elk, beaver, other:**
- **Fish: bass, salmon, trout, herring, shellfish, other:**

b. List any threatened and endangered species known to be on or near the site.

Bull trout, steelhead

c. Is the site part of a migration route? If so, explain.

Pacific Flyway- nesting and migratory bird route

d. Proposed measures to preserve or enhance wildlife, if any.

The amendments to the CAO, should help protect wildlife habitat in the city.

e. List any invasive animal species known to be on or near the site.

Not applicable - non project action

6. Energy and natural resources

Find help answering energy and natural resource questions[9]

a. What kinds of energy (electric, natural gas, oil, wood stove, solar) will be used to meet the completed project's energy needs? Describe whether it will be used for heating, manufacturing, etc.

None, non-project action

b. Would your project affect the potential use of solar energy by adjacent properties? If so, generally describe.

No, non-project action

c. What kinds of energy conservation features are included in the plans of this proposal? List other proposed measures to reduce or control energy impacts, if any.

None, non-project action. Any project resulting will need to abide by Washington State Energy Code requirements.

7. Environmental health

Health Find help with answering environmental health questions[10]

a. Are there any environmental health hazards, including exposure to toxic chemicals, risk of fire and explosion, spill, or hazardous waste, that could occur because of this proposal? If so, describe.

No, non-project action.

[9] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-6-Energy-natural-resou

[10] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-7-Environmental-health

1. **Describe any known or possible contamination at the site from present or past uses.**
   None - non site-specific action. Some sites in Walla Walla remain contaminated from past uses (former gas station sites, landfill, etc).
2. **Describe existing hazardous chemicals/conditions that might affect project development and design. This includes underground hazardous liquid and gas transmission pipelines located within the project area and in the vicinity.**
   Natural gas pipelines run through Walla Walla. All ground-disturbing projects are required to call before digging to ensure no impact.
3. **Describe any toxic or hazardous chemicals that might be stored, used, or produced during the project's development or construction, or at any time during the operating life of the project.**
   Not applicable - non project action.
4. **Describe special emergency services that might be required.**
   None, non-project action.
5. **Proposed measures to reduce or control environmental health hazards, if any.**
   N/A, non-project action. Any potential future project would be subject to SEPA unless categorically exempt.

b. Noise

1. **What types of noise exist in the area which may affect your project (for example: traffic, equipment, operation, other)?**
   General traffic noise throughout Walla Walla, in northern portions of the city, some aircraft noise from Walla Walla Regional Airport flights.
2. **What types and levels of noise would be created by or associated with the project on a short-term or a long-term basis (for example: traffic, construction, operation, other)? Indicate what hours noise would come from the site)?**
   None, non-project action
3. **Proposed measures to reduce or control noise impacts, if any:**
   Not applicable, non-project action. The CAO seeks to protect critical areas.

8. Land and shoreline use

Find help answering land and shoreline use questions[11]

a. **What is the current use of the site and adjacent properties? Will the proposal affect current land uses on nearby or adjacent properties? If so, describe.**
   Land use depends on the specific site, this is a non-site specific action.

b. **Has the project site been used as working farmlands or working forest lands? If so, describe. How much agricultural or forest land of long-term commercial significance will be converted to other uses because of the proposal, if any? If resource lands have**

[11] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-8-Land-shoreline-use

not been designated, how many acres in farmland or forest land tax status will be converted to nonfarm or nonforest use?

Not applicable, non site specific action

1. **Will the proposal affect or be affected by surrounding working farm or forest land normal business operations, such as oversize equipment access, the application of pesticides, tilling, and harvesting? If so, how?**

No, non-project action

c. Describe any structures on the site.

Not applicable, non project action

d. Will any structures be demolished? If so, what?

Not applicable, non site specific action

e. What is the current zoning classification of the site?

Not applicable, non project action

f. What is the current comprehensive plan designation of the site?

Not applicable, non project action

g. If applicable, what is the current shoreline master program designation of the site?

Not applicable, non site specific action

h. Has any part of the site been classified as a critical area by the city or county? If so, specify.

No, non project action- many known critical areas throughout the City.

i. Approximately how many people would reside or work in the completed project?

Not applicable, non site specific action

j. Approximately how many people would the completed project displace?

None, non project action

k. Proposed measures to avoid or reduce displacement impacts, if any.

Not applicable, non project action

l. Proposed measures to ensure the proposal is compatible with existing and projected land uses and plans, if any.

None, non site-specific action. This is a non-project action that affects future development of the property.

m. Proposed measures to reduce or control impacts to agricultural and forest lands of long-term commercial significance, if any:

None, non site specific action. The City abides by the Growth Management Act (GMA)

9. Housing

Find help answering housing questions[12]

a. **Approximately how many units would be provided, if any? Indicate whether high, middle, or low-income housing.**

Not applicable, non-project action.

b. **Approximately how many units, if any, would be eliminated? Indicate whether high, middle, or low-income housing.**

Not applicable, non-project action.

c. **Proposed measures to reduce or control housing impacts, if any:**

None, non-project action.

10. Aesthetics

Find help answering aesthetics questions[13]

a. **What is the tallest height of any proposed structure(s), not including antennas; what is the principal exterior building material(s) proposed?**

Not applicable, non-site-specific action. Height limits are regulated by the underlying zone, which is not proposed to change.

b. **What views in the immediate vicinity would be altered or obstructed?**

Not applicable

c. **Proposed measures to reduce or control aesthetic impacts, if any:**

Not applicable, non-project action

11. Light and glare

Find help answering light and glare questions[14]

a. **What type of light or glare will the proposal produce? What time of day would it mainly occur?**

Not applicable, non-project action

b. **Could light or glare from the finished project be a safety hazard or interfere with views?**

No, non-site-specific action.

c. **What existing off-site sources of light or glare may affect your proposal?**

None, non project action.

d. **Proposed measures to reduce or control light and glare impacts, if any:**

Not applicable.

[12] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-9-Housing
[13] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-10-Aesthetics
[14] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-11-Light-glare

12. Recreation

Find help answering recreation questions

a. **What designated and informal recreational opportunities are in the immediate vicinity?**

Not applicable, non project action

b. **Would the proposed project displace any existing recreational uses? If so, describe.**

No it would not, as this is a non site specific action

c. **Proposed measures to reduce or control impacts on recreation, including recreation opportunities to be provided by the project or applicant, if any:**

None, non project action

13. Historic and cultural preservation

Find help answering historic and cultural preservation questions[15]

a. **Are there any buildings, structures, or sites, located on or near the site that are over 45 years old listed in or eligible for listing in national, state, or local preservation registers? If so, specifically describe.**

Walla Walla has multiple buildings on the local, state, and national registers. The Downtown District is listed on the national register of historic places. No impacts to structures, non-project action

b. **Are there any landmarks, features, or other evidence of Indian or historic use or occupation? This may include human burials or old cemeteries. Are there any material evidence, artifacts, or areas of cultural importance on or near the site? Please list any professional studies conducted at the site to identify such resources.**

Walla Walla is the homeland of the Cayuse, Walla Walla, and Umatilla people. No impacts, non-project action.

c. **Describe the methods used to assess the potential impacts to cultural and historic resources on or near the project site. Examples include consultation with tribes and the department of archeology and historic preservation, archaeological surveys, historic maps, GIS data, etc.**

None, non site specific action

d. **Proposed measures to avoid, minimize, or compensate for loss, changes to, and disturbance to resources. Please include plans for the above and any permits that may be required.**

None, non project action

[15] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-13-Historic-cultural-p

14. Transportation

Find help with answering transportation questions[16]

a. **Identify public streets and highways serving the site or affected geographic area and describe proposed access to the existing street system. Show on site plans, if any.**

Walla Walla's Road network is made up of all street classifications, including private lanes. No impacts, non-project action

b. **Is the site or affected geographic area currently served by public transit? If so, generally describe. If not, what is the approximate distance to the nearest transit stop?**

Walla Walla Valley Transit serves the City of Walla Walla.

c. **Will the proposal require any new or improvements to existing roads, streets, pedestrian, bicycle, or state transportation facilities, not including driveways? If so, generally describe (indicate whether public or private).**

No, non site specific action

d. **Will the project or proposal use (or occur in the immediate vicinity of) water, rail, or air transportation? If so, generally describe.**

No, non project action- individual proposed will be regulated by the CAO.

e. **How many vehicular trips per day would be generated by the completed project or proposal? If known, indicate when peak volumes would occur and what percentage of the volume would be trucks (such as commercial and nonpassenger vehicles). What data or transportation models were used to make these estimates?**

Not applicable, non project action

f. **Will the proposal interfere with, affect, or be affected by the movement of agricultural and forest products on roads or streets in the area? If so, generally describe.**

No, non site specific action

g. **Proposed measures to reduce or control transportation impacts, if any:**

None, non project action

15. Public services

Find help answering public service questions[17]

a. **Would the project result in an increased need for public services (for example: fire protection, police protection, public transit, health care, schools, other)? If so, generally describe.**

No, non project action

b. **Proposed measures to reduce or control direct impacts on public services, if any.**

None, non project action

[16] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-B-Environmental-elements/Environmental-elements-14-Transportation

[17] https://ecology.wa.gov/regulations-permits/sepa/environmental-review/sepa-guidance/sepa-checklist-guidance/sepa-checklist-section-b-environmental-elements/environmental-elements-15-public-services

16. Utilities

Find help answering utilities questions[18]

a. **Circle utilities currently available at the site: electricity, natural gas, water, refuse service, telephone, sanitary sewer, septic system, other:**

All of these utilities are available throughout Walla Walla

b. **Describe the utilities that are proposed for the project, the utility providing the service, and the general construction activities on the site or in the immediate vicinity which might be needed.**

None, non project action

C.Signature

Find help about who should sign[19]

The above answers are true and complete to the best of my knowledge. I understand that the lead agency is relying on them to make its decision.

X Jon Maland

Position and agency/organization:

Date submitted:

D.Supplemental sheet for nonproject actions

Find help for the nonproject actions worksheet[20]

Do not use this section for project actions.

Because these questions are very general, it may be helpful to read them in conjunction with the list of the elements of the environment.

[18] https://ecology.wa.gov/regulations-permits/sepa/environmental-review/sepa-guidance/sepa-checklist-guidance/sepa-checklist-section-b-environmental-elements/environmental-elements-16-utilities
[19] https://ecology.wa.gov/Regulations-Permits/SEPA/Environmental-review/SEPA-guidance/SEPA-checklist-guidance/SEPA-Checklist-Section-C-Signature
[20] https://ecology.wa.gov/regulations-permits/sepa/environmental-review/sepa-guidance/sepa-checklist-guidance/sepa-checklist-section-d-non-project-actions

When answering these questions, be aware of the extent the proposal, or the types of activities likely to result from the proposal, would affect the item at a greater intensity or at a faster rate than if the proposal were not implemented. Respond briefly and in general terms.

1. **How would the proposal be likely to increase discharge to water; emissions to air; production, storage, or release of toxic or hazardous substances; or production of noise?**

   The proposed code changes are not expected to result in the above increases. CAO update provides protection of critical areas.

   - **Proposed measures to avoid or reduce such increases are:**

     None proposed. The amendments include limitations on development and a required mitigation sequence that includes avoidance of impacts to critical areas.

2. **How would the proposal be likely to affect plants, animals, fish, or marine life?**

   The proposal is not anticipated to have significant impacts on plants, animals, or fish. The CAO attempts to reduce negative impacts.

   - **Proposed measures to protect or conserve plants, animals, fish, or marine life are:**

     The CAO amendments/update will include measures to protect or conserve plants, animals, etc.

3. **How would the proposal be likely to deplete energy or natural resources?**

   The code updates are not expected to deplete energy or natural resources.

   - **Proposed measures to protect or conserve energy and natural resources are:**

     The code updates are not expected to directly protect or conserve energy.

4. **How would the proposal be likely to use or affect environmentally sensitive areas or areas designated (or eligible or under study) for governmental protection, such as parks, wilderness, wild and scenic rivers, threatened or endangered species habitat, historic or cultural sites, wetlands, floodplains, or prime farmlands?**

   The CAO amendments/update will provide for regulations that protect environmentally sensitive areas and critical area habitats.

   - **Proposed measures to protect such resources or to avoid or reduce impacts are:**

     Updating the City's critical area regulations based on best available science will help to protect, avoid and reduce impacts. Any projects would be subject to SEPA review and

5. **How would the proposal be likely to affect land and shoreline use, including whether it would allow or encourage land or shoreline uses incompatible with existing plans?**

   The city code and shoreline management program regulates the compatibility of proposals with shoreline uses.

   - **Proposed measures to avoid or reduce shoreline and land use impacts are:**

     None proposed.

6. **How would the proposal be likely to increase demands on transportation or public services and utilities?**

None proposed. The amendments update the critical areas code and should have no direct impacts on transportation or public services and utilities.

- **Proposed measures to reduce or respond to such demand(s) are:**

None proposed.

The proposed code changes are not expected to directly increase demands on transportation or public services.

7. Identify, if possible, whether the proposal may conflict with local, state, or federal laws or requirements for the protection of the environment.

This amendment updates the critical areas code consistent with the growth management act. No conflicts with local, state, or federal laws or requirements for environmental protection.

City of Walla Walla
Development Services

Washington State Environmental Policy Act – SEPA

Adoption/Addendum of an existing Environmental Document

File# PLN5-26-0001

Date of Issuance: August 17, 2026

Description of Proposal: Walla Walla Municipal Code (WWMC) Amendments- amendments to Walla Walla Municipal Code Chapter 21.04 - Critical Area Ordinance.

WWMC Chapter 21.04 Amendments to the Critical Area Ordinance. Under the Washington State Growth Management Act (GMA), the City of Walla Walla must incorporate best available science" (BAS) when developing policies and regulations to protect the functions and values of critical areas. Additionally, "special consideration" must be given to conservation or protection measures necessary to preserve or enhance anadromous fisheries.

Proponent: City of Walla Walla, 15 N. 3rd Avenue, Walla Walla, WA 99362

Location of current proposal: All of the City of Walla Walla and City of Walla Walla Urban Growth Area (UGA).

Title of document being adopted: The City of Walla Walla Comprehensive Plan, Walla Walla 2040, and the Final Environmental Impact Statement (FEIS).

The agency that prepared the document being adopted: City of Walla Walla

Date the adopted document was prepared: 5/18/2018

Description of document (or portion) being adopted: The City of Walla Walla Comprehensive Plan, Walla Walla 2040, and the Final Environmental Impact Statement (FEIS), dated May 22, 2018.

Addendum to the FEIS: Pursuant to WAC 197-11-600(4)(c) and the addendum procedures in WAC 197-11-625, the City is issuing this Addendum to the 2018 FEIS. This Addendum provides additional information and analysis based on the June 29, 2026, Environmental Checklist. The information presented does not substantially change the analysis of probable significant adverse impacts or the range of alternatives considered in the 2018 FEIS. The original FEIS remains valid and is not modified or replaced by this Addendum.

If the document being adopted has been challenged (WAC 197-11-630), please describe: No.

The document is available to be read at: City of Walla Walla Development Services office at 55 East Moore Street, Walla Walla, WA.

The City of Walla Walla has identified, adopted, and incorporated by reference this document as being appropriate for this proposal, after independent review. The document meets our environmental review needs for the current proposal and will accompany the proposal to the decision makers. We have determined that this

proposal will not have a probable significant adverse impact on the environment. An Environmental Impact Statement (EIS) is not required under RCW 43.21C.030(2)(c).

Name of agency adopting document: City of Walla Walla

Contact person: Jon Maland, AICP, Sr. Planner, Phone:(509) 524-4710

Responsible Official: J Preston Frederickson, Director

Address: City of Walla Walla Development Services
55 East Moore Street, Walla Walla, WA 99362

Issue Date: August 17, 2026

Signature: _____ **Date:** August 17, 2026

City of Walla Walla Planning Commission
Development Services
55 E. Moore Street
Walla Walla, WA 99362

CITY OF WALLA WALLA PLANNING COMMISSION
DRAFT MEETING MINUTES
Monday, August 3, 2026 – 6:30 P.M.
Hybrid Meeting – In Person and via *Zoom*
Council Chambers, 15 N 3rd Avenue, Walla Walla

1. CALL TO ORDER

Chair Williams called the meeting to order at 6:30 p.m.

2. ROLL CALL

Members Present: Jim Williams, Chair
Arlene Alen, Member
Kristin Jensen, Member
Liz Jessee, Member
Jeff Strickler, Member
Jennifer Walden, Vice-Chair

Members Excused: John Gahbauer, Member

Staff Present: Emily Arteche, Deputy Director
Jon Maland, Sr. Planner
Pam Ransier, Administrative Permit Coordinator
Monte Willis, Council Liaison

Quorum was established.

3. PUBLIC COMMENT

No members of the public provided comment.

4. APPROVAL OF MINUTES

A. Regular Meeting – July 6, 2026

MOTION: **Commissioner Jenson** moved, and **Commissioner Alen** seconded to approve the regular meeting minutes for July 6, 2026 as presented.
Motion carried 6- 0

5. OLD BUSINESS

A. Comprehensive Plan Update — Commission Action

Chair Williams introduced the Comprehensive Plan Update and outlined the next steps to move the draft plan forward in the approval process, including a recommendation by the Planning Commission to City Council.

MOTION: **Commissioner Strickler** moved, and **Commissioner Walden** seconded to recommend approval of the draft 2046 Comprehensive Plan to the City Council.
Discussion: **Commissioner Jessee** noted that a county document related to extreme

weather is in the process of being revised and the document link from the county's website will be available to include in the final version of the 2046 Comprehensive Plan.

Motion carried 6- 0

B. Emily Arteche, Deputy Director, presented a minor change to the list of upcoming code amendments. This change is related to when the city will accept annexation petitions. The requested amendment was received in Development Services after the July workshop. No action is needed at this time.

6. NEW BUSINESS

A. Critical Area Ordinance Amendments **Workshop**

Ms. Arteche, introduced **Nell Lund,** Senior Ecologist with Facet, the city's consultant for the 10-year Critical Areas Ordinance (CAO) update. Using a PowerPoint presentation, Ms. Lund gave an overview of the CAO and what the ordinance governs. Primarily wetlands, aquifer recharge areas, fish and wildlife conservation areas, frequently flooded areas, and geologically hazardous areas. She stressed the importance of using Best Available Science (BAS) during the update process. **Ms. Arteche** explained that Mill Creek was not included in this work as it is a waterway of the state and is included in the Shoreline Master Program, not the CAO.

Commissioners asked clarifying questions and staff and Ms. Lund responded.

Chair Williams asked staff to provide to the commission as soon as possible any public comments on the amendments received prior to the next meeting.

The final draft of the proposed code amendments will be presented to the Planning Commission September 14, 2026, for recommendation to City Council. The City Council will hold a workshop on the code amendments on September 21, 2026, with action at a future date.

7. STAFF UPDATES

- MC Gateway, a planned community near the airport, is working with the city on a development agreement outlining all aspects of the future development.
- A proposed 14-lot residential development on Fern Avenue will go before the Hearing Examiner on August 13, 2026.
- A variance request for a subdivision on E Sumach Street will also go before the Hearing Examiner on August 13. The variance is related to access to a 15-lot subdivision with geographical constraints that prevent a second access point. This variance was originally approved in 2023 but expired before the development could move forward.
- Staff are finalizing a binding site plan for the WinCo property that will create eight building pads.
- Shoreline review is underway for bridge replacement projects at 4th Avenue and 6th Avenue.
- Staff are working on the environmental review for a planned community located near Highway 125, south Myra Road and Village Way.

8. ADJOURNMENT

MOTION: **Commissioner Jessee** moved, and **Commissioner Jessen** seconded to adjourn.

Motion carried 6- 0

Meeting adjourned at 7:15 p.m.

Washington State Department of Commerce

THANK YOU

We have received your amendment submission. Please allow 1-3 business days for review. Please keep the Submittal ID as your receipt and for any future questions. We will also send an email receipt to all contacts listed in the submittal.

Submittal ID: 2026-S-15148

Submittal Date Time: 08/04/2026

Submittal Information

Jurisdiction	City of Walla Walla
Submittal Type	60-day Notice of Intent to Adopt Amendment
Amendment Type	Critical Areas Ordinance

Amendment Information

Brief Description
Proposed Critical Areas Ordinance (CAO) Code Amendments

■ **Yes, this is a part of the 10-year periodic update schedule, required under RCW 36.70A.130.**

Planning Commissions Date 09/14/2026

City Council Date 10/14/2026

Anticipated/Proposed Date of Adoption 10/28/2026

Categories

Submittal Category
Critical Areas Ordinance

Attachments

Attachment Type	File Name	Upload Date
Critical Areas Ordinance - Draft	2026 Draft Critical Areas Amendments.pdf	08/04/2026 10:55 AM

Contact Information

Prefix	Mr.

First Name	Jonathan
Last Name	Maland
Title	Senior Planner
Work	(509) 524-4710
Cell	
Email	jmaland@wallawallawa.gov

☐ **Yes, I would like to be contacted for Technical Assistance.**

Certification

■ **I certify that I am authorized to submit this Amendment for the Jurisdiction identified in this Submittal and all information provided is true and accurate to the best of my knowledge.**

Full Name	Jonathan Maland
Email	jmaland@wallawallawa.gov

NOTICE OF APPLICATION and NOTICE OF PUBLIC HEARING

Walla Walla Municipal Code (WWMC) Amendments - Comprehensive Plan implementing Municipal Code Amendments – 2026

Amendments to Walla Walla Municipal Code Chapter 21.04 - Critical Area Ordinance.
FILE# PLN5-26-0001

Project Summary: This is a proposal to revise various sections of the Walla Walla Municipal Code. The specific code sections and details of the proposed revisions are described below.

Notice is hereby given on this date, **August 18, 2026**, that a development regulation amendment application/proposal described in this notice has been filed with the City of Walla Walla Development Services. The application documents may be reviewed at the City of Walla Walla Development Services Department at 55 E. Moore Street, Walla Walla, or by visiting the city's website at https://www.wallawallawa.gov/government/development-services/public-notice.

Public Hearing: Notice is also hereby given by the City of Walla Walla that a **Public Hearing will be held on the application/proposal by the City of Walla Walla Planning Commission on Monday, September 14, 2026, at 6:30 P.M. at the City Hall Council Chambers, 15 N. 3rd Avenue, Walla Walla, WA (N. 3rd Avenue and Rose Street).**

Members of the public may also attend and participate in the public hearing virtually using this Zoom meeting link https://bit.ly/4pbogQ1 or listen to the meeting by calling 253-215-8782 and entering meeting ID 818 2953 1983.

State Environmental Policy Act (SEPA): The City of Walla Walla Development Services has determined that this proposal is unlikely to have a significant adverse impact on the environment. An environmental impact statement (EIS) is not required under RCW 43.21C.030(2)(c). The City of Walla Walla issued an Adoption/Addendum of an existing Environmental Document on August 18, 2026. We have reviewed the following existing environmental documents: Walla Walla Comprehensive Plan Final Environmental Impact Statement (FEIS), issued May 22, 2018, and Walla Walla Comprehensive Plan - Walla Walla 2040, Ordinance 2018-15, adopted June 13, 2018. The relevant content of these documents is briefly described as an Environmental Impact Statement for the Walla Walla Comprehensive Plan, which evaluates proposed actions, alternatives, and environmental impacts of activities allowed by the Walla Walla Comprehensive Plan & Environmental Impact Statement.

If reference is made below to the application or determination of completeness, copies of the referenced materials are attached hereto.

1. **Applicant:** City of Walla Walla Development Services Department, 55 E. Moore St., Walla Walla, WA 99362
2. **Date of Application:** June 29, 2026
3. **Complete Application:** June 29, 2026
4. **Location of Proposed Action:** Throughout the City Limits of Walla Walla.

5. **Proposed Code Amendments:** Updates to the following chapters and sections of the Walla Walla Municipal Code (WWMC) are summarized below and are being proposed; contact the Development Services Department for the complete text.

   Chapter/Sections: 2.17, 2.27, 2.28, 3.23, 5.02, 5.04, 5.05, 5.09, 10.17. 10.27, 12.14, 13.050.060, 13.07.020, 15.36.020, 19.02.050, 19.06.020, 19.18.040, 19.26.015, 19.26.040, 19.30.010, 19.40.020, 20.10, 20.14.030, 20.14.065, 20.14.095, 20.36.020, 20.38.050, 20.42.020, 20.42.070, 20.46.080, 20.46.110, 20.48.050. 20.50.130, 20.50.170, 20.134.10, 20.139.040, 20.139.070, 20.139.100, 20.170.032, 20.171.070, 20.184.060, 21.040.010, 21.040.020, 21.04.035, 21.04.055, 21.04.075, 21.08.120, 21.08.170, 21.08.173, 21.10.050, 21.10.070 - Amend "Development Services" to "Community Development or Community Development department" and/or "Development Services director to Community Development director" within the applicable Titles and Sections of the Walla Walla Municipal Code.

   WWMC 12.64.020 - Amend text to Future Land Use Map

   WWMC 13.03.601 - City Manager's discretion on sewer services.

   WWMC 13.04.040 and 13.04.150 - City Manager's discretion on water services.

   WWMC 15.04.005 - Calculation of permit fees for a permit-ready accessory dwelling unit.

   WWMC 19.02.030- Amend text for clarification with case law.

   WWMC 19.020.050- Amend from Authorization to Permit

   WWMC 20.02.040- Remove text of "This code is the principal means of implementing the Plan"

   WWMC 20.02.050- Amend for the text of MHC | Mobile/Manufactured Home Park Community

   WWMC 20.02.080 (B) (D), (I)(1) and (I)(2)(J)-new letter- Amend text for accepting annexation petitions anytime during the year and for clarification with case law.

   WWMC 20.02.130- Amend text for clarification with case law.

   WWMC 20.10.080 - Amend text for clarification on City Council decisions.

   WWMC 20.14.065 – Amend text for designated permit responsible official and contact information

   WWMC 20.18.050, 20.22.040, 20.28.020- Amend text for clarification with case law.

   WWMC 20.34.040 - Amend text for the Hearing Examiner to conduct the public hearing and make a recommendation to the City Council on development agreements.

   WWMC 20.48.045- Amend text for Future Land Use Map.

   WWMC 20.50.020- Amend text for Affordable Housing Development on Properties Owned by Religious Organizations in RCW 35.63.280, RCW 35A.63.300, RCW 36.70A.545.

   WWMC 20.50.105 (New Chapter A-F)- Landfill Vicinity Development Standards

   WWMC 20.50.170- Urban planned community modifications, amend for "who has been formally"

   WWMC 20.127.007 - Amend for downtown parking exemption.

WWMC 20.100.040 - Amend to comply with Washington State SB 5509 on daycares, HB 2266 on Emergency Housing/ Shelter, and SB 6026 on the prioritization of commercial uses along the street facing public frontage with residential in the rear of the building; will be applied.

WWMC 20.106.010 - Amend text for clarification with case law.

WWMC 20.110 - Amend this section for Retaining Walls within the Fence code.

WWMC 20.171.070 - Amend text section on the city's Comprehensive Plan.

WWMC 20.178.050- Amend this section on building height in the downtown design standards.

WWMC 21.04.700 - This section moved to Title 20.

WWMC 21.10.010 - Amend this section for text clarification and for clarification with case law.

WWMC Chapter 21.04 - Amendments to the Critical Area Ordinance. Under the Washington State Growth Management Act (GMA), the City of Walla Walla must incorporate best available science" (BAS) when developing policies and regulations to protect the functions and values of critical areas. Additionally, "special consideration" must be given to conservation or protection measures necessary to preserve or enhance anadromous fisheries.

Public Comment: Comments upon this application must be submitted in writing to the City of Walla Walla Development Services at 55 East Moore Street, Walla Walla, WA 99362, or by email to permits@wallawallawa.gov.

The comment period will open on August 18, 2026, and comments must be actually received by the Development Services Department before 5:00 P.M. on Friday, September 4, 2026. **Comments, both oral and written, may also be submitted at the Planning Commission Public Hearing on Monday, September 14, 2026, at 6:30 P.M.**

Interested persons and parties may also receive a copy of any decision(s) made on the proposal by filing a special notice request with the City of Walla Walla as provided in section 20.14.015 of the Walla Walla Municipal Code. Appeal rights are outlined in Chapter 20.38 of the Walla Walla Municipal Code and other code provisions referenced therein. A staff report and information packet with all submitted documents will be available for review on the City of Walla Walla Development Services Department website.

City of Walla Walla Development Services, 55 E. Moore Street, Walla Walla, WA 99362
(509) 524-4710 Email: permits@wallawallawa.gov

From:	Sears, Tricia (DNR)
To:	Jon Maland
Cc:	Sears, Tricia (DNR); Serr, Benjamin (COM)
Subject:	Walla Walla's critical areas ordinance amendments (2026-S-15148): WGS comments
Date:	Friday, August 7, 2026 4:13:55 PM

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi Jonathan,

In keeping with the interagency correspondence principles, I am providing you with comments on Walla Walla's critical areas ordinance amendments (2026-S-15148).

For this proposal submitted via Planview, I looked at the proposal and focused on areas related to WGS work. Of note, but not limited to, I look for language around the geologically hazardous areas, mineral resource lands, mining, climate change, and natural hazards mitigation plan.

Specifically in this proposal, for critical areas I reviewed the 2026 Draft Critical Areas Amendments.

The document has a table with four column headers of the code provision, the section, the proposed amendment, and the category and notes. It's an interesting format to show the proposed changes. It doesn't provide context for the changes as much as having a document with the chapters and sections in full, with the strikethrough and new language.

Section 21.04.015 Critical Areas. Figure 1 is being struck because it is outdated, according to the note. There is no proposed replacement for it.

Section 21.04.020 Critical Areas. Definitions. Best Available Science. Suggest "Sources of best available science are included" be revised to say "Sources of best available science are included, but not limited to,"

Section 21.04.035(A). Critical Areas. Great to see the critical areas maps listed.

Section 21.04.090(B)(2-3) Critical Areas. Reasonable Use. Good to see the addition of "prepared by a qualified professional." The definition of qualified professional is not included so it is not clear how it is defined.

Section 21.04.115(C) (1) and (4) and (H). Critical Areas. Great to see the addition "of impact and mitigation activities." Great to see the record to title requirement.

Section 21.04.500(B)(4), (D), and (E) and Section 21.04.510. Good to see these changes.

Below, I include our usual language for this and future endeavors.

Recognizing the limitations of the current proposals, I want to mention that it would be great for you to consider these in current or future work, be it in your comprehensive plan, development code,

and SMP updates, and in your work in general:

- Consider adding a reference to the definition of geologically hazardous areas, WAC 365-190-120, in other areas besides the CAO. In addition, consider adding a reference to WAC 365-196-480 for natural resource lands.
- Consider adding in other areas besides the CAO. If you have not checked our interactive database, the Washington Geologic Information Portal, lately, you may wish to do so. Geologic Information Portal | WA - DNR
- If you have not checked out our Geologic Planning page, you may wish to do so. Geologic Planning | WA - DNR

Thank you for considering our comments. If you have any questions or need additional information, please contact me. For your convenience, if there are no concerns or follow-up discussion, you may consider these comments to be final as of the 60-day comment deadline of 10/3/26.

Have a great day!
Tricia

Tricia R. Sears (she/her/hers)
Geologic Planning Liaison
Washington Geological Survey (WGS)
Washington Department of Natural Resources (DNR)
Cell: 360-628-2867 | Email: tricia.sears@dnr.wa.gov

Angelica Escalante

From: Howard Boggs <1955whb@gmail.com>
Sent: Wednesday, August 26, 2026 2:36 PM
To: Permits
Subject: comments regarding proposed Critical Areas Ordinance changes

My comments that follow are in regards to the proposed riparian buffer and setback.

1. The majority of the land in the city that is adjacent to the streams is already developed. A lot of the development was prior to any stream setbacks. The balance was with the current setbacks. The result is most of the developed land has improvements that would not be allowed under the proposed changes. Further development of these lands will be a challenge, likely resulting in less infill. The undeveloped land will also be impacted resulting in less infill parcels. I doubt the future riparian buffer areas will improve enough to offset the loss of infill parcels.

2. The existing buffer setback is 5'. The proposed new setback is 15'.
With the buffer increasing from 35' or 50' to 100', why make if worst for property owners by making the setback bigger. I suggest a 0'
setback. If that can't work, then keep it at 5'.

Thank you,

Howard Boggs

2549 Sandalwood Court

509-386-6207

State of Washington
DEPARTMENT OF FISH AND WILDLIFE
Eastern Region • Region 1 • 2315 North Discovery Place, Spokane Valley, WA 99216-1566
Telephone: (509) 892-1001 • Fax: (509) 921-2440

August 28, 2026

Jon Maland
City of Walla Walla Planning Office
55 E Moore Street,
Walla Walla WA 99362
jmaland@wallawallawa.gov

RE: WDFW Comments on City of Walla Walla Critical Areas Ordinance (Plan View Case #2026-S-15148)

Dear Mr. Maland,

On behalf of the Washington Department of Fish and Wildlife (WDFW), thank you for the opportunity to formally comment on the draft Critical Area Ordinance (CAO) for the City of Walla Walla during the city's periodic update. We provide these comments and recommendations in keeping with our legislative mandate to preserve, protect, and perpetuate fish and wildlife and their habitats for the benefit of future generations – a mission we can only accomplish in partnership with local jurisdictions. We may decide to submit additional comments on this topic in the future.

Within the State of Washington's land use decision-making framework, WDFW's role is that of technical advisor with respect to the habitat needs of fish and wildlife and the likely implications of various land use decisions on those resources over time. WDFW supports the City's ongoing efforts to integrate environmental protection with thoughtful planning and offers the following comments to help ensure continued alignment with the Growth Management Act (GMA), especially regarding fish and wildlife habitat conservation.

Overall, we found a high level of consistency between your draft CAO, our resources, and our conservation goals centered around anadromous fish and protected hawks. We are excited to be working alongside Walla Walla through these new updates.

The following comments are provided in order of appearance throughout the CAO. All edits in red are WDFW suggested language and policy additions, while broader thematic insertions and references will be indicated below the sample text.

Chapter 20.04.005(B) – Purpose

While WDFW recognizes all riparian ecosystems as important, thank you for adding in the extra sentence referencing the WAC and giving special attention to anadromous fish.

21.04.020 – Definitions

WDFW suggests adding or amending the following definitions to the City of Walla Walla's CAO:

- **Active channel**: The portion of a stream channel defined by the lower limit of continuous riparian vegetation, and it may be delineated by absence of both moss on rocks and rooted vegetation. The upper most elevation of the active channel is sometimes equated with the ordinary high-water mark. (WDFW Vol 1)
- **Active floodplain**: A portion of floodplain that is located between the active channel and adjacent terrace or hillslopes. Depending on the watershed, the flood return interval of the active floodplain varies between 1 and 10 years. (WDFW Vol 1)
- **Anadromous fish:** Fish that spawn and rear in freshwater and mature in the marine environment. (Knight 2009)
- **Compensatory mitigation:** The restoration, creation, enhancement, or preservation of uplands, wetlands, or other aquatic resources for the purposes of compensating for unavoidable adverse impacts that remain after all appropriate and practicable avoidance and minimization has been achieved. "Compensatory mitigation" includes mitigation that:
    - Occurs at the same time as, or in advance of, a project's planned environmental impacts;
    - Is located in a site either on, near, or distant from the project's impacts;
    - and provides either the same or different biological functions and values as the functions and values impacted by the project. (RCW 90.74.010 (1))

***Comment*:** WDFW would like to note that 'compensatory mitigation' should be taking place for *all* critical areas, and not just wetlands, as stated in the current CAO definition.

- **Ecological improvement**: The ecological functions and values, that support biodiversity and resiliency of native plant, animal and fungi species, water quality and quantity, air quality, and food security for all species, are improved over current conditions, at a cumulative scale that can be incrementally implemented through site-specific actions, with any short-term loss of those functions and values being more than offset by overall ecological gains. (WDFW 2024, WDFW 2025)

  NOTE: This is the new term replacing "net ecological gain."
- **Ecosystem-based management (EBM):** Management driven by explicit goals; executed by policies, protocols, and practices; and made adaptable by monitoring and research; based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function. EBM acknowledges that humans are an important ecosystem component and focuses on managing human activities within ecosystems. EBM often involves balancing ecological, economic, and social objectives within the context of existing laws and policies. (WDFW Vol 2)
- **Ecosystem functions:** The products, physical and biological conditions, and environmental qualities of an ecosystem that result from interactions among ecosystem processes and ecosystem structures. Ecosystem functions include, but are not limited to, sequestered carbon, attenuated peak stream flows, aquifer water level, reduced pollutant concentrations in surface and ground waters, cool summer in-stream water temperatures, and fish and wildlife habitats. (WAC 365-196-210 (17))
- **Ecosystem services:** The benefits that the public enjoys as a result of natural processes and biological diversity. (RCW 76.09.020)
- **Ecosystem values:** The cultural, social, economic, and ecological benefits attributed to ecosystem functions. (WAC 365-196-210 (18))

- **Enhancement:** The manipulation of the physical, chemical, or biological characteristics of habitat to heighten, intensify, or improve a specific ecosystem function(s). Enhancement results in the gain of selected habitat function(s) but may also lead to a decline in other ecosystem function(s). Enhancement does not result in a gain in habitat area. (WAC 173-700-104)
- **Fish and Wildlife Habitat Conservation Areas (FWHCAs):** Areas that serve a critical role in sustaining needed habitats and species for the functional integrity of the ecosystem which, if altered, may reduce the likelihood that the species will persist over the long term. These areas may include, but are not limited to, rare or vulnerable ecological systems, communities, areas with high relative population density or species richness, and habitat or habitat elements including seasonal ranges, breeding habitat, winter range, and movement corridors. (WAC 365-190-030 (6)(a))

Comment: Please include these updated functions and values to your current definition such as, vulnerable ecological systems, seasonal ranges, and breeding habitats

- **Habitat Management Plan (HMP):** A project-based, site specific report for land use activities in a FWHCA that could affect critical area functions. (WDFW Vol 2)
- **Hazard Tree:** A tree that a jurisdiction's building official or other recognized professional (e.g., certified arborist, registered landscape architect, or certified forester) has determined poses a near-term hazard to public safety or to an existing permanent structure or public utility. (WDFW Vol 2)
- **Large Woody Debris (LWD):** Large dead woody material (such as fallen trees and branches) in various stages of decomposition that provide nutrients to forest and aquatic resources and serve as habitat in forest and riparian ecosystems. Large wood is usually defined as having a diameter greater than 4 in (10 cm) and length greater than 6 ft (≈ 2 m). (WDFW Vol 2)

- **Mitigation bank:** A site where wetlands and/or other aquatic resources or natural habitats are restored, created, enhanced, or in exceptional circumstances, preserved, expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources. (23 CFR 777.2)
- **No net loss:** Standards that are intended to limit the impacts from new development and other land uses by adopting a mitigation hierarchy to avoid, minimize, remediate, and offset negative impacts on ecosystems. (WDFW 2024)
- **Ordinary High-Water Mark (OHWM):** That mark which is found by examining the bed and banks of a water body and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years that the soils and vegetation have a character distinct from that of the abutting upland area. It also can also be established by fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas. Where the ordinary high-water mark cannot be found, it shall be the line of mean high water in areas adjoining fresh water. (WAC 173-22-030(11))

- **Priority species**: Fish and wildlife species requiring protective measures and/or management actions to ensure their survival. A species identified and mapped as priority species fit one or more of the following criteria (WDFW 2023, as amended):
    - State-listed endangered, threatened, sensitive, or candidate species;
    - Vulnerable aggregations;
    - Of recreational, commercial, and/or tribal importance.
- **Reasonable use exception:** A mechanism by which local jurisdictions may grant relief from code requirements where compliance leaves no reasonable use of the property. (Municipal Research Services Center of Washington 2025)
- **Reestablishment:** The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former aquatic resource. Reestablishment results in rebuilding a former aquatic resource and results in a gain in aquatic resource area and functions. Reestablishment falls under the broader term of restoration. (WAC 173-700-104)
- **Rehabilitation:** The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions to a degraded aquatic resource. Rehabilitation results in a gain in aquatic resource function but does not result in a gain in ecological resource area. (WAC 173-700-104)
- **Restoration**: A broad term referring to both reestablishment and rehabilitation. (WAC 173-700-104)
- **Riparian management zone (RMZ):** The area that has the potential to provide full riparian functions. In forested ecoregions, this is the area within one $SPTH_{200yr}$ (minimum 100 feet) measured from the wider of the OHWM, CMZ, or active floodplain.
  In dryland ecoregions the RMZ begins at the wider of OHWM, CMZ, or active floodplain; its width is equal to the greater of one $SPTH_{200yr}$, 100 feet, or the outermost point of the riparian vegetative community. (Folkerts et al. 2025)
- **Site-potential tree height ($SPTH_{200yr}$):** The average maximum height of the tallest dominant trees for a given age (200 years) and site class. (WDFW Vol 1)

21.04.085. B - Allowed activities.

The following vegetation removal activities:

a. The removal of the noxious weed species designated by Washington State in Chapter 16-750 WAC or the local weed control authority with hand labor and light equipment, or other invasive species; Removal of noxious and invasive plants should minimize the impacts to fish, wildlife, and habitat through the use of hand removal or light equipment, use of only WA Dept. Of Ecology approved aquatic herbicides and when necessary, avoidance of hazardous substances, prevention of soil compaction, and timing restrictions to protect fish and wildlife during sensitive periods. These conditions should apply whether the activity is exempt or permitted.

b. The removal of hazard trees from sensitive areas and buffers that are posing a threat to public safety, or an imminent risk of damage to a permanent structure with consultation from a certified arborist

> ***Comment:*** Many jurisdictions have some specific language regarding tree removal methods, replacement (usually 2:1), and standards if trees are removed from a buffer or critical area.

Please see the language below from Whitman County's CAO Allowed Activies.6 – Vegetation Removal: "The applicant submits a report from a certified arborist, registered landscape architect, or professional forester that documents the hazard and provides a replanting schedule for the replacement trees;

ii. Tree cutting shall be limited to pruning and crown thinning, unless otherwise justified by a qualified professional. Where pruning or crown thinning is not sufficient to address the hazard, trees should be removed or converted to wildlife snags;

iii. All vegetation cut (tree stems, branches, etc.) shall be left within the critical area or buffer unless removal is warranted due to the potential for disease or pest transmittal to other healthy vegetation;

iv. The landowner shall replace any trees that are removed with new trees at a ratio of two replacement trees for each tree removed (2:1) within one (1) year in accordance with an approved restoration plan. Replacement trees may be planted at a different nearby location if it can be determined that planting in the same location would create a new hazard or potentially damage the critical area. Replacement trees shall be species that are native and indigenous to the site and a minimum of one (1) inch in diameter-at-breast height (dbh) for deciduous trees and a minimum of six (6) feet in height for evergreen trees as measured from the top of the root ball;

v. If a tree to be removed provides critical habitat, such as an eagle perch, a qualified wildlife biologist shall be consulted to determine timing and methods or removal that will minimize impacts; and

vi. Hazard trees determined to pose an imminent threat or danger to public health or safety, to public or private property, or of serious environmental degradation may be removed or pruned by the landowner prior to receiving written approval from the county provided that within fourteen (14) days following such action, the landowner shall submit a restoration plan that demonstrates compliance with the provisions of this Chapter."

21.04.095 Critical area reports – General requirements.

C.2.d - A map with latitude/longitude coordinates, GIS files, or township/range/section

C.9 Plans for adequate mitigation, and monitoring, as needed, to offset any impacts, in accordance with sections 21.04.105 through **21.04.120**, including, but not limited to:

C.9.c. The mitigation plan shall include a written report identifying environmental protection goals and objectives of the compensation proposed to ensure no net loss of ecological function and values through either, or a combination of, preservation, rehabilitation, and re-establishment.

E. Validity Period for Critical Areas Report. Critical area reports shall be valid for a period of five years. After such date, the Director shall determine whether a revision or additional assessment is necessary.

Comment: Walla Walla County added this into their CAO, and for consistency it would be nice for the City to also retain Reports and be able to utilize them for up to 5 years.

21.04.105: Mitigation requirements.

G. Mitigation sites shall be protected in perpetuity. This protection shall be through conservation easement, deed restriction, donation to a trust, or other legally binding method.

21.04.115: Mitigation plan requirements.

D. Monitoring and Adaptive Management ~~Program~~ Plan. The mitigation plan shall include a program for monitoring construction of the compensation project, ~~and~~ for assessing a completed project, and for potential changes in maintenance based on changing conditions or need for ecological uplift.

> ***Comment*:** A monitoring and adaptive management (MAM) program differs from a monitoring plan, as a MAM "Program" involves monitoring and improving multiple permits, regulations, and programs to ensure the protection of critical areas with continued evaluation across multiple critical area uplift endeavors. A plan is typically project specific with timelines. However, if the City is interested in creating a MAM program, WDFW would be happy to advise.

H. Critical Area Tracts and Designations. A notice on title or critical area tract shall be used to delineate and protect those critical areas, buffers, and mitigation and habitat plans, ~~and~~ in development proposals for subdivisions, short subdivisions, or other affected lots as detailed under WWMC 21.04.125 at the discretion of the director.

I. Preservation and Protection Plan: This protection shall be through conservation easement, deed restriction, donation to a trust, or other legally binding method.

21.04.600: Fish and wildlife habitat conservation areas – Designation

A.1.b - The Washington State Department of Fish and Wildlife maintains the most current listing (Priority Habitats and Species List, WDFW 2023, current or as amended), and ~~should~~ will be consulted ~~as necessary~~ for current listing status.

A.8 - Land essential for preserving eco-connectivity between habitat blocks, migration corridors, breeding grounds, and open spaces.

21.04.630: Critical area report – Additional requirements for habitat conservation areas.

B.2. - All habitat conservation areas, priority habitats and species, and recommended buffers within two hundred and fifty feet of the project area

C.4 -A ~~discussion~~ report detailing ~~of~~ ongoing and future management practices that will protect habitat after the project site has been developed, including proposed adaptive management, monitoring and maintenance programs.

C.5 - A map of the project and/or survey area, TYPE OF coordinates, and GIS files if available

21.04.640: Performance standards – General requirements.

G.1 – "…Required buffer widths shall reflect the sensitivity of the habitat and the type and intensity of human activity proposed to be conducted nearby and shall be consistent with the management recommendations issued by the Washington Department of Fish and Wildlife"

> ***Comment:*** Our BAS is stating site potential tree height ($SPTH200_{yrs}$) should be the standard for buffer widths, with our online mapping tool being the best way to quickly determine the buffer needs for your area.

G.3.c - Provide for a monitoring and maintenance plan for a period of at least five years, ~~except this provision may be waived for single-family residential lots.~~

> ***Comment:*** WDFW recommends that critical areas, their restrictions, and maintenance plans, should be disclosed to property owners on their titles and deeds. Many jurisdictions have monitoring and maintenance requirements roll over and be continued despite a change in landowner. Adding the provision to be waived for residence lots seems to contradict added point H in 21.04.115: Mitigation plan requirements.

H.3.b - The applicant shall be required to install a permanent wildlife friendly fence around the habitat conservation area or buffer when domestic grazing animals are present or may be introduced on site.

> ***Comment:*** Wildlife friendly fencing guidelines can be found here and usually include nonflammable materials and smooth wire to allow wildlife passage.

21.04.650: Performance standards – Specific habitats.

A.1 - No development shall be allowed within a habitat conservation area or buffer with which state or federal endangered, threatened, or sensitive species or habitat have a primary association.

A.1.a - WDFW-mapped species and habitats within the City include, but are not limited to, Bull trout, Chinook salmon, Steelhead, and Ferruginous hawk and shrubsteppe.

D.2.a - A riparian habitat shall have at least the buffer width recommended in Table 6, unless a greater width is required pursuant to subsection (D)(4) of this section or best available science.

> ***Comment:*** Table 6 is recommending 100 ft, which may be compliant with our BAS of SPTH, however a site evaluation would be best to determine the correct buffer width.

D.2.c - Functionally disconnected buffers: Where impervious surfaces or other lawfully established structures functionally and effectively disconnect the riparian buffer from the stream, the Department director may approve a complete or partial buffer modification of the standard width to exclude non-functional areas with the guidance of qualified professionals.

> ***Comment***: Should be revised to include an additional condition on buffer averaging and prevention measures for no net loss (NNL). First, the buffer shall not be reduced below 100 feet at its narrowest point, regardless of the total area preserved, to ensure the minimum pollution removal function is maintained at all points along the corridor. Second, any portion of the buffer used to satisfy the averaging calculation, including any widened segments, shall be permanently protected through a deed restriction or equivalent legal mechanism

recorded with the County Auditor prior to permit issuance. Without permanent protection, the wider segments that justify a narrowed area elsewhere can be subsequently altered, undermining the functional basis of the averaging approval. To strengthen it further, we offer this example, adopted by Clark County: "Functionally Isolated Riparian Habitat Areas. Riparian habitat areas which are at least one hundred (100) feet from the ordinary high water mark and disconnected from the water body by a continuous public or private roadway serving three (3) or more lots shall be excluded from fish and wildlife habitat conservation areas."

D.5 – Buffer Averaging

Comment: WDFW does not recommend buffer width averaging for RMZs, and any intrusion into the buffer should be limited to the outer 25%. Buffer averaging does not align with WDFW's scientific recommendations (Vol. 2) because the RMZ represents the minimum width required to ensure no net loss of all ecological values and functions, including water quality, wildlife habitat, and flood mitigation. Reducing the buffer in any area below the RMZ will result in a net loss of these critical functions, as the RMZ is based on the best available science to fully protect all riparian ecosystem values and functions. See RMZ widths via WDFW's mapping resource.

21.04.671Fish and wildlife habitat conservation areas – Mitigation standards.

WDFW does not have specific mitigation standards or ratios, but we are working on it. We would recommend more specific language be incorporated into the City's CAO to create clear and consistent mitigation parameters. If you would like assistance with this, please reach out to staff.

WDFW RMZ guidance recommends that the RMZ be fully vegetated. See Skagit County example (Title 14.24.530.1.c.i). Standard riparian buffer widths presume the buffer is densely vegetated with a native plant community appropriate for the ecoregion, consisting of an average of 80% native cover, comprised of trees, shrubs and groundcover plants. If the existing buffer is sparsely vegetated or vegetated with invasive species, the buffer must either be enhanced through an approved mitigation plan or increased by 33% or to a 100 ft minimum, whichever is greater.

The preference for on-site, in-kind mitigation should also be explicitly stated within the FWHCA section. Fish-bearing streams depend on intact, site-specific ecological functions and values (including shading, large wood recruitment, filtration, and habitat connectivity) that occur at the impact location. These functions are inherently localized and cannot be fully replicated off-site, as aquatic species rely on distributed watershed processes for survival and recovery.

While off-site mitigation or mitigation banking may provide ecological benefits in some circumstances, it often does not replace the localized functions necessary to support fish populations at a watershed scale. Allowing off-site mitigation as a primary option may also create unintended incentives for project design that accepts degradation of on-site habitat, relying instead on compensatory actions elsewhere. Code provisions should therefore prioritize on-site, in-kind mitigation except where it is demonstrated to be infeasible.

Please review WAC 220-660-080 4.b. for guidance that specifies WDFW's requirements. For more information, please review the document *State of Washington Alternative Mitigation Policy Guidance For Aquatic Permitting Requirements from the Departments of Ecology and Fish and Wildlife.*

A description of proposed riparian management zones See COM Critical Areas Handbook, Chapter 3: Structuring Critical Areas Regulations.

- one conditions and how proposed conditions will increase riparian management zone functions in terms of fish habitat protection;
- Performance standards for measuring enhancement success through a monitoring period of at least five years;
- Provisions for monitoring and submission of monitoring reports documenting riparian management zone conditions, as compared to performance standards, for enhancement success; and
- A discussion of ongoing management practices that will protect riparian management zone functions and habitat value through maintenance of vegetation density within the riparian management zone.

WDFW is pleased to see the City of Walla Walla take special care to increase their buffers, address local species of importance, and updating the CAO to incorporate best available science. We value the relationship we have with your jurisdiction and the opportunity to work collaboratively with you. We have assembled a list of land-use planning priorities and resources to help support your periodic update process. If you have any questions, need technical assistance, or resources at any time, please don't hesitate to contact Garrett LaCivita, the Land Use Lead, or your Regional Habitat Biologist.

Sincerely,



Mark Wachtel
Region 1 Habitat Manager
Washington Department of Fish and Wildlife
Mark.wachtel@dfw.wa.gov

cc: Garrett LaCivita, R1 Land Use Lead (Garrett.lacivita@dfw.wa.gov)
Tom Schirm, Asst. Regional Habitat Program Manager (Thomas.Schirm@dfw.wa.gov)
Jackie McCool, Walla Walla County Habitat Bio (Jackie.Mccool@dfw.wa.gov)
Marian Berejikian, Environmental Planner (Marian.Berejikina@dfw.wa.gov)
Ben Serr, Commerce Regional Planner (benjamin.serr@commerce.wa.gov)

City of Walla Walla Development Services

City of Walla Walla Planning Commission
Development Services
55 E. Moore Street
Walla Walla, WA 99362

CITY OF WALLA WALLA PLANNING COMMISSION
DRAFT MEETING MINUTES
Monday, September 14, 2026 – 6:30 P.M.
Hybrid Meeting – In Person and via *Zoom*
Council Chambers, 15 N 3rd Avenue, Walla Walla

1. CALL TO ORDER

Chair Williams called the meeting to order at 6:30 p.m.

2. ROLL CALL

Members Present: Jim Williams, Chair
Arlene Alen, Member
John Gahbauer, Member
Kristin Jensen, Member
Liz Jessee, Member
Jeff Strickler, Member
Jennifer Walden, Vice-Chair

Staff Present: Emily Arteche, Deputy Director
Lisa Wasson-Seilo, Sr. Planner
Jon Maland, Sr. Planner (via *Zoom*)
Pam Ransier, Administrative Permit Coordinator

Quorum was established.

3. PUBLIC COMMENT

Jeffrey Robinson – Speaking in his capacity as a private citizen, thanked the Planning Commission and staff for the work and thought put into items brought before them and expressed appreciation to each member.

RL McFarland – Although a member of the Walla Walla County Planning Commission, Mr. McFarland stated he was speaking on his own behalf. He noted that Mr. Robinson had spoken as a private citizen, but he then created a conflict when he spoke to the commissioners as a council member, thus cancelling his claim to be speaking as a private citizen.

4. APPROVAL OF MINUTES

A. Regular Meeting – August 3, 2026

Chair Williams noted a minor scrivener's error in the minutes.

MOTION: **Commissioner Jensen** moved, and **Commissioner Alen** seconded to approve the regular meeting minutes for July 6, 2026 as amended.

Motion carried 7- 0

5. OLD BUSINESS

A. Annual Code Amendments & Critical Areas Ordinance Update

Public Hearing & Commission Action

Using a PowerPoint presentation**, Lisa Wasson-Seilo, Sr. Planner**, provided an overview of the proposed annual code amendments and updates to the Critical Areas Ordinance. She noted that comment letters had been received on the amendments and these comments had been provided to the commissioners by email and distributed at the meeting.

Chair Williams opened the public hearing at 6:39 p.m. and invited members attending in person to provide their comments on the record. Using the attendance sign-in sheet, he called each person in turn.

Judith Johnson, 209 N Clinton Street, Walla Walla – Ms. Johnson spoke in largely in favor of the proposed changes [to the Critical Areas Ordinance update] but had some concerns on the implementation and maintenance of riparian areas on private property.

Casey McClellan, [no address given] – Mr. McClellan lives on Stone Creek. He asked procedural and vesting questions of staff. Mr. McClellan feels the increased buffer zones would impact their ability to build a new home on the property. He questioned development in the Urban Growth Area. [Staff noted that the hearing was on the annual code amendments, not the Comprehensive Plan and offered to speak with him on this subject at a later date].

Vicky McClellan, 1212, 1202 Pleasant Street, Walla Walla – Ms. McClellan expressed concern regarding the speed of the code amendments. She asked for greater detail of buffers as determined by best available science. Ms. McClellan noted the online map appeared blurry when increasing its size.

Christy Schoessler, 849 & 839 Abbott Rd, Walla Walla County – Ms. Schoessler noted a lack of direct notification of tonight's meeting. She spoke about her property in the county and the restrictions that will be applied once the new buffers are implemented. Ms. Schoessler expressed her dislike of the term "best available science" and the diversion of Yellowhawk Creek to Mill Creek during summer 2025. She commented on the lack of time to prepare for the changes.

Michael Murr, Miami Beach, Florida – Mr. Murr noted he did not receive direct communication from the city regarding the CAO amendments. He commented on his estimated number of properties that will have their values impacted by the change in buffer distances. Mr. Murr expressed support for slowing down the code implementation process and to look at how other cities chose to adopt a modified version, acknowledging this will cost the city more money to commission a new study specific to Walla Walla. Mr. Murr offered suggestions for how to ease the impact on residents affected by the change.

Jim Hayner, 1504 Ironwood Drive – Mr. Hayner provided a copy of a GIS map showing the areas he identified as a critical area and offered his analysis of how many homes and acres will be impacted by the CAO update. He noted a current lack of housing in the city and commented that the update will remove more housing opportunities in the city. Mr. Hayner provided a brief history of the Critical Areas Ordinance and questioned the change in current science. He provided a summary of his own research and analysis of wildlife found in and around streams in Walla Walla. Mr. Hayner concluded that wildlife in riparian areas will be safe with a 35-foot buffer.

RL McFarland, 3731 Middle Waitsburg Road, Walla Walla County – Mr. McFarland is a Walla Walla County Planning Commission member but was speaking as a private citizen. He questioned the decision to change the name of the Development Services department to

Community Development, noting it's the same department name as the county's counterpart and will confuse members of the public.

Travis Watts, 3437 Powerline Road, Walla Walla County – Mr. Watts commented on the lack of notification of the proposed change. He owns investment property at Pleasant Street/Berney Drive situated along Yellowhawk Creek. Mr. Watts explained how the proposed Critical Areas Ordinance changes would affect the number of lots in his planned subdivision, increase the costs of development, and speed up his development timeline. He would like the city to slow down the process and find exceptions to adopting the updates as presented. Mr. Watts expressed concern for homes [within the new buffer distances] that may be damaged and could not be replaced.

Jean Dolling, 708 Detour Road, Walla Walla County – Ms. Dolling gave an overview of water conservation, water use practices, annual flooding, and noxious vegetation. She encouraged people to make decisions regarding environmental practices. Ms. Dolling commented on the lack of notification about tonight's meeting. She noted that unfunded mandates often end up in litigation as the losing party.

Kip Kelly, County Commissioner, 1214 Yellowhawk Way, Walla Walla – Mr. Kelly recounted a small subdivision he platted along Yellowhawk Creek in 2022 and the money he spent on environmental and cultural resource studies required as part of his short plat process. He stated that, if his lots were not grandfathered [to the old standards] and were included in the 100-foot buffer, he would expect compensation for the monies invested for requirements at the time of his short plat application. Mr. Kelly expressed dislike for the term "best available science" and considers it insulting and overused and used as an explanation for a pre-determined outcome. He commented that all variables should be taken into consideration when determining regulations. Mr. Kelly requested grandfathering language to be included in the adopted ordinance protecting properties platted before the adoption date.

Drew Davis, 2364 Provenance Loop, Walla Walla – Mr. Davis acknowledged that much of what he planned on saying was included in a comment letter submitted to city staff. He disagreed with information provided as best available science and the resulting recommendation. Mr. Davis stated the city had latitude to deviate from the state's recommendation. Mr. Davis provided his understanding of the history of Walla Walla's waterways and his analysis of the number of homes that could be impacted by the CAO change. He recommended site specific studies due to the many variables found in the city. Citing the Growth Management Act and past land capacity analyses, Mr. Davis objected to what he considered an enhancement to local properties and encouraged further studies. Because of the proposed buffer changes, he asserted the Comprehensive Plan would be inaccurate if the changes were adopted. Mr. Davis echoed Mr. Watts' concerns about the inability to replace severely damaged structures and questioned how the property values would be affected. He recommended city staff reject its consultant's research and start anew with a different perspective, citing restrictive standards used by communities west of the Cascade mountains as a reason to re-study the area.

Barbara Knudson, 1011 Home Street, Walla Walla – Ms. Knudson currently owns a multi-acre property with creeks and ponds on it. She has no plans to build multiple homes due to city requirements to meet density standards. Ms. Knudson advocated to other homeowners that may be impacted by the proposed change to riparian buffers, for potential owners who would no longer purchase property along a creek, and for property owners who would be required to remove their existing lawns because of its proximity to the new buffer. She took exception to the number of properties at the south end of the city that are using septic systems and stated

the city should be providing infrastructure and requiring the properties to connect to city sewer.

Allen Ketelsen, 3050 Brisbane Street, Walla Walla County – Mr. Ketelsen owns a construction company. He stated that the proposed changes will impact his business and spoke about his inability to subdivide property he owns that Yellowhawk Creek bisects (this property is located outside the city limits) and other property along Russell Creek that will be impacted as well. He noted the number of his clients that will be impacted by the code change.

Chair Williams asked if anyone attending virtually would like to comment. Seeing none, he closed the public hearing at 7:39 p.m. He noted that there were two code amendments on the agenda and asked if there were any questions of staff regarding the annual code amendments.

Chair Williams asked for an explanation of the department name change. **Ms. Arteche** explained that "Community Development" was a more accurate representation of the services the department offered.

Commissioner Walden questioned the potential confusion of the city and county offices. **Ms. Arteche** responded with examples of communication and other types of public information will contain "city" in the heading.

Commissioner Jessee asked for additional information regarding a code change to 13.04 that changed the approving body from council to the City Manager. **Ms. Arteche** explained that this was a code amendment requested by Public Works and dealt with emergency situations that would require convening a special meeting by council to approve emergency connections to city utilities.

MOTION: **Commissioner Strickler** moved, and **Commissioner Alen** seconded to recommend approval of the draft 2026 Code Amendments to the City Council as presented.

Motion carried 7- 0

Chair Williams asked for commissioner comments regarding the Critical Areas Ordinance update.

Commissioner Strickler expressed his appreciation of wildlife in general and noted concern regarding how the increased buffers would impact local development. He commented on the lack of local control when jurisdictions are given state mandates that don't consider unique conditions. Citing a lack of in-depth information on how each potentially impacted property will be affected, he called for additional studies. Commissioner Strickler stated he felt the proposed buffer changes conflict with the Comprehensive Plan's ideal of infill development in the city and the Urban Growth areas. He noted that other cities have chosen to conduct their own studies and adopt their own version of the Critical Areas Ordinance, acknowledging that those cities paid for additional studies and had to legally defend their choice. Commissioner Strickler questioned if Walla Walla was pro-growth if the amendments are adopted.

Commissioner Jessee noted her agreement with other comments and concerns brought forward at the meeting by citizens and Commissioner Strickler. She proposed amending the draft ordinance to include language addressing grandfathered properties.

Commissioner Gahbauer noted his agreement with other written and verbal comments and concerns brought forward by citizens and commissioners. He noted that many streams in the area are not fish habitats and indicated there were other ways to achieve positive outcomes. Based on his own research, Commissioner Gahbauer noted that state policies provide flexibility for

jurisdictions such as City of Kenmore regarding implementing state requirements. He stated his belief that more time is needed to further study diverse options before approving the amendments.

Commissioner Jensen expressed her appreciation for attendees participating in person. She acknowledged the continually evolving science used to determine best environmental practices. Commissioner Jensen commented that she wasn't sure of how much time and flexibility the state would grant the city. She noted that the city could be better at communicating proposed changes that impact property owners and asked for greater clarification and more time regarding vesting rights.

Commissioner Alen thanked citizens for submitting comments regarding the proposed amendment. She encouraged the city to find ways to improve communication to citizens when code amendments are brought forward while acknowledging that is a difficult task due to the widely varied ways people consume information. Commissioner Alen stressed the need to review outcome data of how the proposed amendment will affect business and property owners. She asked for the approval process to be slowed and commented she would not be able to approve the amendments as presented.

Commissioner Walden asked what would happen if the code amendments were not adopted by December 31, 2026. **Ms. Arteche** explained that the city would be in direct violation of state law. **Commissioner Walden** noted her shift in understanding how the change could impact property owners upon hearing and reading testimony from citizens. She encouraged staff to change the proposed buffer requirements outlined in a comment letter submitted prior to the meeting without relying on scientific reports conducted for the city.

Chair Williams expressed his concern regarding voting on the amendments after hearing statements provided at the meeting and requested another workshop to further discuss the commission's options.

MOTION: **Commissioner Strickler** moved, and **Commissioner Jessee** seconded to recommend city council direct Development Services to revise the draft Critical Areas Ordinance to align with infill and Urban Growth Area goals of the Comprehensive Plan following available science matching local conditions, also taking into consideration the Washington statute allowing a city to adopt critical area regulations that can depart from science-based recommendations on the basis of legal, social, cultural, economic, and political information.

Motion carried 7- 0

6. STAFF UPDATES

Staff proposed cancelling the October meeting as there are no work items ready to present at that time, and asked for a formal motion.

MOTION: **Commissioner Walden** moved, and **Commissioner Alen** seconded to cancel the October 5, 2026 Planning Commission meeting.

Motion carried 6 - 1

- Bath & Bodyworks at the Town Center is slated to open October 3, 2026.
- WinCo anticipates opening to the public by late October.

7. ADJOURNMENT

MOTION: **Commissioner Jensen** moved, and **Commissioner Jessee** seconded to adjourn.

Motion carried 7- 0

Meeting adjourned at 8:10 p.m.

Angelica Escalante

From: Howard Boggs <1955whb@gmail.com>
Sent: Wednesday, August 26, 2026 2:36 PM
To: Permits
Subject: comments regarding proposed Critical Areas Ordinance changes

My comments that follow are in regards to the proposed riparian buffer and setback.

1. The majority of the land in the city that is adjacent to the streams is already developed. A lot of the development was prior to any stream setbacks. The balance was with the current setbacks. The result is most of the developed land has improvements that would not be allowed under the proposed changes. Further development of these lands will be a challenge, likely resulting in less infill. The undeveloped land will also be impacted resulting in less infill parcels. I doubt the future riparian buffer areas will improve enough to offset the loss of infill parcels.

2. The existing buffer setback is 5'. The proposed new setback is 15'.
With the buffer increasing from 35' or 50' to 100', why make if worst for property owners by making the setback bigger. I suggest a 0'
setback. If that can't work, then keep it at 5'.

Thank you,

Howard Boggs

2549 Sandalwood Court

509-386-6207

September 11, 2026

Walla Walla Planning Commission
City of Walla Walla
Walla Walla, Washington

RE: Proposed Updates to Critical Areas Ordinances

Dear Members of the Walla Walla Planning Commission:

We recognize that the Washington State Growth Management Act requires jurisdictions to periodically review and update their critical areas regulations. We appreciate the city's work to meet these requirements while balancing environmental protections with the needs of property owners, builders, and the broader community.

As the city moves forward with these changes, we respectfully ask the Planning Commission and City Council to consider delaying implementation of the updated Critical Areas Ordinances until the end of the year. Providing additional time before the new regulations take effect would allow builders, developers, property owners, and other affected stakeholders to better understand the changes, evaluate their impacts on existing and planned projects, and adjust accordingly. A reasonable transition period can help prevent unnecessary disruptions to projects already in the planning or development process.

We would also like to raise concerns regarding the Washington Department of Fish and Wildlife's recommendation for a 100-foot buffer under its Best Available Science guidance. We understand and support the importance of protecting critical areas and fish and wildlife habitat. However, it is also important to recognize that WDFW's proposed buffer is a recommendation rather than a statewide mandate requiring the city to adopt a 100-foot standard.

The difference between a 75-foot and 100-foot buffer can be significant for individual properties and development projects. Increasing these setbacks can affect usable lot area, lot configurations, development feasibility, and ultimately the number of homes that can be constructed. At a time when communities throughout Washington are working to increase housing supply and improve housing affordability, we believe these impacts deserve careful consideration.

We encourage the city to evaluate the approaches being taken by other local jurisdictions when determining what standards are appropriate for Walla Walla. For example, the City of Kennewick's draft critical areas regulations associated with its Comprehensive Plan update continue to utilize 75-foot buffers for fish-bearing streams and 50-foot buffers for non-fish-

bearing streams. This demonstrates that communities can consider Best Available Science while developing regulations that reflect local conditions and balance environmental protection with housing and development needs.

The Home Builders Association of Tri-Cities and Walla Walla supports responsible growth and appropriate environmental stewardship. At the same time, we believe regulations should be locally appropriate and carefully evaluated for their potential effects on housing availability, property rights, and development feasibility.

We respectfully ask the Planning Commission to consider both of our requests as it reviews the proposed ordinance: provide a transition period by delaying implementation until the end of 2026, and carefully evaluate whether a 100-foot buffer is necessary and appropriate for Walla Walla rather than adopting the WDFW recommendation without consideration of reasonable local alternatives.

Sincerely,

Bailee Butcher
Executive Director/CEO
Home Builders Association of Tri-Cities and Walla Walla

TARRAGON NORTHWEST

September 11, 2026

City of Walla Walla Planning Commission
Walla Walla City Council
c/o Development Services Department
55 E. Moore Street
Walla Walla, WA 99362

Re: File PLN5-26-0001, 2026 Critical Areas Ordinance Amendments
Proposed 100-foot riparian buffers, WWMC 21.04.650 and Table 6

Dear Commissioners and Council Members:

I am writing on behalf of Tarragon NW, a Walla Walla based real estate investment and development company. I am submitting this letter for the September 14th Planning Commission hearing and ask that it be entered into the record and carried forward to the City Council workshop and to the Council's eventual action on this ordinance.

I understand that the required comprehensive plan update is a broad process involving review and consideration of numerous elements under the Growth Management Act (GMA), and that it will result in several changes to the City's plans and development regulations. My comments concern the proposed changes to the City's critical area ordinance, and more specifically the increase of the minimum riparian buffer for the City's creeks, including intermittent open channels (other than Mill Creek) from 35 or 50 feet to 100 feet on each side, together with the increase of the building setback from the buffer from 5 feet to 15 feet. I ask the Commission and Council to consider two things. First, I believe the City Council has meaningful discretion in how it incorporates best available science into its critical areas regulations. The GMA requires the City to include and meaningfully consider that science, but it does not require the City to simply adopt a state agency's recommended buffer without considering its local applicability and weighing other relevant factors. Second, if the City does move toward larger buffers, the ordinance itself should have more detail and flexibility.

I want to be clear at the outset that none of this is a criticism of Development Services staff or the City's consultant. They are carrying a large 2046 workload on a statutory clock, and the draft reflects the recommendation the City received from the state agencies. My concern is with that recommendation and with the policy choice in front of you, which is the Commission's and the Council's to make.

The City has discretion in applying the state guidance. The staff report categorizes the buffer increase as "State Mandated, RCW 36.70A.172." I read the statute more narrowly than that label suggests. It says the City "shall include the best available science in developing policies and development regulations to protect the functions and values of critical areas." That is a substantive obligation, but it does not require the City to adopt a particular buffer width recommended by a state agency. In fact, the implementing regulations expressly contemplate weighing best available science with other relevant factors and require state agency scientific information to be reviewed for local applicability.

The Department of Commerce rule that implements this statute says so directly. WAC 365-195-915(1)(c) contemplates that a city may adopt critical areas regulations that depart from science-based recommendations on the basis of "legal, social, cultural, economic, and political information," provided it identifies the information in the record that supports the decision, explains its rationale, and identifies the risks to critical area functions

and any measures chosen to limit those risks. That is a recognized path under the Growth Management Act, not a violation of it.

WDFW's own guidance reinforces this distinction. Its August 28, 2026 comment letter in this packet describes WDFW's role as "that of technical advisor." Its Riparian Ecosystems, Volume 2 states that the document "is not, in and of itself, science. Rather, it consists of policy recommendations," and acknowledges that "considerations other than fish and wildlife will be incorporated into land use decision making." Even on the specific question of Table 6, WDFW's letter describes a 100-foot buffer as one that "may be compliant" with its guidance. That is materially different from saying a uniform 100-foot buffer is required by state law. WDFW is providing technical guidance for the City's consideration, not imposing a legislatively mandated buffer width.

The GMA also does not put one goal above the others. RCW 36.70A.020 directs the City to balance urban growth, reduced sprawl, housing, economic development, property rights and the environment, and RCW 36.70A.3201 tells the Growth Management Hearings Board to defer to local choices about how to do that balancing. The Legislature reinforced the housing side of that balance with HB 1220 and the housing element planning requirements now in RCW 36.70A.070(2), which the 2046 Comprehensive Plan is built around.

Scale and impact of proposed change.

The staff report and the SEPA addendum contain no estimate of how much developable land, how many housing units, or how much assessed value is removed by the buffer increase. The SEPA determination rests on the 2018 Comprehensive Plan FEIS, which never analyzed a 100-foot buffer, and concludes there is no significant impact. The housing capacity assumptions in the 2046 plan were built on today's 35 and 50-foot buffers. If the City adopts 100 feet, the land supply that plan counts on is smaller than the plan says it is, and that gap has not yet been measured.

I have attempted to put the scale of this change into simple terms. A 100-foot buffer on each side of a creek creates a 200-foot-wide corridor. One acre is 43,560 square feet, meaning every 218 lineal feet of creek places approximately one acre within the buffer. Add the proposed 15-foot building setback on each side and the total corridor grows to 230 feet, or roughly one acre for every 189 lineal feet of creek. Compared to the current 35-foot standard, the increase alone adds approximately one acre of buffer for every 335 lineal feet of channel. For waterways currently subject to a 35-foot buffer, moving to 100 feet represents approximately a 186% increase in buffered land area. Even compared to the current 50-foot standard applicable to portions of Yellowhawk Creek, moving to 100 feet doubles the buffered land area, a 100% increase.

Walla Walla's indigenous name means "place of many waters," and the ordinance applies corridors of Yellowhawk, Russell, Reser, Caldwell, Stone, Garrison, Bryant and Titus Creeks and to "others within city limits/UGA including intermittent open channels between piped sections." Few cities in the state have as many miles of regulated channel running through their developable core as Walla Walla. Before it adopts this standard, the City should measure the lineal feet of regulated channel inside the city limits and UGA, translate it into acres and housing units, and put that number in the record.

The consequence of removing otherwise developable land inside the existing UGA is a reduction in the City's capacity to accommodate its share of projected growth. That places additional pressure on the remaining land supply and makes the City's own goals for infill, efficient land use, and housing production more difficult to achieve. At a minimum, a regulation with this magnitude of impact should be evaluated against those competing GMA objectives, rather than considered solely through the lens of critical areas protection.

How this applies to the creeks of Walla Walla.

WDFW's 100-foot figure is a floor it applies when the site-potential tree height or the riparian vegetative community is narrower than 100 feet. The site-potential tree height model comes from forested ecosystems. WDFW's own Volume 2 acknowledges that in dryland ecoregions like ours the riparian community is "often comprised of shrubs, sedges, grasses, and forbs," and in that setting it recommends protecting the existing riparian vegetative community. The 100-foot line is a default that stands in for site science, not a measurement of anything on the ground in Walla Walla.

The City's own Table 6, which is being struck, shows what is on the ground: existing riparian averages of 14 feet on Bryant Creek, 20 feet on Stone Creek, 21 feet on Russell Creek, 24 feet on Garrison Creek, 25 feet on Titus Creek and 31 feet on Yellowhawk Creek. Inside the city limits these streams have been piped, relocated, straightened and channelized. Streets and bridges cross them. Along most of their length there are homes, garages, commercial buildings and parking lots within 100 feet of the water, a great many within 50 feet, and many built right up to the bank, because they went in decades before any buffer standard existed. That is the condition the ordinance would regulate.

So the question the Commission and Council should ask is a plain one: what, specifically, is a 100-foot buffer protecting inside the city limits of Walla Walla? Does moving the line from 35 or 50 feet to 100 feet produce a material gain in ecological function, or does it simply remove the remaining opportunity for growth in the one place the Comprehensive Plan says growth should go? For example, placing a 100-foot buffer over a 20-foot functional corridor does not protect a function that exists. It is a restoration program, paid for by whichever landowners happen to own the property, and there is no science in this record showing that those scattered infill parcels will ever deliver the riparian function the buffer width assumes.

The current tiered, reach-by-reach approach in Table 6 was itself adopted on a best available science basis in 2010, with widths matched to the targeted function of each reach. That is closer to what WDFW's guidance actually describes for dryland streams than a single citywide number is. It is also worth noting that Mill Creek, the main stem, carries a 35-foot buffer under the Shoreline Master Program while its tributaries would carry 100 feet under this ordinance.

If the goal is anadromous fish, the places where a 100-foot buffer protects an intact function are the undeveloped reaches in the County, not the reaches inside the city where the Comprehensive Plan is asking for infill. The City should direct its effort there and work with the County and the Conservation District on those reaches, rather than spend its own housing supply on buffers that will not perform.

Effect on existing property owners.

The buffer increase is usually discussed as if it only affects new development but there are broader implications. There are thousands of homes and structures in this city that sit within 100 feet of a creek. Many of them comply with the current 35 or 50-foot standard but many are even closer. The day this ordinance takes effect, every one of those homes becomes a nonconforming improvement inside a buffer in which, under 21.04.650(C), "all structures and activities shall be located outside of the riparian habitat buffers."

The draft does not yet address what that means for those owners. The only relief in the code is 21.04.085(B)(2), which allows maintenance and repair of existing buildings "provided that the activity does not further alter, impact, or encroach upon" the buffer. That leaves a lot of questions unanswered. If a house that is now inside the 100-foot buffer burns down, can the owner rebuild it on the same foundation? Can an owner add a

bedroom, a garage or a second story? Can they pour a patio, build a deck or replace a shed? Does a lender or insurer treat a nonconforming structure in a critical area buffer the same way it treats a conforming one? Does a nonconforming label follow the property through a sale, and what does it do to the value and the marketability of the home? A large number of people in this community will find themselves inside a line they had no reason to expect would move, and I do not believe the full effect on them has been weighed yet.

Consider alternatives.

I am not asking the Commission or Council to adopt a particular alternative. I am asking you to look critically at whether the proposed language, and particularly the uniform 100-foot minimum, is the right answer for Walla Walla. The existing reach-based Table 6 has been in place for years. Before replacing it with a standard that represents such a significant increase, I encourage you to ask what is not working with the current approach, whether an increase of this magnitude is necessary, and whether retaining the existing standards or considering a more modest change would better balance the many objectives you are charged with weighing. The ultimate policy decision belongs to you, and I encourage you to exercise that judgment carefully before adopting a change of this magnitude.

Clarity in the Ordinance.

At the August 3 workshop, staff stated that projects already underway would not be subject to the new standards and that existing structures would be grandfathered with no retroactive enforcement. I appreciate that statement and feel it should be reflected in the ordinance, not in the minutes. I know many property owners who are left scrambling trying to figure out what this means for their ability to use or develop their property. To provide clarity, I ask that the ordinance include the following:

1. A transition and vesting section stating that any application that is complete before the effective date of December 31, 2026 is reviewed under the critical areas regulations in effect on the date it was complete. This is consistent with RCW 58.17.033 and RCW 19.27.095.
2. A lots-of-record provision stating that building permits on lots within a recorded final plat or approved binding site plan, where the plat or its critical areas review identified the building areas and the creek, are reviewed under the buffer standard in effect when the final plat was approved. Those lots were sized, priced and sold on that standard.
3. Strengthening and adding of the flexibility tools like the functionally disconnected buffer provision, buffer averaging, and the Director's authority to reduce buffers with enhancement under Table 7. Are there more tools that can provide greater flexibility?
4. Language about treatment of non-conforming structures that answer the questions above. Provisions to allow existing lawful structures within a buffer to be maintained, repaired, rebuilt after casualty, and reasonably expanded on the landward side or within the existing disturbed area, without a critical area report, and how accessory improvements such as decks, patios, pools and outbuildings on already-developed lots are treated.
5. A reasonable use exception in 21.04.090 that works for small infill lots, where the buffer would otherwise consume the entire buildable area, without requiring a variance.

This is a legislative decision, and it will shape where Walla Walla is able to grow. I ask the Commission and the Council to take it seriously and to remember that the state has handed you a recommendation and a process for weighing it, not an order.

Thank you for your consideration.

Sincerely,

Drew Davis



President, Tarragon NW

cc: Emily Arteche, Deputy Director, Development Services
Preston Frederickson, Deputy City Manager
Jon Maland, AICP, Senior Planner

Members of the City of Walla Walla Planning Commission and City Council:

I'd like to raise a concern about the stream buffer standards currently being proposed by Washington State Fish & Wildlife as part of the current review of the City and County Critical Area Ordinances — not to argue against protecting our waterways, but to encourage more complete framing of what this policy proposal actually represents. I have attached a copy of WDFW's own explanation of it's proposed policy, **2025 Riparian Management Zones Map: A User Guide for Local Governments from WDFW's Priority Habitats and Species Program,** as published on the WDFW web site.

As proposed, the required buffer on both sides of all streams, creeks, as well as man made, seasonal irrigation water features that dry up after the season, will be SPTH200, the height of a native 200 year old tree, determined by WDFW to be 100', which represents a 50' to 65' increase to previously established standards. The proposed standard, SPTH200, the presumed height of a native 200 year old tree, is described as if it were a precise, scientifically derived measurement of the "correct" buffer width for every stream. In reality, it apparently primarily originated from a study of specific streams in the wet, sloped, forested Cascade and Coast Ranges of Oregon and Washington. While being genuinely useful information — it's a description of conditions in one type of forest ecosystem, not a general formula proving that a buffer must equal exactly one specific tree height to protect a stream in every ecosystem in Washington State. In addition, when there is no nearby 200 year old tree that reaches 100', WDFW proposes that the default buffer width becomes 100' anyway. Not exactly site specific nor science-informed.

Even WDFW's own guidance acknowledges this nuance: the agency states that Volume 2 of its riparian ecosystems report represents policy recommendations based on the science, **not the science itself**. WDFW is transparent that applying SPTH200 as a regulatory standard is **a policy choice**— a conservative, protective one, but a choice nonetheless.

This willingness to go beyond strict scientific consensus is visible elsewhere in WDFW's own recent guidance. In its 2025 Riparian Management Zones Map user guide, the agency states plainly that it recommends protecting the entire stream network — **including non-fish-bearing streams** — because it **found no science justifying weaker protection for those streams**, and it explicitly acknowledges that this recommendation **departs from widespread practice elsewhere of applying narrower buffers to non-fish-bearing streams.** Once again, not exactly site specific nor science-informed.

I raise this not to criticize the recommendation itself, but to highlight that WDFW is properly transparent in stating that its own proposed standard is a policy judgment that goes beyond, and diverges from, common practice — not a settled scientific consensus that other jurisdictions have simply failed to catch up to.

I'd also note that the tree-height method was primarily developed in wet, sloped, forested landscapes in the western part of the state. Applying it uniformly to different ecological settings — drier regions, different soil types, different topography, different vegetation communities — extends a coastal-forest-derived standard well beyond the conditions it was originally studied in, without independent validation on those drier settings affected.

Conservative, protective buffers are reasonable public policy, especially for salmon recovery and water quality. But I'd ask that our local planning materials and public discussions describe and consider SPTH200 accurately: as a policy choice with a specific origin and scope — one that the issuing agency itself acknowledges departs from common practice in places — not as an unambiguous scientific fact. That distinction matters, because it affects how much flexibility should be built into local ordinances for site-specific review, alternative mitigation, or variance requests — flexibility that's harder to justify if the standard is presented as scientifically absolute rather than as a reasonable-but-debatable policy judgment.

I would also ask that such policy discussions include consideration of non-scientific issues such as private property rights, compensation for property designated as a needed buffer zone, and relief from the ongoing imposition of property taxes on property taken for use as such buffer zones.

Thank you for your attention to this matter.

Dave Campbell

⚠ Check our wildfire information page (/about/wdfw-lands/wildfire) for fire restrictions and wildfire-related closures before you visit WDFW-managed lands.

Washington Department of FISH & WILDLIFE

2025 Riparian Management Zones Map: A User Guide for Local Governments from WDFW's Priority Habitats and Species Program

Category:
Priority Habitats and Species (/publications?category=26217)

Published: Nov. 17, 2025

Revised: Dec. 15, 2025

Pages: 28

Author(s): Keith Folkerts, Ken Muir, Julia Michalak, PhD

Download document (PDF) (/sites/default/files/publications/02671/wdfw02671.pdf)

Overview

Riparian areas occupy the transition zone that begins at the stream's edge and extends upland. These areas provide habitat to an estimated 85% of Washington's terrestrial vertebrate species, and riparian vegetation provides critical ecosystem functions that support and protect instream health. Protection of these areas is especially important for salmon recovery efforts, and other decision-making affecting threatened or endangered species. For these reasons, WDFW identifies riparian habitat as a Priority Habitat and recommends that local governments designate and protect Riparian Management Zones (RMZs) as a Fish and Wildlife Habitat Conservation Area (FWHCA), a type of critical area under the Growth Management Act.

After extensive review of available evidence, WDFW identified a method to define the upland RMZ boundary according to the lateral distance over which essential riparian functions are provided. This Site Potential Tree Height at 200 years ($SPTH_{200yr}$) is the estimated average height attained by dominant trees in that location after 200 years of growth. In addition to serving directly as shelter and sustenance to many species, trees contribute shade, leaf litter, and large woody debris to streams; they also reduce pollutants, attenuate destructive overbank flooding, and enhance many forms of recreation along watercourses. In addition to these functions, intact RMZs also provide direct benefits to surrounding communities by filtering pollutants, stabilizing streambanks, reducing flooding, and supporting overall watershed resilience. Tree height therefore provides a generalized yet flexible means to estimate the distance over which riparian functions are provided.

The $SPTH_{200yr}$ estimate is obtained by identifying the tallest species of tree growing in the area and the soil type. The RMZ's width is a distance of one $SPTH_{200yr}$ measured from the stream's bankfull width, active floodplain, or outer edge of the channel migration zone (CMZ), whichever is wider. In places where tree height is less than 100 feet, the RMZ width is set to a minimum distance of 100 feet to account for the pollutant removal function provided by RMZs. As described in Riparian Ecosystems Volumes 1 and 2, a 100-foot RMZ typically provides 95% pollution removal for phosphorus, sediment, most pesticides, and approximately 85% for surface nitrogen. Because we found no science that justified lesser protections for non-fish-bearing streams, we recommend that RMZ protections be provided to the entire stream network – this is a departure from widespread practice of protecting a narrower RMZ for non-fish-bearing streams.

The PHS RMZ map is intended to provide local jurisdictions with estimated locations of RMZs delineated based on a $SPTH_{200yr}$ standard to support the designation and protection of critical areas. The map was created using best available scientific data estimating stream locations, likely tree species, and the maximum tree height at 200 years for streams across all of Washington. ***The map represents estimated locations only and site-scale delineation of an RMZ critical area requires field verification.***

Suggested citation

Folkerts K, K. Muir, J. Michalak. 2025. PHS Local Government User Guide: 2025 Riparian Management Zones Map. Habitat Program, Washington Department of Fish and Wildlife, Olympia.

Pamela Ransier

From: Michael Melder <meldergt@gmail.com>
Sent: Monday, September 14, 2026 4:50 PM
To: Permits; Pamela Ransier
Cc: Michael Melder
Subject: Critical Areas Comments

Good Evening,
Thank you for the opportunity to provide my personal commentary on the draft critical areas ordinance code updates. I am a licensed professional civil engineer in Washington state and have spent the last 14 years of my career working in Walla Walla. In reviewing the existing code and draft code updates there are several sections that will be detrimental to development within the City of Walla Walla.

Overall my two main concerns in review of the Draft Code are below.

1. It appears the author's focus when rewriting this chapter was on specific "Critical Areas", and not the entirety of "Critical Areas" as defined in the Code. The focus appears to be around water bodies, drainages, streams, wetlands, or associated buffers. However, the underlying City's Municipal Code defines a Critical Area below.

   "Critical areas"
   include any of the following areas or ecosystems: aquifer recharge areas, fish and wildlife habitat conservation areas, frequently flooded areas, geologically hazardous areas, and wetlands, as defined in Chapter **36.70A** RCW and this chapter.

   This definition, a review of the City's Critical Area Maps, and a review of the Code shows that nearly 100% of the City of Walla Walla falls within a single, or multiple, defined Critical Areas making all property within any Critical Area subject to the existing code and future code amendments.

2. What are the economic impacts associated with property valuations and taxes for properties that are now further encumbered? Has the Walla Walla County Tax Assessor and the City of Walla Walla conducted an evaluation of the potential tax liability associated with this change?

In addition to my two overall concerns about the author's intent and Draft Ordinance – the City's website (Critical Areas Ordinance | City of Walla Walla) has other language/statements that is not readily identified in the Code update.

Website Statement -
Walla Walla is in a dryland ecosystem. Within dryland ecosystems, WDFW's new science calls for cities to set a site-specific Riparian Management Zone (RMZ) area with a 100-foot minimum width of existing riparian vegetation, whichever is greater. This distance is generally needed to remove most pollutants and protect water quality. The state's mapping tool shows where this 100-foot RMZ should be applied. Overall, following this new BAS will significantly increase buffer width requirements for both fish-bearing and non-fish-bearing streams in Walla Walla.

Comments –
1. Where is an RMZ defined in this code? I do not see any references to RMZ being defined or delineated in the Draft Ordinance.
2. What is the maximum width of an RMZ identified within the City of Walla Walla? The maximum width reference is in regards to the statement on the City's website noting - "whichever is greater".

Comment – Can the City please provide definitions to the following based on language in the code.

Define “Reasonable Use”
Define "Reasonable Economic Use"
Define a "Trail Corridor"

Chapter 21.04.085(B)(2-3, 7-23) Critical Areas – Allowed Activities
Comment – The allowed uses generally appear to be associated with maintenance, or non-invasive uses, in and around water bodies. If a use is not outright allowed, is it disallowed? There are a host of uses within the defined Critical Areas inside city limits that are needed such as Commercial, Residential, and Public uses that need to be allowed without the need for professional studies or approval by the Director. This section does not reference other Allowed Uses as defined in 21.04.220.

Chapter 21.04.085(B)11)–

Comments –

1. Is the above Allowed Use for Minor Sitework applicable to All Critical Areas?
2. Minor Site Investigation that displaces more than 5 cubic yards of material shall require submittal of specific plans and restoration plans.
   As a point of emphasis a typical geotechnical test pit (2x6x12) is in excess of 5 CY.

- What is the “Specific Plans and Restoration Plans” required? This creates a substantial burden on our geotechnical engineers and due diligence and obtaining advance approvals.
- Is this 5 CY value cumulative for Minor Site Investigative Work, per project, per discipline/individual action performed?
  - IE – If a single test pit is excavated that is beyond 5 CY, other minor work listed is now responsible for “Specific Plans and Restoration Plans”?

3. How does damage to native trees/plants/shrubs in Critical Areas viewed when it comes to clearing property lines, locating/establishing project boundaries, pins, etc.?

Chapter 21.04.090(B)(2-3)
Comments –

1. Define what is to be included in an Exception Request. The terms used in this section are very subjective, "including mitigation plan, if necessary," and "any other related project documents", "special studies" are too vague to understand, and/or scope for a project.
2. The exception is at the sole discretion of the "Director". What is the appeal process if applicant disagrees with the "Director"? Is the "Director's" decision binding?

...the applicant demonstrates that other permitted uses in the areas that have less impact on the critical area and buffer are not technically feasible as an alternative."

Comment –

1. Who determines if the Applicant demonstrates sufficient information?

...to allow for reasonable economic use of the property; and upon request, the director may require the applicant to provide a neighborhood analysis that evaluates the surrounding conditions in the immediate vicinity to verify that the applicant's request is consistent with the minimum necessary reasonable use criteria.

Comments –

1. What is the scope of a neighborhood analysis and who is the qualified professional that can prepare this document?
2. What are the "Minimum necessary reasonable use criteria"?

Chapter 21.04.085(B)(2-3)9.d. -

“Sensitive area and/or buffer widths shall be increased, where possible, equal to the width of the trail corridor, including disturbed areas; and”

Comment – See above request to define a “Trail Corridor”.

Chapter 21.04.130(A)
Comments -

- Are all future building permits subject to a critical areas report given the presence of one or multiple critical areas encompassing the vast majority of the City of Walla Walla and it’s UGA?

Chapter 21.04.200(B) –
Comments

1. The 10-year time of travel is considered a CARA by the City of Walla Walla. This is classified as a Critical Area.
2. How are allowed uses such as Commercial, Industrial, and Residential Uses defined for this area?
3. How are the impacts to Walla Walla County being addressed based on the City’s Code for this section? The CARA effectively goes to the ridge of the Blue Mountains in encumbers substantial property outside the City of Walla Walla.

Chapter 21.04.320(B)(3) –
Comments –
Note the statement in this chapter “…and other critical areas…”. Are citizens required to do complete critical areas studies for all projects within 250’ of any critical area?

In closing, it would appear that the wording and updates to this code chapter have been hasty and without a full understanding and appreciation of the impacts social, environmental, economic impacts. I would like to see further study to address the above concerns and further clarifications added to the code to avoid unforeseen hardships on the citizens of our community.

Respectfully,

Michael Melder, PE
Civil Engineer

9/14/2026

Re: Proposed Critical Areas Ordinance Amendments

Dear Council Members and Commissioners,

I support the City's efforts to protect critical areas and the environmental functions they provide. My concern is with establishing a blanket 100-foot minimum buffer without adequately considering site-specific conditions and the significant impacts this change could have on individual properties.

The City has indicated that the proposed amendments are based on Best Available Science. I believe it is important to distinguish between the scientific recommendations and the City's decision to establish a uniform 100-foot development restriction.

WDFW's methodology recognizes that riparian areas should be evaluated based on site-specific conditions, including vegetation, soils, topography, and habitat functions. Property owners should have an opportunity to demonstrate the appropriate buffer based on the actual conditions present on their property.

Impact on Existing Homes and Property Owners

The City should also consider the impact on existing homes and homeowners, not just future development. A new 100-foot buffer could significantly restrict reasonable improvements such as additions, remodels, garages, accessibility improvements, and other necessary changes.

A homeowner who purchased property under the existing regulations should not unexpectedly lose a substantial portion of the property's reasonable ability to be improved simply because the regulations have changed.

Citywide Housing and Growth Impacts

The City should also evaluate the cumulative impact of a 100-foot buffer across Walla Walla. With numerous waterways and areas potentially affected by critical-area regulations, this requirement could affect a significant amount of otherwise developable residential land.

This could conflict with City goals for residential density, infill development, affordable housing, avoiding urban sprawl, and efficient use of existing streets and utilities. Protecting critical areas and accommodating growth should not be viewed as competing objectives.

Notice to Affected Property Owners

I own a vacant parcel that is substantially affected by the proposed 100-foot requirement. I only became aware of the proposed change about a month ago and learned about it through another individual rather than through direct communication from the City.

I understand that the City has provided public notice through its established process. However, with the City intending to adopt the ordinance in October, affected property owners have very limited time to understand the proposal, evaluate its impact, obtain professional advice, and meaningfully participate.

I respectfully ask the City to identify properties that may be substantially affected and provide those owners with additional notice and a reasonable opportunity to participate before the ordinance is finalized.

Property and Development Impacts

The proposed requirement could have significant consequences for property rights, housing, lot configuration, development costs, and project feasibility.

On my property, the proposed change could materially alter the development potential and configuration, potentially resulting in the loss of 15 residential lots and threatening the economic viability of the project.

I believe there are reasonable alternatives that could achieve the City's environmental objectives while providing greater flexibility, including:

- Site-specific buffer determinations;
- Buffer averaging;
- Mitigation where appropriate;
- Reasonable provisions for improvements to existing homes; and
- Protections for projects that have already vested or made substantial investments under existing regulations.

Request for Additional Review and Time

I respectfully request that the Planning Commission not recommend adoption of the blanket 100-foot minimum without additional review.

I am not asking the City to weaken environmental protection. I am asking the City to ensure that the regulations follow the science, allow for site-specific evaluation, provide meaningful notice to affected property owners, and balance environmental protection with the impacts on private property, existing homeowners, housing, and development feasibility.

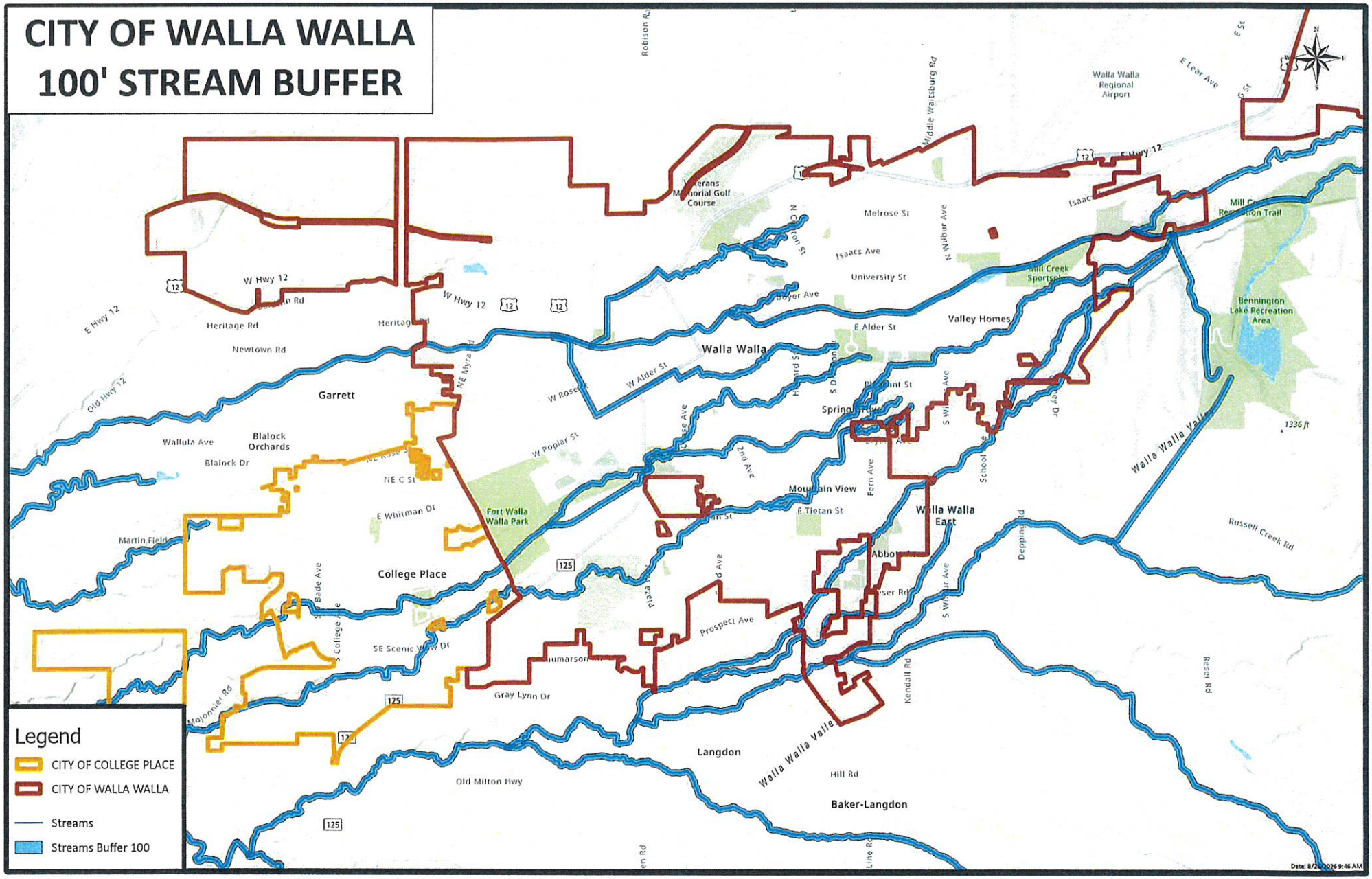
Thank you for your consideration.

Sincerely,



Travis Watts
3437 Powerline Road
Walla Walla, WA 99362
509.386.0955

CITY OF WALLA WALLA
100' STREAM BUFFER



Over 1400 lots and/or parcels affected

100' Buffer on all waterways covers over 1000 acres

SERENITY POINT
WHERE THE PATH TO PEACE BEGINS

410 S Wilbur Ave. Walla Walla, Wa. 99362
phone. (509) 529-6036
email.Info@SerenityPointCounseling.com
SerenityPointCounseling.com

Opposition to Proposed Critical Areas Ordinance

This letter comes in opposition to the proposed Walla Walla Critical areas ordinance, that will, if approved, will increase properties that have waterways from a 35-foot to 100-foot buffer zone. This proposed buffer zone would infringe on property owners' rights and freedom to what we can or cannot do on our own property.

Serenity Point Counseling Services, LLC, purchased our property in March 2020 with assistance from Washington Department of Commerce via Senate Bill 6248 with the specific goal of expanding behavioral health services in the city and county of Walla Walla.

Our property, 410 S Wilbur Ave., has a portion of Garrison Creek that runs through it. Half of the property is used for our behavioral health services, and the other half is a vacant lot. In 2022, to continue our expansion, the owners of Serenity Point began working with the City of Walla Walla and the Department of Commerce to divide our property in half with the goal of developing sixteen (16) affordable housing units.

Through the City of Walla Walla pre-application process, engineering and architectural services Serenity Point has invested $44,914.50 into our project. As a requirement by the City of Walla Walla, to authorize the dividing of our property line running North to South, Serenity Point was required to construct an east to west public sidewalk along the fenced northern perimeter of our property. With permits, a Bond, construction of the sidewalk and replacing our fence Serenity Point invested another $87,238.76. Finally, after the property division, Serenity Point paid $85,350 to the Department of Commerce plus filing fees to release all interest for the vacant lot portion of the property to Serenity Point. In total Serenity Point has invested $217,503.26 in our goal to create these 16 units.

The property division was finalized on August 24, 2026. The following week Serenity Point Ownership was notified of the proposed critical areas ordinance and were encouraged to schedule another pre-application meeting with City of Walla Walla officials.

At this meeting we were informed that in order keep our project vested under the current ordinances that we would be required to amend our current short plat that will require additional engineering services, an updated SEPA report and as of late last week City officials decided that we would also need to provide a Critical Areas report. All that needed to be completed by and presented by September 15, 2026, to keep our project vested under the current ordinance.

Because of the short turnaround time, the indecisiveness of city requirements for the amended short plat and capital turn around, Serenity Point was unable to meet the September 15 time frame so as a result a change in the proposed ordinance will have a significant and dramatic impact with a reduction of the developmental area of our property and four years of planning,

SERENITY POINT
WHERE THE PATH TO PEACE BEGINS

410 S Wilbur Ave. Walla Walla, Wa. 99362
phone. (509) 529-6036
email.Info@SerenityPointCounseling.com
SerenityPointCounseling.com

preparing and investment on our project that would bring much needed affordable housing to our community.

We present this historic overview as an example and emphasize how this proposal to change the current ordinance will impact on us and other property owners that share in the beauty of our property and water ways, if implemented.

In conclusion, we request our City Council to recognize how these proposed critical areas ordinance will infringe on our rights and freedoms and to oppose this change and protect us, the property owners.

Submitted With Respect, on this 21st day of September 2026

Patrick C. Flores, Managing Member
Serenity Point Counseling Services, LLC

To: Members of the Walla Walla City Council
From: James K. Hayner
Date: September 22, 2026
Re: Critical Area Ordinance

I have become quite interested and very concerned about the new proposed Critical Area Ordinance. I appeared and spoke at the public hearing at the Planning Commission. I also participated by zoom in the City Council's recent work session. It is clear to me that the City Planning Department has fully adopted the idea that Walla Walla must utilize 100-foot buffers. The staff has hired a consulting firm which has this same predilection. The city staff seems to have either ignored or avoided considering the significant economic impact that a 100-foot buffer zone would have on the city and its citizens. I believe that the city staff is making a decision more on an ideological basis than one based on what is best for the city, one anchored by the best local science and health of our city's riparian areas.

There are other cities which are refusing to adopt 100-foot buffers as the default, and are either completing their own studies, or making much more flexible methods of using smaller buffer areas. I understand that Bellevue and Kennewick are each adopting a critical ordinance with significant flexibility for landowners. I know that the city of College Place is taking the position that they are very happy with the riparian health around streams and they are not going to adopt a 100-foot buffer. I suspect that there are other cities around the state which are also challenging the 100-foot buffer as it applies to their local jurisdictions.

The Planning Commission recommendation did include a phrase that the city staff should explore the best available science for our local area. But, as was evident at the work session, the city staff paid no heed to the City Planning Commission recommendation and instead has resisted any change or modification from a full 100-foot buffer.

The magnitude of harm by adopting a 100-foot buffer zone in Walla Walla is significant. The city staff identified over 42 miles of riparian water rights. This relates to over 1,100 acres of land. One section of land consisting of 640 acres is one mile square. Now drop two parcels of 1 mile square each on any map of the city of Walla Walla and you will see the significant impact on the city. The study by the consultant indicated that the buffers adopted by the city should have no net loss of riparian area from any prior buffers. In fact, the consultant has opined that by adopting a 100-foot buffer in Walla Walla, there would be a 70% gain of riparian areas. This means that of the 1,100 acres affected by such a 100-foot buffer, 700 to 800 acres will be directly affected by the buffer such that development on those properties will be impaired or disallowed.

As Councilman Eskil explained, Walla Walla has been developing for over 150 years along riparian waterways. It has been the consensus of residents of the city that they have done so in an environmentally sensitive manner. Riparian buffers have provided adequate safeguards to our many streams. Expanding the riparian buffer significantly will have no tangible benefit, but will in fact produce significant harm to our citizens and their property. We do not believe that there has been any harm to the riparian waterways. Many houses are built close to streams.

The Walla Walla zoning code is primarily based upon R-96 zoning around the city. This means that the minimum lot size is 9,600 square feet. Many lots meet the minimum and are approximately 100x100. Thus, for any undeveloped lot in the R-96 zone that is 100x100 and that has a stream that touches any portion of that lot, it would now be undevelopable and unbuildable. The city's zoning policy expresses an interest of having at least 4 lots per acre. With the new 100-foot buffer that is going to be virtually impossible. Lot sizes are going to have to increase dramatically. Density is going to be reduced as opposed to increased. The Comprehensive Plan suggests that Walla Walla should reply upon infill and more density. These goals are absolutely impossible with a 100-foot buffer zone for the entire city.

Councilman Outlaw asked the question as to what would happen to existing homes if the owners want to build additions. I believe the answer he received was disingenuous. The obvious answer is that unless that house has the ability to adhere to a new 100-foot buffer and the new and larger setbacks, no change will be allowed. No extra room could be added, there would be no ADU allowed, there would be no new patio. Furthermore, there is a question as to what might happen if a house were to burn to the ground. I suspect that they would only be able to rebuild in exactly the same footprint as the original house, and they would be denied the right to utilize any different footprint that encroached closer to the water than the existing footprint. Furthermore, there is a question as to how long this grandfather right would exist. If a house were burnt to the ground and the residents were not capable of rebuilding within a relatively short period, is the grandfather right to rebuild forfeited?

The city staff continues to put emphasis on the best scientific evidence. The state has rolled out a very long report developed over a period of nine years. Remember that this report was developed under the direction of Governor Inslee who has been one of the most aggressive environmentally protective Governors in the country. If you remember, he ran for a short period of time for President on a very environmental protective platform. Even though this report took nine years, the conclusion was predetermined. However, the question is whether that report actually covers the best scientific evidence for every locale in the state. I do not believe it does. Furthermore, I do not believe that there is one best scientific conclusion. I offer as an example the decades of controversy over protecting salmon in the Columbia and Snake Rivers. There have been dozens of best scientific evidence reports which have come to diametrically opposed conclusions. If you go to several medical doctors and ask for the best scientific evidence as to treatment you will get a variety of opinions. I think it is both possible and important that the city develop its own best scientific evidence for purposes of the Critical Area Ordinance.

The city staff argues that developing its own ordinance will be a lot of work and will cost hundreds of thousands of dollars. They may be right. But by unilaterally adopting a 100-foot buffer they have chosen to ignore the millions of dollars of economic loss that the city will incur and landowners will incur in loss of property value.

At the Planning Commission hearing two different landowners testified that they had parcels of land of about 6 acres each. They plan to subdivide that land. Each one has a stream running through the property. Nevertheless, based upon current setbacks they could meet the city's goal of four houses per acre and each of the subdivisions would have about 25 lots. Both of those landowners indicated that with a 100-foot buffer, their property now becomes undevelopable for

housing. Just in those two parcels, the city will lose 50 lots. If those lots have a conservative value of $100,000 each, that is $5M taken out of the tax base. Now assume that those lots were all developed with average price level homes of $500,000. You have now taken out of the tax base $25M. Also assume that to develop those houses there is substantial sales tax being generated of several million dollars. Therefore, in just these two parcels of 12 acres the city will lose over $30M in tax base and/or actual taxes paid during construction. That land will likely never be able to be developed and will become virtually useless. And this is only 12 to 13 acres of the 700 acres that will be adversely affected by a 100-foot buffer zone.

Every landowner who has land that is affected will have a legitimate claim that the value of their land has been significantly reduced for tax purposes. Furthermore, landowners are likely to assert claims and/or lawsuits on the basis that they have incurred actual damages by the inverse condemnation of their property by the city. The economic detrimental effect could be hundreds of millions of dollars as compared to a couple hundred thousand dollars in developing a local best scientific evidence report. The city could choose carefully to make sure that the consultant used is practical in nature and has a bias for smaller buffer areas.

I do not think it is out of the realm of possibility that many landowners, developers, realtors, and citizens would happily contribute to a fund to develop best science for our local area which proved that our riparian areas were healthy with a 35-foot setback and we do not need a 100-foot setback.

The proposed Critical Area Ordinance overrides all of the city's efforts for lot infill, higher density, and affordable housing.

City attorney Tim Donaldson argues that if the city does not adopt this mandated 100-foot buffer, that it may not be eligible for certain state grants. Assuming that Tim is correct, the city still has to weigh the loss of those grants against the significant economic impact of the 100-foot buffers. The city needs to study this more carefully, taking into account all of the various consequences and impacts before it unilaterally accepts a report that only reflects one view of the scientific evidence.

City of Walla Walla - 2026 Critical Areas Ordinance Update

Technical, Legal, and Policy Concerns Raised by Walla Walla's Draft Critical Areas Ordinance

Questions the record should answer before adoption.

Technical, legal, and policy review of the proposed replacement of the City's differentiated riparian buffers with a uniform 100-foot minimum standard and the supporting record.

SUBMITTED TO
City of Walla Walla City Council

MATTER
2026 Critical Areas Ordinance Update
File PLN5-26-0001

SUPPORTING RECORD
Planning Commission and 2026 CAO proceedings

PREPARED BY
Matt Heuer, Government Affairs Director
Walla Walla Valley Association of REALTORS®

WALLA WALLA VALLEY
ASSOCIATION OF REALTORS®

Purpose

These concerns relate primarily to the proposed replacement of Walla Walla's existing differentiated 35-foot and 50-foot riparian buffers with a uniform 100-foot minimum buffer for most open streams regulated under the City's Critical Areas Ordinance.

There is no dispute that Walla Walla must protect critical areas. There is no dispute that the City must include Best Available Science, or BAS, when developing its regulations. There is also no dispute that WDFW recommends substantial riparian protection and generally recommends a 100-foot minimum RMZ in dryland settings when the pollution-removal function controls.

The questions are different:

Has the specific choice of a uniform 100-foot standard been accurately represented as legally required? Has the City adequately examined Walla Walla's local conditions? Has it evaluated reasonable alternatives? Has it demonstrated why the existing differentiated system is inadequate? Has it reconciled the proposed regulation with other GMA and Comprehensive Plan obligations? Does the City understand the ramifications of the proposed 100-foot buffer? And has it created a sufficiently complete record to support the policy choice it is asking elected officials to make?

The available record raises substantial concerns on each of those questions.

On September 14, 2026, the Planning Commission declined to recommend the draft CAO as presented and instead unanimously recommended that City Council direct staff to revise the ordinance to better align with the Comprehensive Plan and local needs. This review is submitted to inform the Council's consideration of that recommendation.

Contents

01 Washington law does not mandate a 100-foot riparian buffer

02 Labeling the proposal 'State Mandated' obscures the distinction between state law and local policy choice

03 WDFW expressly distinguishes its science from its policy recommendations

04 WDFW expressly recommends site-specific RMZ determinations and warns against one-size-fits-all widths

05 The City has not performed an alternatives analysis showing why other approaches are inadequate

06 The Facet memorandum is a GIS planning analysis, not an ecological efficacy study

07 The City has not demonstrated that its existing differentiated system is failing

08 Walla Walla's own evidence shows materially different conditions, yet the proposal imposes one answer

09 WDFW selected a pollutant-removal target; the City has not shown it independently selected that target

10 The proposal expands regulated land dramatically without quantifying the incremental ecological benefit

11 Much of the proposed buffer is already developed, impervious, or functionally disconnected

12 The proposal blurs the distinction between mandatory protection and desired restoration

13 The record does not show how the City balanced environmental protection with other GMA goals

14 Housing-capacity and infill consequences have not been quantified

15 Consequences for existing lawful homes and lots remain insufficiently defined

16 Discretionary relief does not erase the burden created by the underlying regulation

17 The SEPA record should be revisited in light of the documented scale of the change

18 Other Washington jurisdictions show that BAS can support a documented, differentiated approach

19 The City's description of a 'separate analysis' is inconsistent with the record produced

20 Recommended Corrective Action

01 Washington law does not mandate a 100-foot riparian buffer

RCW 36.70A.172 requires cities and counties to include Best Available Science when developing policies and development regulations protecting the functions and values of critical areas. It also requires special consideration of measures necessary to preserve or enhance anadromous fisheries.

RCW 36.70A.060 requires adoption of development regulations protecting critical areas.

Neither statute prescribes a 100-foot buffer.

WAC 365-195-915 further recognizes that a jurisdiction may depart from a science-based recommendation when the record identifies the information relied upon, explains the rationale, identifies the risks associated with the departure, and explains measures used to address those risks.

> CONTENTION
> **The state mandates a result - protection of critical-area functions through regulations developed using BAS. It does not mandate WDFW's preferred 100-foot regulatory response.**

02 Labeling the proposal 'State Mandated' obscures an important distinction between state law and local policy choice

The City's staff materials repeatedly categorize significant CAO amendments as 'State Mandated' under RCW 36.70A.172.

The staff report explains the BAS requirement and then states:

> **"To this end, the riparian buffer zones on either side of the City's creeks and streams are proposed to increase from 35 or 50 feet...to 100 feet."**

That presentation collapses two separate decisions:

- the Legislature's requirement that the City include BAS and protect critical-area functions; and
- the City's decision about which local regulation to adopt after applying that science.

> CONTENTION
> **Decision-makers should be expressly told that 100 feet is a City policy choice informed by a WDFW recommendation, not a buffer width imposed by RCW 36.70A.172.**

That distinction matters because elected officials may reasonably evaluate a supposed state mandate differently than a local legislative choice.

03 WDFW expressly distinguishes its science from its policy recommendations

This distinction is not an interpretation offered by opponents of the ordinance. WDFW says it itself.

Volume 1 states that Volume 2's management guidance is:

> **"not in and of itself 'best available science.'"**

Instead, Volume 2 represents WDFW's recommendations for how local governments could incorporate BAS into policies, plans, and regulations.

Volume 2 repeats the point even more directly:

> **"The information presented in this management recommendation document is not, in and of itself, science. Rather, it consists of policy recommendations which are informed by the best available science..."**

Volume 2 also describes WDFW's role in Washington land-use decision-making as that of 'advisor,' working with decision-makers and landowners to accommodate both human needs and fish and wildlife needs.

This distinction is especially important because City staff itself has acknowledged Volume 1 as the BAS source and Volume 2 as management guidance.

> CONTENTION
> **The City should not treat WDFW's recommended implementation policy as though the recommendation itself were synonymous with BAS or a statutory mandate.**

04 WDFW expressly recommends site-specific RMZ determinations and warns against one-size-fits-all widths

Volume 2 contains one of the clearest statements relevant to Walla Walla's proposal:

> **"Establish RMZ widths based on site-specific conditions."**

WDFW explains that riparian ecosystem width varies with ecological conditions and states that the most efficient protection recognizes those differences rather than adopting uniform-width, one-size-fits-all RMZs, because uniform standards can produce over-protection in some locations and under-protection in others.

WDFW also cautions that Volume 2 contains statewide recommendations and does not address unusual site-scale environmental conditions or issues specific to particular ecological communities. It strongly encourages those issues to be addressed locally with WDFW regional habitat biologists, technical experts, tribes and other stakeholders.

WDFW's comments on Walla Walla are consistent with that guidance: although it stated that 100 feet 'may be compliant,' it also indicated that site evaluation would be preferable for determining the correct width.

CONTENTION

WDFW's own management guidance does not support treating statewide guidance as a substitute for evaluating materially different local stream conditions.

05 The City has not performed the alternatives analysis that would demonstrate why other approaches are inadequate

The July 1 Facet memorandum compares the mapped footprint of only two regulatory scenarios:

- Walla Walla's existing 35/50-foot framework; and
- WDFW's 100-foot dryland RMZ scenario.

It does not evaluate the ecological performance of the existing buffers, nor does it evaluate:

- 60-foot buffers;
- 75-foot buffers;
- revised reach-specific standards;
- different treatment of different stream types;
- narrower buffers combined with native vegetation enhancement;
- stormwater treatment;
- low-impact development;
- habitat connectivity improvements;
- differentiated treatment of heavily developed or functionally disconnected reaches; or
- packages combining multiple protective measures.

Facet therefore does not establish that reasonable alternatives fail to protect required functions.

CONTENTION

Comparing the mapped footprint of the existing ordinance with one preferred regulatory alternative is not the same as evaluating the existing ordinance or modeling meaningful alternatives and demonstrating why they are insufficient.

06 The Facet memorandum is a GIS planning analysis, not an ecological efficacy study

Facet's work is valuable for understanding the geographical consequences of changing the ordinance.

It identifies streams, overlays buffer scenarios, examines impervious surfaces, and estimates functionally disconnected areas.

But Facet expressly states that its analysis is appropriate for broad-scale planning and 'should not be used for site-level determinations.'

It therefore answers:

> **"How much land will fall inside the regulatory area if the City adopts 100 feet?"**

It does not answer:

"What width is necessary on each Walla Walla stream or reach to protect the functions actually present there?"

CONTENTION

The City's principal technical study quantifies the footprint of the proposed policy. It does not establish the ecological necessity of that policy.

07 The City has not demonstrated that its existing differentiated system is failing

Walla Walla already regulates these waterways.

The existing ordinance identifies specific streams and reaches, their characteristics, targeted ecological functions, existing riparian widths and different regulatory buffers.

For example, the existing record distinguishes Yellowhawk Creek from Russell Creek and Reser Creek based upon fish use, downstream influence, shade, woody debris, vegetation and other characteristics.

Volume 2 makes the absence of a performance analysis more significant. WDFW specifically recommends implementation and effectiveness monitoring to determine whether existing regulations are actually producing intended environmental outcomes such as shade and bank stability.

The current record does not appear to identify:

- which functions are presently being lost under Walla Walla's existing buffers;
- on which reaches those losses occur;
- whether existing permit implementation is failing;
- whether violations rather than buffer width are causing failures; or
- what monitoring demonstrates that the existing standards cannot protect those functions.

CONTENTION

Before replacing an existing BAS-derived differentiated system with a dramatically more restrictive system, the City should identify what is failing and demonstrate how the proposed regulation corrects that failure.

08 Walla Walla's own evidence demonstrates materially different conditions, yet the proposed ordinance imposes the same answer

The City's existing information identifies average riparian widths of approximately:

- Yellowhawk: 31 feet
- Russell: 21 feet
- Reser: 23 feet
- Stone: 20 feet
- Garrison: 24 feet
- Bryant: 14 feet
- Titus: 25 feet

Those waterways also differ in fish use, channelization, vegetation, surrounding development, hydrology, downstream influence and existing ecological function.

The City's existing reach-based table itself reflects those differences. Yellowhawk is identified for summer steelhead migration and limited rearing habitat, while other reaches are identified for differing combinations of downstream influence, stormwater and pollutant control, wildlife habitat, shade, woody debris and existing riparian conditions.

Nevertheless, the proposed Table 6 places nearly all open streams into the same 100-foot minimum category.

CONTENTION

The City's own evidence demonstrates ecological heterogeneity. WDFW says site-specific differences matter. A uniform regulatory answer therefore requires a persuasive local explanation that does not presently appear in the record.

09 WDFW selected a policy target for pollutant removal, but the City has not demonstrated that it independently selected that target for Walla Walla

This is an important distinction.

Volume 1 states:

> **"Riparian buffer width recommendations depend on the particular pollutant to be removed and the desired removal efficacy. Policy makers must choose the desired removal efficacy."**

WDFW's Volume 2 then makes its management recommendation. Where SPTH or riparian vegetation is less than 100 feet, WDFW recommends a 100-foot minimum intended to achieve approximately 95% removal for most pollutants, although it notes approximately 85% for surface nitrogen.

Those are two different propositions:

- The science describes how performance changes with width.
- WDFW then recommends a particular policy target.

The Jacobs memorandum for Enumclaw illustrates this directly. It reproduces the WDFW/Quinn pollutant-removal data at different performance levels and states that the amount of pollutant removal desired is a community choice.

CONTENTION

WDFW has made its policy recommendation. The City's record should demonstrate why Walla Walla independently concluded that WDFW's selected performance target is appropriate for every regulated urban stream.

10 The proposal expands regulated land dramatically without quantifying the corresponding incremental ecological benefit

Facet estimates that the current buffer system encompasses approximately 268.8 acres.

Under the 100-foot scenario, that becomes approximately 757.4 acres.

The mapped buffer footprint therefore increases by approximately 489 acres, nearly tripling the regulated area and increasing it from roughly 2.1% to 5.8% of the study area.

What the analysis does not calculate is the corresponding incremental ecological gain. For example:

- How much additional sediment removal occurs?
- How much additional nitrogen removal occurs?
- How much additional shade results?
- Which reaches gain meaningful habitat connectivity?
- Which additional acreage contributes woody debris?
- Which acreage performs little or no present riparian function?
- How much of the approximately 489-acre expansion is already developed private property?
- What incremental habitat or water-quality improvement is expected on already-developed parcels if existing lawful development remains in place?

CONTENTION

A large regulatory expansion should be supported by analysis of what additional ecological performance the additional regulated acreage actually purchases.

11 The City's own analysis shows that a substantial portion of the proposed buffer is developed, impervious, or functionally disconnected

Under the 100-foot scenario, Facet finds approximately 30.4% of the mapped area to be impervious or functionally disconnected.

Facet also acknowledges that the expanded buffers reach developed parcels, roads and other land uses that may not presently provide riparian function.

Even Facet's 'vegetated' category includes lawns, parks, fields and managed open space, rather than only functioning native riparian vegetation.

The record does not separately quantify how much of the approximately 489-acre expansion consists of already-developed parcels, nor how much additional ecological function the ordinance is expected to produce on those parcels. Workshop discussion also indicated that existing developed property owners would not simply be required to restore habitat because the regulatory line moved.

Volume 2 adds important nuance. WDFW warns that impervious surfaces and untreated stormwater can themselves alter peak flows, channel form and pollutant removal. That supports a broader regulatory analysis rather than simply treating impervious land as irrelevant.

CONTENTION

In developed urban watersheds, the appropriate question is not merely 'How wide is the line?' The City should evaluate whether combinations of buffer protection, stormwater treatment, infiltration and pollutant removal, low-impact development, vegetation enhancement and other measures more effectively address the actual functions and impairments present.

12 The proposal blurs the distinction between mandatory protection and desired restoration

WDFW strongly favors both protection and restoration.

Volume 2 acknowledges that historical development has degraded riparian systems and states that WDFW believes remaining intact habitat alone is insufficient to provide the full functions fish and wildlife need. WDFW consequently recommends restoration where possible.

But WDFW also distinguishes restoration from protection. Volume 2 describes voluntary restoration actions, and Volume 1 expressly notes that the planning, regulatory and legal contexts governing protection and restoration differ.

Washington's Swinomish decision likewise recognizes that the GMA's duty to protect existing critical-area functions is not automatically equivalent to a mandate to restore historically lost functions.

CONTENTION

Where the proposed 100-foot area extends across developed urban land that no longer provides full riparian function, the City should identify whether the regulation is protecting existing function, preventing a new loss, mitigating a proposed impact, or attempting to restore a function that is presently absent. Those purposes may support different regulatory tools and different legal analyses.

13 The supporting record does not demonstrate how the City balanced environmental protection with other GMA and Comprehensive Plan objectives

The GMA contains multiple planning goals, including environmental protection, housing, property rights, urban growth, economic development, permit predictability and citizen participation.

Those goals are not ranked by RCW 36.70A.020.

Walla Walla's own 2046 Comprehensive Plan calls for:

- infill development;
- housing choice;
- accessory dwelling units;
- efficient use of existing infrastructure;
- additional residential development; and
- evaluation of the effects of development regulations.

WDFW itself recognizes this balancing process. Volume 1 states that natural-resource and land-use policies must often balance ecological, economic and social goals, and that determining an acceptable balance requires a political process involving stakeholders, local governments, tribes and state agencies.

Volume 2 likewise acknowledges that human needs must be incorporated into land-use decision-making.

CONTENTION

The City should demonstrate the balancing exercise the GMA, the Comprehensive Plan and WDFW's own framework contemplate. The existing record fails to do this.

14 Housing-capacity and infill consequences have not been quantified

Facet establishes that the proposed 100-foot standard expands the mapped buffer footprint by nearly 489 acres.

The available record does not appear to quantify:

- affected buildable acreage;
- housing units potentially foregone;
- infill parcels constrained;
- redevelopment capacity affected;
- reductions in building envelopes;
- interaction with the City's housing-capacity analysis;
- impacts on the assumptions underlying Walla Walla 2046; or
- economic effects on affected property.

The concern was independently raised in public comments, including Howard Boggs' observation that many stream-adjacent areas are already developed and that substantially larger buffers could reduce future infill opportunities.

CONTENTION

The City should know whether a regulation affecting hundreds of additional urban acres conflicts with the growth and housing assumptions on which its newly adopted Comprehensive Plan depends.

15 The consequences for existing lawful homes and lots remain insufficiently defined

Many affected properties were developed before the adoption of current critical-area setback requirements or under substantially different regulatory standards. The proposed 100-foot standard will place many of those existing homes and lots inside a newly expanded regulatory area.

Questions raised in the public record include:

- Can an existing home be rebuilt after a fire?
- Can an owner build a second story?
- Can a garage be added?
- Can a deck or patio be constructed?
- What happens to an undeveloped legal lot?
- What rights attach to recorded plats?
- What happens to pending applications?
- How are additions treated?

A practical question for existing owners	How does any new nonconforming status affect resale, insurance, financing or marketability?

These are not abstract issues. They determine the practical effect of the ordinance on existing lawful property owners.

CONTENTION

A major citywide regulatory amendment should clearly establish the rights retained by existing owners rather than requiring those answers to emerge later through individual administrative interpretations.

16 Discretionary relief does not erase the burden created by the underlying regulation

The draft contains several mechanisms that may modify the standard buffer in particular circumstances. Those provisions are important, but they are not equivalent to an unaffected property right.

Functionally disconnected areas. Where impervious surfaces or lawfully established structures disconnect the buffer from the stream, the Director may approve a complete or partial modification to exclude non-functional areas.

Buffer averaging. The draft allows portions of a buffer to be narrowed, but the total area after averaging must equal the area required without averaging and the narrowest point may not be less than 75% of the standard width. On small, already-developed parcels, there may be little or no practical room to move the displaced buffer elsewhere.

Decreased buffer widths. A separate case-by-case provision allows the Director to approve a reduction when specified criteria are satisfied. For a 100-foot standard, Table 7 identifies a potential reduction to 75 feet with approved habitat enhancement or water-quality treatment.

To obtain relief, a property owner may still be required to:

- retain a qualified professional;
- prepare a critical-area report;
- establish existing ecological conditions;
- demonstrate satisfaction of regulatory criteria;
- prepare habitat enhancement;
- address water quality;
- conduct monitoring; and
- obtain discretionary Director approval.

The applicant bears the cost of the professional studies, documentation, enhancement planning, monitoring and administrative process necessary to establish eligibility for relief.

The required enhancement plan must identify existing conditions, demonstrate improved riparian function and include a five-year monitoring program.

> CONTENTION
> **The existence of discretionary modification or relief mechanisms does not mean a property is unaffected. Cost, delay, uncertainty, professional studies and administrative discretion are regulatory impacts themselves, and those burdens are borne by the property owner.**

17 The SEPA record should be revisited in light of the scale of the regulatory change now documented

The City's SEPA materials state that the proposed amendments are not expected to create significant adverse impacts.

However, the available SEPA discussion does not appear to analyze the approximately 489 additional acres subsequently identified by Facet, nor does it quantify effects on housing capacity, infill, redevelopment or existing lawful development.

This does not establish that the City's SEPA determination is invalid. It does create a legitimate record question:

> **"Did the environmental review adequately consider the probable land-use consequences of the specific regulatory proposal ultimately advanced?"**

> CONTENTION
> **Before final adoption, the City should determine whether the Facet acreage findings and resulting development consequences warrant supplemental or additional SEPA consideration.**

18 Other Washington jurisdictions demonstrate that BAS can support a documented, differentiated local approach

Enumclaw provides a useful example, but it should be described accurately.

Jacobs' BAS memorandum did not recommend that Enumclaw simply disregard WDFW's guidance.

At the time of the Jacobs analysis, Enumclaw had:

- Type S: 100 feet
- Type F: 75 feet

- Type Np: 50 feet
- Type Ns: 25 feet

Jacobs concluded that Type S was consistent with WDFW's local SPTH analysis, recommended considering an increase in Type F to 100-105 feet, and recommended reconsideration of Np and Ns widths. Significantly, Jacobs did not simply recommend converting every stream to 100 feet. For Type Ns, it specifically discussed increasing the width enough to achieve at least 80% pollutant removal, depending on adjacent land uses and buffer quality.

Jacobs also recommended evaluating baseline conditions, protecting remaining functions, enhancing degraded areas, maintaining connectivity and using complementary management practices.

Enumclaw ultimately adopted differentiated stream standards in 2025:

- Type S: 100 feet
- Type F: 100 feet
- Type Np: 60 feet
- Type Ns: 30 feet

WDFW objected during that process that the Np and Ns widths remained below its recommended 100-foot minimum.

The value of Enumclaw as an example is therefore not that its numbers should be copied by Walla Walla, nor that its ordinance has somehow been judicially declared valid. The lesson is that another Washington city commissioned a signed BAS analysis, examined local conditions and functions, received WDFW's 100-foot recommendation, considered it, and nevertheless adopted a differentiated local regulatory framework.

Kennewick provides an eastern Washington example. Kennewick's 2026 BAS review, prepared with Parametrix, identified WDFW's 100-foot dryland RMZ recommendation and recommended considering at least 100 feet for non-fish-bearing streams. Kennewick nevertheless retained a differentiated local framework, including 75-foot Type F and 50-foot Type N stream buffers, together with habitat assessment, buffer-averaging and functionally disconnected-area provisions.

> **CONTENTION**
> **Walla Walla can engage the same science without treating one statewide recommendation as the only legally available outcome. What matters is the quality of the local record supporting the choice.**

19 The City's description of a 'separate analysis' is materially inconsistent with the technical record produced in response to the public-records request

Deputy Director Emily Arteche advised that the City had completed a separate analysis outside the ordinance work and that the results demonstrated alternative setback buffers 'could not provide better protection for the riparian management zone.'

That statement indicated that alternatives had actually been evaluated and rejected based on technical analysis.

A public-records request was therefore submitted seeking:

- that analysis;
- supporting consultant work;
- technical reports;
- GIS information;
- maps; and
- related supporting records.

The City closed the request after producing the July 1 Facet memorandum, the September Planning Commission PowerPoint and directing the requester to the August 3 Facet presentation.

The Facet memorandum does not contain the finding described. It compares the mapped footprint of the existing 35/50-foot regulatory framework with the 100-foot WDFW scenario. It does not evaluate the ecological performance of the existing buffers, analyze 60 feet or 75 feet as alternatives, evaluate revised reach-specific standards, or test combinations of narrower buffers and complementary measures. It does not conclude that those alternatives fail. It does not conclude that alternative setbacks 'could not provide better protection.'

The discrepancy therefore leaves two possibilities:

Either additional responsive analysis exists and was not produced, or the analysis was characterized to the requester as materially more extensive and conclusive than the record actually demonstrates.

> **CONTENTION**
> **Before elected officials rely upon the assertion that alternatives were studied and rejected, the City should identify the specific analysis supporting that statement and place it in the legislative record.**

20 Recommended Corrective Action

There are a number of lawful approaches the City could take to address these concerns. The following is one recommended path, not the only solution. The goal is not to substitute another arbitrary number for 100 feet, but to complete the analysis necessary to determine the appropriate regulation for Walla Walla.

The City should consider:

1. Pause final adoption of the uniform 100-foot riparian-buffer amendments.

2. Request written guidance from the Washington Department of Commerce regarding the December 31 periodic-update deadline, procedural options available to the City, and application of the statutory substantial-progress provisions.

3. Commission qualified ecological professionals to perform a reach-by-reach analysis of Walla Walla's streams.

4. Establish baseline existing conditions and identify the ecological functions presently occurring on each reach.

5. Evaluate meaningful candidate buffer widths and their expected performance.

6. Evaluate complementary measures including native vegetation enhancement, stormwater treatment, infiltration and pollutant removal, low-impact development, connectivity improvements and other mitigation.

7. Distinguish protection of existing ecological function from restoration of degraded or absent functions.

8. Quantify housing, infill, redevelopment and existing-property impacts, and clearly establish owners' rights, nonconforming-property treatment and administrative standards.

9. Build the written BAS record necessary to explain the City's eventual decision, including the risks associated with any departure from a scientific recommendation and the measures used to address those risks.

10. Incorporate monitoring and adaptive management, consistent with WDFW's own recommendation that local governments measure whether regulatory requirements are actually producing intended ecological outcomes.

11. Return the completed analysis to the Planning Commission, City Council and public before final adoption.

The Association recognizes that this work may require additional funding, staff capacity and time. Those practical constraints should be identified and weighed openly as part of the legislative decision rather than substituted for the technical and policy analysis itself.

Walla Walla does not appear to qualify for the GMA's automatic 24-month small-jurisdiction extension. However, RCW 36.70A.130 provides limited treatment for jurisdictions fewer than 12 months out of compliance with the periodic-update deadline for critical-area development regulations as making substantial progress toward compliance for specified state financial-eligibility purposes.

That provision is not an extension of the legal deadline and does not eliminate litigation risk.

It does demonstrate that state law contemplates circumstances in which a jurisdiction may continue completing critical-area regulations after the periodic-update date rather than treating December 31 as justification for adopting an inadequately developed regulatory record.

The City should therefore obtain written Commerce guidance before deciding that schedule pressure requires immediate adoption.

THE STANDARD FOR COMPLETING THIS WORK IS STRAIGHTFORWARD

Show the work.

If a reach-specific analysis demonstrates that a 100-foot buffer is necessary to protect the required functions of Yellowhawk Creek or another waterway, the City should have a defensible basis for adopting 100 feet there. If another reach can protect its required functions using a narrower buffer combined with stormwater treatment, native vegetation enhancement, mitigation or other protective measures, the City should have the scientific and legal record necessary to support that decision as well.

The objective should not be the largest buffer. It should not be the smallest buffer. The objective should be the locally appropriate, scientifically supportable and legally defensible buffer.

Respectfully submitted,

Matt Heuer
Government Affairs Director
Walla Walla Valley Association of REALTORS®

FACET

City of Walla Walla - Stream Buffer Analysis

Date:	July 1, 2026
To:	Emily Arteche, Jon Maland - City of Walla Walla, Development Services
From:	Sam Payne, Ecologist & Wildlife Biologist; Nell Lund, Senior Ecologist
Project Name:	Walla Walla CAO Update – Stream GIS Analysis
Facet Number:	2507.0393.01

1. Introduction

This technical memorandum summarizes the results of a spatial analysis conducted to inform the City of Walla Walla's evaluation of potential riparian management zone (RMZ) modifications as part of the critical areas ordinance update. The analysis compares the City's existing stream buffer framework with a dryland RMZ scenario based on current guidance from the Washington Department of Fish and Wildlife (WDFW). The evaluation also considers the extent of impervious surface and functionally disconnected buffer areas within each scenario to support a planning-level understanding of potential regulatory and ecological implications.

In 2020, WDFW published a synthesis of the best available science for riparian ecosystems (Quinn, Wilhere, and Krueger 2020), followed by management recommendations that support a shift from regulating stream buffers to regulating RMZs (Rentz et al. 2020). Although RMZs are conceptually and practically similar to stream buffers, they are intended to protect the broader ecological functions provided by riparian ecosystems, including water quality protection, stream shading, habitat connectivity, pollutant removal, bank stability, and other functions beyond direct stream habitat.

While much of WDFW's RMZ framework is based on site potential tree height (SPTH), dryland ecosystems, including those in the City of Walla Walla, are addressed through a simplified dryland RMZ framework. Under that framework, open streams are assigned a minimum 100-foot water quality buffer, which may be expanded where the surrounding riparian vegetative community extends farther. For this analysis, piped stream segments were assumed to have no buffer, and Shorelines of the State were excluded because they are regulated under the City's Shoreline Master Program.

2. Methods

2.1 DATA ACQUISITION

To compare the recommended RMZs with existing stream buffers, available GIS data were processed to create stream, buffer, and RMZ layers for each scenario within the City of Walla Walla. The following data types were collected and processed for this analysis.

Table 1. Data, sources, and purposes in this analysis

Data Type	Data Source	Purpose
Streams Shapes *Received 2026*	City of Walla Walla Streams Layer, including intermittent streams	Stream centerlines used for buffer scenarios
Stream Typing *Received 2026*	City of Walla Walla CAO	Buffers distances determined by stream-specific ordinances
Riparian-related Data *Received 2026*	City of Walla Walla (USGS and USFW)	Used to create existing riparian areas. NHD Waterbody, NHD Major Areas, Washington Riparian Areas, and Washington Wetlands were sent by the City of Walla Walla, sourced from the USGS National Hydrography dataset and from the USFW National Wetlands Inventory
City Limits *Received 2026*	City of Walla Walla	Used as a study area
Impervious Surface *Received 2026*	City of Walla Walla	Used to evaluate development implications of potential RMZs

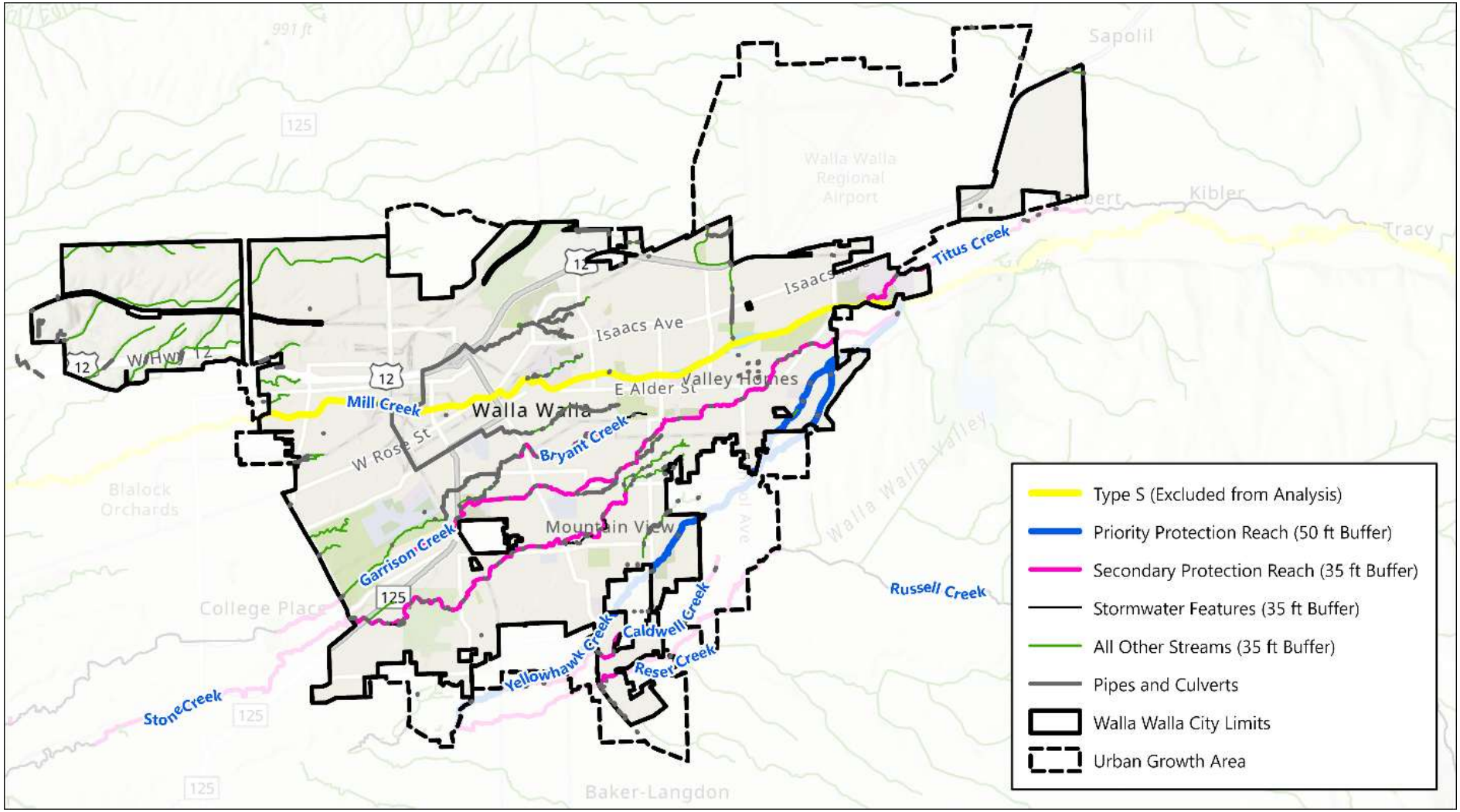


Figure 1. Walla Walla streams mapped by existing CAO criteria

2.2 ALTERNATIVE SCENARIOS

Two alternative scenarios were evaluated which include (1) the current regulatory environment, and (2) dryland RMZs aligning with recommendations by WDFW (Rentz et al. 2020).

Under the current regulatory framework in Walla Walla Municipal Code (WWMC) 21.04, Critical Areas, streams are assigned fixed-width buffers based on the established buffer width for each defined reach. The current framework includes 50-foot buffers for designated *priority protection reaches*, 35-foot buffers for other designated streams (referred to as *secondary protection reaches* for the purpose of this analysis), and 35-foot buffers for all other regulated streams. Piped stream segments are not subject to buffer requirements.

WDFW's dryland ecosystem RMZ recommendations establish a 100-foot water quality buffer, which may be expanded to include the full extent of the surrounding riparian vegetative community. Based on the average riparian vegetation widths identified in WWMC 21.04.650, none of the evaluated reaches exceeds the 100-foot RMZ; however, localized areas within the city may warrant wider buffers where riparian vegetation extends beyond 100 feet (Table 2). For purposes of this analysis, piped stream segments are assumed to have no buffer.

Table 2. Walla Walla streams and current buffers, and average width of riparian vegetation according to WWMC 21.04.650.

Stream	Existing Buffer (ft)	Existing Riparian Average from City (ft)
Mill Creek *From Gose Street to Bennington Lake dam diversion*	SMP managed stream, not included in analyses	Not applicable
Yellowhawk Creek *Russell Creek to Mill Creek*	50	31
Russell Creek *Dipping Road to Yellowhawk Creek*	35	21
Reser Creek *Wilbur Avenue to Russell Creek*	35	23
Caldwell Creek *Headwaters to Yellowhawk Creek*	35	None listed
Stone Creek *Headwaters to Teal Street*	35	20
Garrison Creek *Yellowhawk Creek to Lions Park (excluding wetland)*	35	24
Bryant Creek *Sprague Avenue to Fort Walla Walla Park*	35	14

Stream	Existing Buffer (ft)	Existing Riparian Average from City (ft)
Titus Creek *Blackberry Lane to Mill Creek by Community College*	35	25
All Other Creeks *Within City Limits/UGA*	35	Not listed
All Piped Stream Segments *Applies to all creeks*	0	Not applicable

2.3 IMPERVIOUS SURFACE AND DISCONNECTED BUFFERS

In addition to generalized buffer mapping and summary statistics, spatial analysis was conducted to characterize land cover patterns under both stream regulation scenarios. Because development-related impacts are a primary consideration, the extent of impervious surface area was quantified within each buffer scenario, along with the proportion of areas functionally disconnected by impervious cover.

To more accurately represent functionally disconnected buffers surrounding development areas, a buffer-and-dissolve polygon aggregation technique was also applied. This approach consolidates developed buffer areas in close proximity and more effectively represents areas of functional isolation that are not impervious. A visualization of this technique is shown in Figure 2. This city-wide analysis is for estimating purposes only and is intended to support review of riparian buffer regulations.



Figure 2. Visualization showing a sample area along Garrison Creek with impervious surface cover in black, and additional functionally disconnected buffers in blue.

2.4 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations apply to the spatial analysis and should be considered when interpreting the results:

1. Stream buffers were generated from mapped stream centerlines rather than the ordinary high water mark because centerline data were the available spatial data source.
2. Shorelines of the State are excluded from this analysis because they are regulated under the City's Shoreline Master Program.
3. Streams of unknown jurisdictional status were included.
4. The impervious surface and functionally disconnected buffer analyses are considered reliable for broad-scale planning purposes but should not be used for site-level determinations.
5. The analysis is limited by the accuracy of the underlying datasets. Although dataset limitations may compound across analytical steps, the source data are considered generally reliable for broad-scale planning purposes.

3. Results

The City of Walla Walla contains 43.2 stream miles, of which 2.4 miles (5.7%) currently have a 50-foot buffer, 27.2 miles (63.0%) have a 35-foot buffer, and 13.5 miles (31.4%) are piped and not associated with a regulated buffer. Under the dryland RMZ scenario, all 29.7 miles (68.6%) of non-piped streams would be assigned a minimum 100-foot buffer.

Existing impervious surfaces account for approximately 12.4% of the current buffer area, with an additional 3.5% classified as functionally disconnected, for a combined total of 16%. The remaining 84.0% of the buffer area is vegetated, representing a range of conditions from intact riparian forest to managed landscapes such as open fields and maintained lawns.

The total buffer extent is projected to increase from 268.8 acres to 757.4 acres under the dryland RMZ scenario, representing approximately 2.1% and 5.8% of the total city area, respectively. Within the expanded buffer, impervious surfaces are estimated to comprise 24.4% of the total area, with an additional 6.0% identified as functionally disconnected (30.4% combined). Although newly incorporated buffer areas are associated with a higher proportion of impervious cover and functional disconnection, approximately 69.6% of the total buffer area would remain vegetated, providing important ecological functions for stream and riparian systems. See summary in Table 3 below.

Table 3. Summary of areal calculations for stream buffers, impervious surfaces, and functionally disconnected buffer area.

Category	Current Buffers (ac)	Dryland RMZs (ac)
Total Area	268.8	757.4
Impervious Surface	33.4 (12.4%)	184.9 (24.4%)
Total Area – Functionally Disconnected Buffers	42.9 (16.0%)	230.4 (30.4%)
% of vegetated buffer area[1]	84.0%	69.6%

1 Vegetated areas in this GIS analysis may include a range of conditions from relatively intact riparian corridors to managed landscapes (e.g. lawns, parks) and other open spaces.

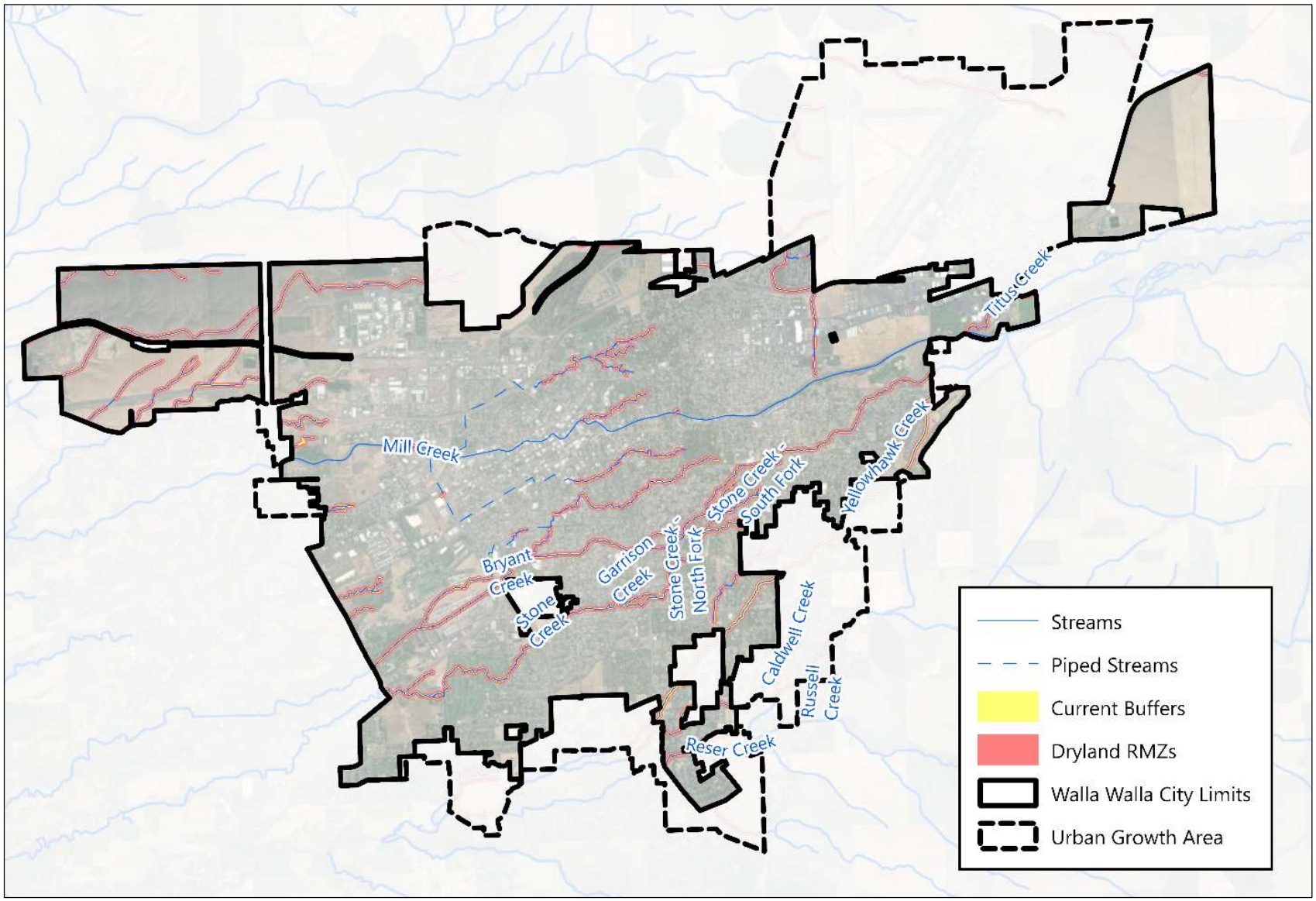


Figure 3. Current buffers and potential dryland RMZs in Walla Walla.

4. Discussion

This analysis indicates that applying WDFW's dryland RMZ recommendations would increase the total area subject to riparian protection within the City of Walla Walla. Under the current regulatory framework, most non-piped streams are regulated with 35-foot buffers, with a smaller proportion regulated with 50-foot buffers. In contrast, the dryland RMZ scenario applies a minimum 100-foot water quality buffer to all non-piped stream segments. This change would increase the total mapped buffer area from approximately 268.8 acres to approximately 757.4 acres, increasing the proportion of the city and UGA within mapped stream buffers from approximately 2.1% to 5.8%.

The impervious surface results also indicate that the dryland RMZ scenario would cover a greater proportion of developed or altered land than the current buffer scenario. Under existing buffers, impervious surfaces and functionally disconnected areas together account for approximately 16.0% of the mapped buffer area. Under the dryland RMZ scenario, the combined impervious and functionally disconnected area increases to approximately 30.4%. This pattern is expected in an urban setting because wider buffers extend farther into developed parcels, road corridors, and other land uses that may not currently provide riparian function.

Although the expanded RMZ scenario includes a higher proportion of impervious and functionally disconnected land, most of the land cover within potential riparian protection zones remains vegetated. Approximately 69.6% of the dryland RMZ is not impervious or functionally disconnected, and remains primarily vegetated. These vegetated areas may include a range of conditions, from relatively intact riparian corridors to managed landscapes such as lawns, parks, fields, and other open spaces. It may also include some areas of non-vegetated land that were not captured in the impervious surface data set, or landcover which is both non-impervious and non-vegetated. They may also include some non-vegetated areas not captured by the impervious surface dataset.

While vegetated areas vary in their ecological condition and functional value, they represent locations where existing riparian functions may be retained and where restoration, enhancement, or redevelopment requirements could improve long-term riparian function. For comparison, an estimated 84.0% of the area within current buffers is vegetated, whereas the newly added buffer area is estimated to be 62.6% vegetated.

The following WDFW riparian management recommendations should also be considered for implementation (Rentz et al. 2020):

- Maintaining and improving functions through regulatory and voluntary means,
- Increased regulations for clearing and grading activities within RMZs,
- Expanding Habitat Management requirements
- Implementing strict exemption requirements.
- Identifying and prioritizing restoration,
- Maintaining and improving riparian connections, and
- Applying stormwater management.

Additional strategies that the City of Walla Walla can consider to improve protection of riparian areas

are described in the WDFW Riparian Management Zone Checklist for Critical Areas Ordinances[1], which is a voluntary list of considerations in addition to the Commerce CAO Checklist. These strategies include:

1. **Restore or Enhance Riparian Vegetation:** For riparian/stream buffer areas to provide intended functions they are presumed to be densely vegetated with native vegetation typical of our ecoregion. Restoration actions recommended by WDFW include protecting existing habitat, connecting fragmented habitats, restoring natural processes, and creating or enhancing habitat. In some cases, buffer averaging may require enhancement measures to address degraded conditions.
2. **Improve Water Quality:** WDFW recommends a minimum 100-foot buffer width to provide for adequate pollutant removal to protect water quality as described earlier in this memo (Quinn, Wilhere, and Krueger 2020; Rentz et al. 2020). Water quality can also be supported by applying stormwater regulations and incentivizing low impact development and/or Salmon-Safe project certifications, where appropriate.
3. **Mapping Restoration Areas:** The City could consider mapping areas to pinpoint the best sites to restore considering connectivity and adjacency to other mapped Priority Habitats.
4. **Incentives to Daylight Streams:** To support restoration, the City may choose to provide regulations that specifically address daylighting streams at sites with existing legally established nonconforming uses. For stream daylighting or enhancement projects, this may include riparian vegetation improvements, increasing off-channel habitat, reversing channel incision, improving channel morphology, improving streambank stability, and increased quantity of large woody debris (Rentz et al. 2020).
5. **Reinforcing Mitigation Sequencing:** To reduce unnecessary habitat impacts within riparian ecosystems, it is recommended to provide improved regulations for mitigation sequencing. As described in WAC 365-196-380, "Avoidance is the most effective way to protect critical areas". Applicants should be required to demonstrate that mitigation sequencing was used in each project proposal that may impact habitat functions or values, including that avoidance was considered.
6. **Stricter Clearing and Grading Requirements:** It is recommended that the City limit clearing, filling, and grading activities within riparian areas, unless they are directly related to restoration, as these activities can negatively impact riparian ecosystems (Rentz et al. 2020). This includes considering restricting placement of on-site septic systems within 100' of riparian areas. It is also recommended that the City incorporate specific habitat assessment requirements as suggested in Riparian Ecosystems, Volume 2: Management Recommendations (Rentz et al. 2020).
7. **Expanded Habitat Management Plan (HMP) Requirements:** WDFW recommends that when an activity is proposed in a RMZ or could affect riparian or aquatic functions, a Habitat Management Plan (HMP) should be required. For consistency with the guidance in WDFW

[1] WDFW RMZ Checklist for Critical Areas Ordinances, August 2023: rmrcaochecklist.pdf

Riparian Ecosystems, Volume 2: Management Recommendations, the Habitat Management Plan requirements could be expanded to include the following: Measurable standards and expectations to monitor compliance and defined triggers for requiring more actions, i.e., performance standards. Examples of measurable standards could include extent of vegetative cover, composition of riparian vegetation and maximum invasive plant cover. The Habitat Management Plan is recommended to also identify the frequency of visits to monitor the site and specify who is responsible for preparing, reviewing, and submitting monitoring reports.

As the City of Walla Walla considers this assessment, we recognize stream regulations will be reviewed from an implementation feasibility perspective and are balanced with other Growth Management Act (GMA) requirements. Pursuant to WAC 365-195-915, when nonscientific information, including legal, social, cultural, economic, or political considerations, is used to support critical area policies or regulations that depart from recommendations based on the best available science, the record must: (1) identify the nonscientific information relied upon to justify the departure; (2) explain the rationale for deviating from science-based recommendations; and (3) identify any potential risks to climate resiliency and to the functions and values of the affected critical area(s), along with any additional measures adopted to mitigate such risks.

5. References

Quinn, T., G.F. Wilhere, and K.L. Krueger. 2020. "*Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications.*" Olympia: Washington Department of Fish and Wildlife.

Rentz, T, Amy Windrope, Terra Rentz, Keith Folkerts, and Jeff Azerrad. 2020. "*Riparian Ecosystems, Volume 2: Management Recommendations*." Olympia, Washington: Washington Department of Fish and Wildlife.

Washington Department of Fish and Wildlife (WDFW). 2023 (Amended August 2023). Riparian Management Zone Checklist for Critical Area Ordinances, A Technical Assistance Tool. (RMZ Checklist). https://wdfw.wa.gov/sites/default/files/2023-08/rmr-cao-checklistaddendum.pdf.

Wetlands in Washington State

Volume 1: A Synthesis of the Science



Final

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Washington Department of FISH and WILDLIFE



Funding for this project was funded in part through a grant from the United States Environmental Protection Agency (EPA Region 10 and EPA Headquarters Grant #'s CD-970018-01 and CD-970585-01, Ralph Rogers, grant officer). The views herein are those of the authors and do not necessarily reflect the views of EPA.

If you have special accommodation needs or require this publication in an alternate format, please contact Tim Schlender at 360-407-6096 (Voice) or TTY (for the speech or hearing impaired) at 711 or 800-833-6388.

Published by the Department of Ecology's Shorelands and Environmental Assistance Program, P.O. Box 47600, Olympia, WA 98504-7600. For more information contact Teri Granger at 360-407-6857, e-mail: tgra461@ecy.wa.gov

Wetlands in Washington State

Volume 1: A Synthesis of the Science

FINAL
March 2005
Ecology Publication #05-06-006

Written by: Dyanne Sheldon[1], Tom Hruby Ph.D.[3], Patricia Johnson[3], Kim Harper[2], Andy McMillan[3], Teri Granger[3], Stephen Stanley[3], Erik Stockdale[3]

1. Sheldon and Associates
2. Sheldon and Associates (currently with the Washington State Department of Ecology)
3. Washington State Department of Ecology

Printed on recycled paper

This document is available on the Department of Ecology web site at
http://www.ecy.wa.gov/biblio/0506006.html.

For a CD or printed copy of this report, contact:

Department of Ecology Publications Distribution Office
Address: PO Box 47600, Olympia WA 98504-7600
E-mail: jewi461@ecy.wa.gov
Phone: (360) 407-7472

Refer to Publication #05-06-006

For the *Responses to Comments* on the draft of this volume refer to Publication #05-06-007.

For the Draft *Freshwater Wetlands in Washington State – Volume 1: A Synthesis of the Science* refer to Publication #03-06-016.

For Volume 2 of this two-volume series, *Wetlands in Washington State – Volume 2: Guidance for Protecting and Managing Wetlands*, refer to Publication #05-06-008.

Preferred citation:

Sheldon, D., T. Hruby, P. Johnson, K. Harper, A. McMillan, T. Granger, S. Stanley, and E. Stockdale. March 2005. Wetlands in Washington State - Volume 1: A Synthesis of the Science. Washington State Department of Ecology. Publication #05-06-006. Olympia, WA.

Table of Contents

LIST OF TABLES ..... **xi**

LIST OF FIGURES ..... **xiii**

ACKNOWLEDGEMENTS ..... **xv**

CHAPTER 1 INTRODUCTION TO THE DOCUMENT **1-1**

1.1 BEST AVAILABLE SCIENCE (BAS) **1-2**
1.1.1 Volume 1 as BAS 1-3
1.1.2 Making Hypotheses and Assumptions 1-4
1.2 SCOPE OF VOLUME 1 ..... **1-5**
1.3 RELEVANCE OF SCIENTIFIC INFORMATION TO CONDITIONS IN WASHINGTON **1-6**
1.4 OVERVIEW OF VOLUME 1 ..... **1-7**
1.5 PUBLIC INVOLVEMENT AND REVIEW OF VOLUME 1 ..... **1-11**
1.5.1 The Process of Public Involvement 1-11
1.5.2 Responding to Comments and Reviewing Suggested Literature 1-12
1.6 CONCLUSIONS **1-13**

CHAPTER 2 WETLANDS IN WASHINGTON AND HOW THEY FUNCTION **2-1**

2.1 READER'S GUIDE TO THIS CHAPTER **2-1**
2.1.1 Chapter Contents 2-1
2.1.2 Where to Find Summary Information and Conclusions 2-2
2.1.3 Sources and Gaps in Information 2-2
2.2 BASIC ECOLOGICAL PRINCIPLES USEFUL IN MANAGING WETLANDS AND IN UNDERSTANDING THE IMPACTS OF HUMAN ACTIVITIES **2-3**
2.3 INTRODUCTION AND BACKGROUND ON WETLAND FUNCTIONS **2-5**
2.3.1 An Evolving Understanding of Wetland Functions 2-5
2.3.2 How Wetland Functions Are Defined 2-6
2.3.3 Environmental Factors that Control Wetland Functions 2-9
2.3.3.1 Environmental Controls of Functions at the Landscape Scale 2-11
2.3.3.2 Environmental Controls of Functions at the Site Scale 2-15
2.3.3.3 Summary of the Controls of Wetland Functions 2-15
2.3.4 Summary of Key Points 2-18
2.4 CLASSIFICATION OF WETLANDS IN WASHINGTON AS A KEY TO UNDERSTANDING THEIR FUNCTIONS **2-18**
2.4.1 Commonly Used Classification Systems in Washington 2-19
2.4.1.1 The Cowardin Classification 2-19
2.4.1.2 The Hydrogeomorphic Classification 2-19
2.4.1.3 Other Classifications Used in Washington 2-21
2.4.2 Geographical Differences in Wetland Functions 2-21
2.4.3 Wetland Regions in Washington 2-22
2.4.4 Description of the Wetland Classes for Washington 2-24

2.4.4.1 Riverine Wetlands 2-24
2.4.4.2 Depressional Wetlands 2-25
2.4.4.3 Slope Wetlands 2-26
2.4.4.4 Lacustrine (Lake) Fringe Wetlands 2-27
2.4.4.5 Flats Wetlands 2-27
2.4.4.6 Tidal Fringe Wetlands 2-28
2.4.5 Subclasses of Wetlands in Washington 2-28
2.4.6 Summary of Key Points 2-29
2.5 OVERVIEW OF WETLAND FUNCTIONS IN WASHINGTON STATE 2-29
2.5.1 Functions Related to Improving Water Quality 2-30
2.5.2 Functions Related to Maintaining the Water Regime in a Watershed (Hydrologic Functions) 2-30
2.5.3 Functions Related to Habitat 2-31
2.5.4 Summary of Key Points 2-32
2.6 HOW WETLANDS PERFORM FUNCTIONS IN WASHINGTON STATE 2-32
2.6.1 Functions that Improve Water Quality 2-34
2.6.1.1 Removing Sediment 2-35
2.6.1.2 Removing Phosphorus 2-38
2.6.1.3 Removing Nitrogen 2-40
2.6.1.4 Removing Metals and Toxic Organic Contaminants 2-41
2.6.1.5 Removing Pathogens 2-44
2.6.2 Functions Related to Maintaining the Water Regime in a Drainage Basin (Hydrologic Functions) 2-44
2.6.2.1 Reducing Peak Flows 2-45
2.6.2.2 Reducing Erosion 2-48
2.6.2.3 Recharging Groundwater 2-50
2.6.3 Functions Related to Habitat 2-52
2.6.3.1 The Use of Wetlands by Species of Wildlife 2-52
2.6.3.2 Characteristics that Make Wetlands Important as Habitat 2-53
2.6.3.3 Use of Wetlands by Vertebrates in Washington 2-56
2.6.3.4 Habitat Requirements of Some Wetland-Dependent Species in Washington 2-59
2.6.3.5 Habitat for Plants 2-66
2.6.3.6 Supporting Food Webs (Primary Production and Export) 2-67
2.6.4 Summary of Key Points 2-67
2.7 CHAPTER SUMMARY AND CONCLUSIONS 2-68

CHAPTER 3 ENVIRONMENTAL DISTURBANCES CAUSED BY HUMAN ACTIVITIES AND USES OF THE LAND 3-1

3.1 READER'S GUIDE TO THIS CHAPTER 3-1
3.1.1 Chapter Contents 3-1
3.1.2 Where to Find Summary Information and Conclusions 3-2
3.1.3 Sources and Gaps in Information 3-2
3.2 INTRODUCTION TO HUMAN-CAUSED DISTURBANCES 3-3
3.2.1 The Link between Wetland Functions, Human Land Uses, and Changes in Wetlands 3-4
3.2.2 Types of Disturbances Resulting from Human Land Uses 3-5

3.2.3 Disturbances to the Movement of Water at the Landscape Scale 3-6
3.2.3.1 Movement of Water in Undisturbed Landscapes 3-8
3.2.3.2 Movement of Water in Disturbed Landscapes 3-9
3.2.3.3 The Role Of Impervious Surface In Changing Water Regimes 3-11
3.2.3.4 The Role Of Dams In Changing Water Regimes 3-12
3.2.4 Disturbances to the Quality of Water at the Landscape Scale 3-13
3.2.5 Disturbances to Habitats at the Landscape Scale (Fragmentation) 3-13
3.2.6 Summary of Key Points 3-14
3.3 DISTURBANCES CAUSED BY AGRICULTURE 3-15
3.3.1 Loss of Wetlands and Changes to the Physical Structure of Wetlands from Agricultural Practices 3-15
3.3.2 Increased Amounts of Water in Wetlands Resulting from Agricultural Practices 3-17
3.3.3 Decreased Amounts of Water in Wetlands Resulting from Agricultural Practices 3-19
3.3.4 Increased Fluctuations of Water Levels in Wetlands Resulting from Agriculture 3-19
3.3.5 Increased Input of Sediment Resulting from Agriculture 3-20
3.3.6 Increased Input of Nutrients Resulting from Agriculture 3-21
3.3.7 Increased Input of Toxic Contaminants Resulting from Agriculture 3-21
3.3.8 Increased Levels of Salt Resulting from Agriculture 3-22
3.3.9 Fragmentation of Habitat Resulting from Agriculture 3-22
3.3.10 Other Disturbances Resulting from Agriculture 3-23
3.3.11 Summary of Key Points 3-23
3.4 DISTURBANCES CAUSED BY URBANIZATION 3-24
3.4.1 Loss of Wetlands Resulting from Urbanization 3-24
3.4.2 Increased Amount of Water in Wetlands Resulting from Urbanization 3-25
3.4.2.1 Increased Frequency of Erosive Flows 3-25
3.4.2.2 Increased Volume of Runoff and Longer Duration of Flows 3-26
3.4.2.3 Consequences of Changes in Water Regime 3-26
3.4.3 Increased Fluctuations of Water Levels Resulting from Urbanization 3-27
3.4.4 Increased Input of Sediment Resulting from Urbanization 3-28
3.4.5 Increased Input of Nutrients Resulting from Urbanization 3-28
3.4.6 Increased Input of Toxic Contaminants Resulting from Urbanization 3-29
3.4.6.1 Heavy Metals and Hydrocarbons 3-30
3.4.6.2 Organic Matter 3-30
3.4.6.3 Pesticides 3-31
3.4.7 Fragmentation of Habitat Resulting from Urbanization 3-31
3.4.8 Other Disturbances Resulting from Urbanization 3-32
3.4.9 Summary of Key Points 3-32
3.5 DISTURBANCES CAUSED BY FOREST PRACTICES 3-32
3.6 DISTURBANCES CAUSED BY MINING 3-33
3.7 CHAPTER SUMMARY AND CONCLUSIONS 3-33

CHAPTER 4 NEGATIVE IMPACTS OF HUMAN DISTURBANCES ON THE FUNCTIONS OF WETLANDS 4-1

4.1 READER'S GUIDE TO THIS CHAPTER 4-1

4.1.1 Chapter Contents 4-2
4.1.2 Where to Find Summary Information and Conclusions 4-3
4.1.3 Sources and Gaps in Information 4-3
4.2 THE GEOGRAPHIC SCALE OF IMPACTS TO WETLAND FUNCTIONS 4-5
4.3 IMPACTS FROM CHANGING THE PHYSICAL STRUCTURE WITHIN A WETLAND 4-5
4.3.1 Impacts on Hydrologic Functions from Changing the Physical Structure 4-6
4.3.2 Impacts on Functions that Improve Water Quality from Changing the Physical Structure 4-6
4.3.3 Impacts on Plants from Changing the Physical Structure in a Wetland 4-7
4.3.4 Impacts on Invertebrates from Changing the Physical Structure of the Habitat 4-8
4.3.5 Impacts on Amphibians and Reptiles of Changing the Physical Structure of the Habitat 4-9
4.3.6 Impacts on Fish from Changing the Physical Structure of the Habitat 4-10
4.3.7 Impacts on Birds of Changing the Physical Structure of the Habitat 4-10
4.3.8 Impacts on Mammals from Changing the Physical Structure of the Habitat 4-11
4.3.9 Summary of Key Points 4-12
4.4 IMPACTS FROM CHANGING THE AMOUNT OF WATER IN A WETLAND 4-12
4.4.1 Impacts on Hydrologic Functions from Changing the Amount of Water 4-13
4.4.2 Impacts on Functions that Improve Water Quality from Changing the Amount of Water 4-13
4.4.3 Impacts on Plants from Changing the Amount of Water 4-14
4.4.4 Impacts on Invertebrates from Changing the Amount of Water in the Habitat 4-15
4.4.4.1 Impacts on Invertebrates from Reducing the Amount of Water in the Habitat 4-16
4.4.4.2 Impacts on Invertebrates from Increasing the Amount of Water in the Habitat 4-17
4.4.5 Impacts on Amphibians and Reptiles from Changing the Amount of Water in the Habitat 4-17
4.4.6 Impacts on Fish from Changing the Amount of Water in the Habitat 4-18
4.4.7 Impacts on Birds from Changing the Amount of Water in the Habitat 4-18
4.4.7.1 Impacts on Birds from Reducing the Amount of Water in the Habitat 4-18
4.4.7.2 Impacts on Birds from Increasing the Amount of Water in the Habitat 4-19
4.4.8 Impacts on Mammals from Changing the Amount of Water in the Habitat 4-19
4.4.9 Summary of Key Points 4-20
4.5 IMPACTS FROM CHANGING THE FLUCTUATION OF WATER LEVELS WITHIN A WETLAND 4-20
4.5.1 Impacts on Hydrologic Functions from Changing the Fluctuations in Water Levels 4-21
4.5.2 Impacts on Functions that Improve Water Quality from Changing the Fluctuations in Water Levels 4-22
4.5.3 Impacts on Plants from Changing the Fluctuations in Water Levels 4-22
4.5.4 Impacts on Invertebrates from Changing the Water Level Fluctuations in the Habitat 4-23
4.5.5 Impacts on Amphibians and Reptiles from Changing the Water Level Fluctuations in the Habitat 4-24
4.5.6 Impacts on Fish from Changing the Water Level Fluctuations in the Habitat 4-25

4.5.7 Impacts on Birds from Changing the Water Level Fluctuations in the Habitat... 4-25
4.5.8 Impacts on Mammals of Changing the Water Level Fluctuations in the Habitat 4-25
4.5.9 Summary of Key Points ... 4-25
4.6 IMPACTS FROM CHANGING THE AMOUNT OF SEDIMENT COMING INTO A WETLAND ... 4-26
4.6.1 Impacts on Hydrologic Functions from Changing the Amount of Sediment ... 4-26
4.6.2 Impacts on Functions that Improve Water Quality from Changing the Amount of Sediment ... 4-26
4.6.3 Impacts on Plants from Changing the Amount of Sediment... 4-26
4.6.4 Impacts on Invertebrates from Changing the Amount of Sediment in the Habitat ... 4-28
4.6.5 Impacts on Amphibians and Reptiles from Changing the Amount of Sediment in the Habitat ... 4-29
4.6.6 Impacts on Fish from Changing the Amount of Sediment in the Habitat... 4-30
4.6.7 Impacts on Birds from Changing the Amount of Sediment in the Habitat... 4-30
4.6.8 Impacts on Mammals from Changing the Amount of Sediment in the Habitat... 4-30
4.6.9 Summary of Key Points ... 4-30
4.7 IMPACTS FROM INCREASING THE AMOUNTS OF NUTRIENTS COMING INTO A WETLAND... 4-31
4.7.1 Impacts on Hydrologic Functions from Increasing the Amounts of Nutrients... 4-31
4.7.2 Impacts on Functions that Improve Water Quality from Increasing the Amounts of Nutrients ... 4-32
4.7.3 Impacts on Plants from Increasing the Amounts of Nutrients ... 4-32
4.7.4 Impacts on Invertebrates from Increasing the Amounts of Nutrients in the Habitat ... 4-33
4.7.5 Impacts on Amphibians and Reptiles from Increasing the Amounts of Nutrients in the Habitat ... 4-34
4.7.6 Impacts on Fish from Increasing the Amounts of Nutrients in the Habitat ... 4-35
4.7.7 Impacts on Birds from Increasing the Amounts of Nutrients in the Habitat ... 4-35
4.7.8 Impacts on Mammals from Increasing the Amounts of Nutrients in the Habitat 4-36
4.7.9 Summary of Key Points ... 4-36
4.8 IMPACTS FROM INTRODUCING TOXIC CONTAMINANTS TO A WETLAND ... 4-37
4.8.1 Impacts on Hydrologic Functions from Toxic Contaminants... 4-37
4.8.2 Impacts on Functions that Improve Water Quality from Toxic Contaminants... 4-37
4.8.3 Impacts on Plants from Toxic Contaminants ... 4-37
4.8.4 Impacts on Invertebrates from Toxic Contaminants in the Habitat ... 4-38
4.8.4.1 Impacts of Heavy Metals on Invertebrates ... 4-38
4.8.4.2 Impacts of Pesticides, Oil, and Other Contaminants on Invertebrates ... 4-39
4.8.5 Impacts on Amphibians and Reptiles from Toxic Contaminants in the Habitat.. 4-41
4.8.6 Impacts on Fish from Toxic Contaminants in the Habitat ... 4-42
4.8.7 Impacts on Birds from Toxic Contaminants in the Habitat ... 4-42
4.8.8 Impacts on Mammals from Toxic Contaminants in the Habitat ... 4-44
4.8.9 Summary of Key Points ... 4-44
4.9 IMPACTS FROM CHANGING THE ACIDITY (pH) OF SOILS OR WATER IN A WETLAND... 4-44
4.9.1 Impacts on Hydrologic Functions from Changing the Acidity ... 4-44

4.9.2 Impacts on Functions that Improve Water Quality from Changing the Acidity.. 4-45
4.9.3 Impacts on Plants from Changing the Acidity 4-45
4.9.4 Impacts on Invertebrates from Changing Acidity in the Habitat 4-45
4.9.5 Impacts on Amphibians and Reptiles from Changing the Acidity in the Habitat 4-48
4.9.6 Impacts on Fish from Changing the Acidity in the Habitat 4-49
4.9.7 Impacts on Birds from Changing the Acidity in the Habitat 4-49
4.9.8 Impacts on Mammals from Changing the Acidity in the Habitat 4-49
4.9.9 Summary of Key Points 4-50
4.10 IMPACTS FROM INCREASING THE CONCENTRATIONS OF SALT IN A WETLAND 4-50
4.10.1 Impacts on Hydrologic Functions from Increasing Concentrations of Salt 4-50
4.10.2 Impacts on Functions that Improve Water Quality from Increasing Concentrations of Salt 4-51
4.10.3 Impacts on Plants from Increasing Concentrations of Salt 4-51
4.10.4 Impacts on Invertebrates from Increasing Concentrations of Salt in the Habitat 4-52
4.10.5 Impacts on Amphibians and Reptiles of Increasing Concentrations from Salt in the Habitat 4-52
4.10.6 Impacts on Fish from Increasing Concentrations of Salt in the Habitat 4-53
4.10.7 Impacts on Birds from Increasing Concentrations of Salt in the Habitat 4-53
4.10.8 Impacts on Mammals from Increasing Concentrations of Salt in the Habitat 4-54
4.10.9 Summary of Key Points 4-54
4.11 IMPACTS FROM FRAGMENTING WETLAND HABITATS 4-54
4.11.1 Impacts on Hydrologic Functions from Fragmentation 4-55
4.11.2 Impacts on Functions that Improve Water Quality from Fragmentation 4-55
4.11.3 Impacts on Plants from Fragmentation 4-55
4.11.4 Impacts on Invertebrates from Fragmentation 4-56
4.11.5 Impacts on Amphibians and Reptiles from Fragmentation 4-56
4.11.5.1 Amphibians 4-56
4.11.5.2 Reptiles 4-59
4.11.6 Impacts on Fish from Fragmentation 4-59
4.11.7 Impacts on Birds from Fragmentation 4-60
4.11.8 Impacts on Mammals from Fragmentation 4-62
4.11.9 Summary of Key Points 4-62
4.12 IMPACTS FROM OTHER HUMAN DISTURBANCES 4-63
4.12.1 Impacts on Plant Communities from Altering Soils 4-63
4.12.2 Impacts on Wildlife from Roads 4-63
4.12.3 Impacts on Wildlife from Noise 4-65
4.12.4 Impacts on Wildlife and Plant Communities from Recreational Activities 4-66
4.12.5 Introduction of Invasive and Exotic Species in Wetlands 4-68
4.12.5.1 Impacts on Wetlands from Exotic and Invasive Plants 4-68
4.12.5.2 Impacts on Species Using Wetlands from Domestic Pets 4-69
4.12.5.3 Impacts on Species Using Wetlands from Exotic Mammals and Birds 4-69
4.12.5.4 Impacts on Native Invertebrates from Exotic Invertebrates in Wetlands 4-70
4.12.5.5 Impacts on Native Amphibians from Exotic Species in Wetlands 4-70
4.12.5.6 Impacts on Wetland-associated Species from Exotic Fish 4-71
4.12.6 Summary of Key Points 4-72
4.13 CHAPTER SUMMARY AND CONCLUSIONS 4-73

CHAPTER 5 THE SCIENCE AND EFFECTIVENESS OF WETLAND MANAGEMENT TOOLS 5-1

5.1 READER'S GUIDE TO THIS CHAPTER 5-1
5.1.1 Chapter Contents 5-1
5.1.2 Where to Find Summary Information and Conclusions 5-2
5.1.3 Data Sources and Data Gaps 5-2
5.2 INTRODUCTION AND BACKGROUND ON REGULATORY TOOLS 5-3
5.3 HOW WETLANDS ARE DEFINED AND DELINEATED 5-4
5.3.1 How Agencies Define Wetlands 5-4
5.3.2 Biological vs. Regulated Wetlands 5-5
5.3.3 Small Wetlands 5-7
5.3.3.1 Amphibians and Small Wetlands 5-8
5.3.3.2 Birds and Small Wetlands 5-9
5.3.3.3 Mammals and Small Wetlands 5-10
5.3.4 Isolated Wetlands 5-11
5.3.5 Delineation Methods 5-13
5.3.6 Summary of Key Points 5-13
5.4 WETLAND RATING SYSTEMS 5-14
5.4.1 Other Characteristics Used for Rating 5-16
5.4.1.1 Bogs 5-17
5.4.1.2 Alkali Wetlands 5-19
5.4.1.3 Mature and Old-Growth Forested Wetlands 5-20
5.4.1.4 Vernal Pools 5-20
5.4.1.5 "Natural Heritage" Wetlands 5-20
5.4.1.6 Estuarine Wetlands 5-21
5.4.1.7 Wetlands in Coastal Lagoons 5-21
5.4.1.8 Interdunal Wetlands 5-22
5.4.2 Summary of Key Points 5-22
5.5 BUFFERS 5-23
5.5.1 Terms Used to Describe Buffers 5-24
5.5.2 Functions Provided by Buffers 5-25
5.5.3 Buffers and Protection of Water Quality 5-27
5.5.3.1 Removing Sediment 5-28
5.5.3.2 Removing Nutrients 5-32
5.5.3.3 Removing Toxics and Pathogens 5-35
5.5.3.4 Maintaining Microclimate 5-36
5.5.3.5 Summary of Key Points 5-38
5.5.4 Buffers and Wildlife Habitat 5-38
5.5.4.1 Maintaining Terrestrial Habitat Adjacent to Wetlands 5-39
5.5.4.2 Screening Adjacent Disturbances 5-46
5.5.4.3 Maintaining Habitat Connections 5-48
5.5.4.4 Summary of Key Points 5-49
5.5.5 Buffer Maintenance and Effectiveness over Time 5-49
5.5.5.1 Human Alteration to Buffers 5-49
5.5.5.2 Loss of Trees to Blowdown 5-50
5.5.5.3 Reduced Capacity for Sediment/Nutrient Removal 5-50

5.5.5.4 Summary of Key Points....5-51
5.5.6 Summary of Buffer Ranges and Characteristics from the Literature....5-51
5.5.6.1 Summary of Key Points....5-55
5.6 CHAPTER SUMMARY AND CONCLUSIONS....5-56

CHAPTER 6 THE SCIENCE AND EFFECTIVENESS OF WETLAND MITIGATION....6-1

6.1 READER'S GUIDE TO THIS CHAPTER....6-1
6.1.1 Chapter Contents....6-1
6.1.2 Where to Find Summary Information and Conclusions....6-2
6.1.3 Sources and Gaps in Information....6-3
6.2 INTRODUCTION AND BACKGROUND TO WETLAND MITIGATION....6-4
6.2.1 Wetland Mitigation Sequence....6-4
6.2.2 The Emergence of Compensatory Wetland Mitigation....6-6
6.3 SUCCESS OF COMPENSATORY MITIGATION WETLANDS....6-6
6.3.1 Results of Literature Studies....6-8
6.3.2 Summary of Key Points....6-9
6.4 COMPLIANCE WITH PERMIT REQUIREMENTS....6-10
6.4.1 Compliance Overall....6-10
6.4.2 Project Installation....6-13
6.4.3 Installation According to Plan....6-14
6.4.4 Establishment of Wetland Acreage....6-16
6.4.5 Attainment of Goals, Objectives, and Performance Standards....6-18
6.4.6 Monitoring....6-19
6.4.7 Maintenance....6-21
6.4.8 Regulatory Follow-Up....6-21
6.4.9 Summary of Key Points....6-22
6.5 TYPES OF COMPENSATORY MITIGATION....6-24
6.5.1 Restoration....6-24
6.5.1.1 Use of Restoration....6-25
6.5.1.2 Effectiveness of Restoration....6-26
6.5.2 Creation....6-26
6.5.2.1 Use of Creation....6-27
6.5.2.2 Effectiveness of Creation....6-27
6.5.3 Enhancement/Exchange....6-27
6.5.3.1 Use of Enhancement....6-28
6.5.3.2 Effectiveness of Enhancement....6-28
6.5.4 Preservation....6-30
6.5.4.1 Use of Preservation....6-30
6.5.4.2 Effectiveness of Preservation....6-30
6.5.5 Mixed Compensatory Mitigation....6-31
6.5.5.1 Use of Mixed Compensation Projects....6-31
6.5.5.2 Effectiveness of Mixed Compensation Projects....6-31
6.5.6 Wetland Mitigation Banking....6-31
6.5.6.1 Use of Wetland Banking....6-32
6.5.6.2 Effectiveness of Wetland Mitigation Banks....6-32
6.5.7 In-Lieu Fee Programs....6-33

6.5.7.1 Use of In-Lieu Fee Programs 6-33
6.5.7.2 Effectiveness of In-Lieu Fee Programs 6-33
6.5.8 Summary of Key Points 6-34
6.6 REPLACEMENT RATIOS 6-35
6.6.1 Rationale for the Use of Replacement Ratios 6-36
6.6.2 Replacement Ratios Required and Achieved 6-37
6.6.3 Approaches for Determining Replacement Ratios 6-39
6.6.4 Summary of Key Points 6-41
6.7 REPLACEMENT OF WETLAND ACREAGE 6-41
6.7.1 Programmatic Evaluations of Acreage Replacement 6-42
6.7.2 Project-Specific Evaluations of Acreage Replacement 6-44
6.7.3 Summary of Key Points 6-45
6.8 FUNCTIONS AND CHARACTERISTICS PROVIDED BY CREATED, RESTORED, OR ENHANCED WETLANDS 6-45
6.8.1 Wildlife Habitat 6-46
6.8.1.1 Invertebrates 6-46
6.8.1.2 Amphibians 6-47
6.8.1.3 Birds/Waterfowl 6-47
6.8.2 Plants 6-48
6.8.2.1 Comparisons with Reference Wetlands 6-48
6.8.2.2 Cowardin Classes Provided by Compensatory Mitigation Wetlands 6-49
6.8.2.3 Factors Affecting Plants 6-51
6.8.3 Soil Characteristics 6-54
6.8.4 Water Quality 6-56
6.8.4.1 Comparison of Water Quality at Created and Reference Wetlands 6-56
6.8.4.2 Sediment Removal 6-56
6.8.4.3 Nutrient Removal 6-57
6.8.5 Water Quantity 6-58
6.8.5.1 Using Hydrogeomorphic (HGM) Classification to Study Water Regime at Mitigation Sites 6-58
6.8.6 Summary of Key Points 6-59
6.9 REPRODUCIBILITY OF PARTICULAR WETLAND TYPES 6-61
6.9.1 Bogs and Fens 6-61
6.9.2 Vernal Pools 6-62
6.9.3 Alkali Wetlands 6-63
6.9.4 Mature Forested Wetlands 6-63
6.9.5 Summary of Key Points 6-63
6.10 SUGGESTIONS FROM THE LITERATURE FOR IMPROVING COMPENSATORY MITIGATION 6-63
6.10.1 Regulatory Improvements 6-65
6.10.2 Improving Site Selection and Design 6-66
6.10.3 Improving Implementation 6-68
6.10.4 Performance Standards 6-69
6.10.4.1 Shortcomings of Existing Performance Standards 6-69
6.10.4.2 Use of Reference Wetlands in Developing Performance Standards 6-70
6.10.4.3 Longer Period Needed to Evaluate Projects 6-71

6.10.5 Compensatory Mitigation Using a Watershed/Landscape Approach 6-72
6.10.5.1 Methods for Implementing a Landscape Approach 6-72
6.10.6 Mitigation Banking 6-74
6.10.7 Summary of Key Points 6-75
6.11 CHAPTER SUMMARY AND CONCLUSIONS 6-75

CHAPTER 7 CUMULATIVE IMPACTS TO WETLANDS AND THE NEED FOR A NEW APPROACH 7-1

7.1 READER'S GUIDE TO THIS CHAPTER 7-1
7.1.1 Chapter Contents 7-1
7.1.2 Where to Find Summary Information and Conclusions 7-2
7.1.3 Sources and Gaps in Information 7-2
7.2 LOSS OF WETLANDS AS AN INDICATOR OF CUMULATIVE IMPACTS 7-3
7.3 TYPES OF CUMULATIVE IMPACTS 7-4
7.4 CAUSES OF CUMULATIVE IMPACTS IN WASHINGTON 7-6
7.4.1 Case-by-case Permitting as a Cause of Cumulative Impacts 7-6
7.4.2 Lack of Consistent Plans and Regulations between Jurisdictions as a Possible Cause of Cumulative Impacts 7-8
7.4.3 Implementation of Regulatory Programs at the Local Level as a Possible Cause of Cumulative Impacts 7-9
7.4.4 Relating the Types of Cumulative Impacts to Measures Taken by Local Governments 7-10
7.5 CHAPTER SUMMARY AND CONCLUSIONS 7-12

REFERENCES

GLOSSARY

APPENDICES

Appendix 1-A Team Guiding Production of Volume 1

Appendix 1-B Characteristics of a Valid Scientific Process

Appendix 1-C Methods Used for Searching and Reviewing the Literature

Appendix 1-D Reviewers of Volume 1

Appendix 2-A Methods for Organizing and Grouping Information About Wetlands

Appendix 2-B Associations between Species of Wildlife and Wetlands in Washington and Oregon

List of Tables

Table 2-1. Different ways of dividing wetland functions. 2-8

Table 2-2. Environmental factors that have been identified as controls of functions in wetlands. 2-16

Table 2-3. Characteristics of wetland classes in the hydrogeomorphic classification (from Brinson 1993a). 2-20

Table 2-4. Subclasses and families of wetlands in different regions of Washington State (Hruby et al. 1999, 2000) 2-28

Table 2-5. Functions potentially performed by wetlands in different HGM classes in Washington (data compiled from Hruby et al. 1999, 2000, Hruby 2004a, 2004b). 2-33

Table 2-6. Primary mechanisms for removing contaminants in wetlands (extracted from Hammer 1989, Moshiri 1993, Kadlec and Knight 1996). 2-34

Table 2-7. Number of wildlife species by type of wetland habitat and by their association (from O'Neil and Johnson 2001). See Appendix 2-B for definitions of the types of wetlands. 2-56

Table 3-1. Summary of human-caused disturbances and the scale at which they can occur. . 3-6

Table 3-2. Summary of findings on the impacts of impervious cover. 3-12

Table 3-3. Disturbances resulting from different land-use practices that can change the factors that control wetland functions. 3-35

Table 4-1. Summary of studies on effects of contaminants on invertebrates. 4-40

Table 4-2. Summary of studies describing relative tolerance of invertebrates to acidification. 4-46

Table 4-3. Summary of types of environmental disturbances created by some types of land use. 4-75

Table 4-4. Synthesis of the information reported in the literature on the negative impacts of different human disturbances on wetland functions. 4-76

Table 4-5. Synthesis of the negative impacts of some land uses on wetland functions..... 4-77

Table 5-1. Summary of studies on sediment control provided by buffers of various widths. 5-32

Table 5-2. Summary of studies on nutrient removal provided by buffers of various widths. 5-34

Table 5-3. Summary of studies on pathogen control provided by buffers of various widths. 5-36

Table 5-4. Summary of a study on the influence of microclimate provided by buffers of various widths. 5-37

Table 5-5. Summary of studies on wildlife habitat provided by buffers. 5-44

Table 5-6. Summary of studies on screening provided by buffers. 5-47

Table 5-7. Summary of recommendations for buffer dimensions from the literature. 5-52

Table 5-8. A summary of the effectiveness of pollutant removal and the value of the wildlife habitat of vegetated buffers according to buffer width (Desbonnet et al. 1994). 5-53

Table 6-1. Results of studies examining the success of compensatory mitigation. 6-8

Table 6-2. Level of overall compliance of compensation projects. 6-11

Table 6-3. Percent of compensatory mitigation projects that were installed. 6-14

Table 6-4. Percent of compensatory mitigation projects installed according to plan. 6-15

Table 6-5. Establishment of required wetland acreage. 6-17

Table 6-6. Attainment of goals, objectives, and performance standards. 6-19

Table 6-7. Percent of projects requiring monitoring and those actually monitored..... 6-20

Table 6-8. Comparison of replacement ratios that were required and achieved. 6-38

Table 6-9. Permitted wetland loss compared to required wetland compensation. 6-43

Table 6-10. Literature sources and corresponding reference numbers. 6-64

Table 6-11. Suggestions from the literature for regulatory improvement. 6-65

Table 6-12. Suggestions from the literature for improving site selection and design. 6-67

Table 6-13. Suggestions from the literature for improving implementation. 6-68

Table 7-1. Types of cumulative impacts (modified from Council of Environmental Quality 1997) 7-5

Table 7-2. Types of cumulative impacts and examples of factors at the local level that might cause the impacts. 7-11

List of Figures

Figure 2-1. A model of the environmental factors that control wetland functions (Bedford 1999; reprinted with permission). 2-12

Figure 2-2. "Process-structure-function" model. 2-13

Figure 2-3. Diagram summarizing some major environmental factors that control functions of wetlands and how they interact with human-caused disturbances. 2-17

Figure 2-4. Regions in Washington used for classifying wetlands. 2-23

Figure 2-5. Riverine wetlands. Located in active floodplains where overbank flooding of the river or stream structures the wetland environment and controls its functions. 2-24

Figure 2-6. Depressional wetlands. Located in topographic low areas that are closed on at least three sides (they may or may not have an outlet). 2-25

Figure 2-7. Slope wetlands. Located on slopes where groundwater daylights and runs at or just below the soil surface. 2-26

Figure 2-8. Lacustrine fringe wetlands. Located along the edge of large bodies of water, such as lakes. 2-27

Figure 2-9. Slope wetland in the Columbia Basin that formed at a break in the slope. 2-37

Figure 2-10. Features of wetlands that increase structural complexity 2-54

Figure 2-11. Depressional wetland in the Columbia Basin. 2-55

Figure 2-12. The number of reptile and amphibian species found in wetlands in Washington and Oregon 2-57

Figure 2-13. The number of bird species found in wetlands in Washington and Oregon (from Kauffman et al. 2001). 2-58

Figure 2-14. The number of mammal species found in wetlands in Washington and Oregon (from Kauffman et al. 2001). 2-59

Figure 3-1. Diagram summarizing some major environmental factors that control functions of wetlands and how they interact with human-caused disturbances... 3-5

Figure 3-2. Changes in the proportion of groundwater, interflow, evapotranspiration, and surface runoff with different types of land cover in western Washington (Beyerlein 1999; reprinted with permission). 3-10

Figure 5-1. Relationship of percent removal to buffer width for the treatment of sediments contained in surface water runoff (Desbonnet et al. 1994). 5-31

Acknowledgements

Many hours of painstaking work by dedicated experts went into the production of this document. The Core Team (listed in Appendix 1-A) persistently guided us through numerous challenges and did the bulk of the work by gathering and reading articles, dealing with problems with the database, and crafting and re-crafting the framework for the document. Katherine March, from state Fish and Wildlife (WDFW) also searched the public databases, generating long lists of articles to be considered for the synthesis, as well as provided valuable review. Kim Harper, while working as a staff member at Sheldon and Associates, accepted the difficult challenge of managing the database.

The authors and other members of the Core Team spent countless hours reading and summarizing articles and writing and re-writing text. Of special note is Tom Hruby whose knowledge of the literature and ability to translate scientific concepts into lay terms results in his valuable technical writing skills and contribution to many chapters.

Also of special note is the dedication and time spent by Dyanne Sheldon of Sheldon and Associates in the production of this document. She donated many hours of her own time toward the project, often burning the midnight oil to make sure articles were read and text written. Patricia Johnson deserves kudos for her work sifting through the voluminous information on compensatory mitigation and presenting it in a thorough yet easy to read manner.

Staff at the Washington Department of Fish and Wildlife provided review of internal drafts. Special thanks go to Steve Penland and Bob Ziegler for their valuable input and critique.

Sara Noland, 2N Publishing, is to be complimented for her excellent skills editing the draft document. Editing the draft was a real challenge given the numerous authors involved, each with a different writing style, and the changes that were initiated relatively late in the production process. We thank her sincerely for her patience and flexibility. Tom Noland, the other N in 2N Publishing, provided invaluable assistance in scanning and converting graphics into a format suitable for publication, as well as patiently trouble-shooting computer problems.

Thanks also to Mary Lynum for her role as Ecology support staff during completion of the review draft; Yolanda Holder and Paige Boule` from Ecology provided valuable assistance with finalizing and proofing the document. Keren Marzi of Sheldon and Associates is acknowledged for her effort designing several covers for the document, the final cover design being chosen by the Core Team. Thank you to Tim Schlender of Ecology for developing the web site and posting the draft and final versions of the document on the site.

Considerable acknowledgement is due to Dana L. Mock. The final production of Volume 1 would not have been possible without her diligence, hard work, attention to detail, and patience. Dana also took the lead on communications during the production of the final draft.

The document and this effort as a whole were the vision of Andy McMillan, who also obtained the funding from several sources. In addition, Andy wrote portions of the document and provided wise leadership and guidance, as well as contributing his unique ability to the resolution of complex problems.

Finally, of great importance is the acknowledgement of Teri Granger, the project manager. Teri coordinated every aspect of the project, facilitated meetings, provided encouragement to the authors and support staff, wrote and edited portions of the text, and provided overall management while working part time. Her oversight, management and attention to detail kept everyone on track and were greatly valued by all of her colleagues.

This document would never have been produced had it not been for the financial backing provided by the U.S. Environmental Protection Agency. The Washington State Departments of Ecology and Fish and Wildlife also contributed to the funding for this project. We thank the agencies for their support in undertaking such an ambitious endeavor.

Chapter 1
Introduction to the Document

This is the first volume of a two-volume series. This volume contains a summary and synthesis of the recent literature relevant to the science and management of wetlands in the state of Washington. Volume 1 describes what the scientific literature says directly about the topics described below. In some cases where scientific information is lacking, the authors present their own hypotheses or conclusions based on a process of deductive reasoning or their own observations. Hypotheses and conclusions based only on the authors' reasoning or observations are clearly labeled as such.

The focus of Volume 1 is freshwater wetlands in Washington. Estuarine and marine wetlands are discussed in this document only in regard to the wetland rating systems covered in the second volume.

The topics covered in Volume 1 are:

- How environmental factors control the functions of wetlands across the landscape and at individual sites, how freshwater wetlands are classified according to these controls, and what functions are performed by different classes of freshwater wetlands in the state
- How human activities and land uses affect the environmental factors that control the functions of freshwater wetlands
- How disturbances caused by human activities and land uses impact the performance of functions by freshwater wetlands
- How wetlands are protected and managed using common tools such as buffers and compensatory mitigation, including what the literature says about the relative effectiveness of these tools
- How cumulative impacts can result from current approaches to managing and regulating wetlands

Volume 2 of this series translates these scientific findings into guidance to local governments and others regarding programs they can or currently do use to protect and manage wetlands.

This work was collectively prepared by the Washington State Department of Ecology (Ecology), the Washington State Department of Fish and Wildlife (WDFW), and a private consulting firm. The U.S. Environmental Protection Agency (EPA) provided funding and assisted in its production. Representatives from these agencies, as well as staff from the private consulting firm, made up a team (the Core Team) that guided the project. See Appendix 1-A for a list of members of the Core Team.

Both volumes will be of use to all those interested in protecting and managing wetlands. The authors hope they will find these documents useful in gaining a greater understanding of the current science regarding wetlands in the state, their ecology and functions, as well as their protection and management. Examples of groups who might use these documents include federal, state, and tribal staff; planners; resource managers; wetland scientists; builders; farmers; environmentalists; and other concerned citizens.

Local governments, however, are the primary audience for this document. They are a key group involved in wetland protection in the state. Through the Growth Management Act (GMA) (Revised Code of Washington (RCW) 36.70A), every county and city in Washington must designate critical areas (including wetlands) within their boundaries and protect them. In 1995, an amendment to GMA (RCW 36.70A.172 [1]) required that all city and county governments must include best available science (BAS) when developing their critical areas policies and regulations.

This synthesis, therefore, may be of special interest to local governments that do not have the resources to complete their own review of the scientific literature. All local governments, however, should also consider locally and regionally specific information not included in this synthesis if it meets the criteria of a valid scientific process, as described below.

1.1 Best Available Science (BAS)

The Washington Administrative Code (WAC 365-195-905) provides assessment criteria to assist in determining whether information constitutes the best available science, i.e., by having been developed through a valid scientific process. A valid scientific process is one that produces reliable information that is useful in understanding the consequences of regulatory decisions and in developing policies and regulations that will be effective in protecting the functions and values of wetlands and other critical areas.

Appropriate sources of scientific information as defined in WAC 365-195-905 include:

- Research
- Monitoring
- Inventory
- Survey
- Modeling
- Assessment
- Synthesis
- Expert opinion

Information derived from any one of these sources can be considered scientific information if it possesses the required characteristics in WAC 365-195-905 (see Table 1B-1 in Appendix 1-B). For example, a synthesis such as Volume 1 is considered best available science when it has undergone peer review, describes the methods used to obtain the information, presents conclusions based on reasonable assumptions that are logically derived, places the information in proper context, and is well referenced. See Appendix 1-B for a list of all the characteristics of a valid scientific process and their definitions, as well as a table displaying the characteristics needed for each of the sources listed above to be considered BAS.

Methods for preparing and reviewing Volume 1

The primary steps taken to arrive at publication of this document include:

- Searching the literature
- Reviewing, sorting, and prioritizing the reference lists
- Obtaining the reference documents
- Reading and entering information from the documents in a database
- Writing and revising the text
- Obtaining peer and public review
- Responding to comments, revising the text, and completing the document

The processes used for these steps, including the scientific databases and the key words used to search them, are described in Appendix 1-C.

1.1.1 Volume 1 as BAS

Volume 1 meets the definition and characteristics required for a synthesis in the WAC. Findings from scientific journal articles, government publications, technical books, and other sources that meet the definition and characteristics of BAS in WAC 365-195-905 were used and referenced in the synthesis. Conference proceedings and personal communications were occasionally used when no other information was available. In some cases, we were unable to ascertain to what level these additional sources were peer reviewed.

In a few instances, we have cited data collected during the calibration of the *Methods for Assessing Wetland Functions* (Hruby et. al. 1999, 2000) (also known as the Washington State wetland function assessment methods or WFAM) and the Washington State wetland rating systems (Hruby 2004a, b). These data have not been published in scientific journals. However, these observations reported as "unpublished data" in Volume 1, were collected in the field by interdisciplinary teams of wetland experts and used to support and calibrate the function assessment methods and the wetland rating systems. The methods and rating systems have been extensively reviewed and field tested by peer experts as well as the public. The data themselves were offered for review on request during public review and continue to be available on request.

A peer review of documents concerning wetlands, specifically the function assessment methods, wetland rating systems, and these two volumes, means that comments were solicited from a broad range of people on a mailing list of hundreds. This included experts from various disciplines, not just a select few that were in house or close associates. All comments received were addressed. For these volumes, a response to each comment, including rationales for those not used to modify the drafts, has been prepared. To read the comments on Volume 1 and the authors responses go to http://www.ecy.wa.gov/biblio/0506007.html.

1.1.2 Making Hypotheses and Assumptions

As mentioned previously, in some places in the document we offer our conclusions based on the literature when the references searched do not provide specific information on a topic important for wetland management. In such instances, the authors clearly state that a hypothesis, assumption, or conclusion is being made. For example, we use statements such as "in the absence of research to the contrary, it can be assumed…," "it is possible to hypothesize…," or "it can be inferred that…"

In these cases, a description of the logic being used is provided which meets the criteria in WAC 365-195-905 for expert opinion, one of the sources of valid scientific information. The criteria include logical conclusions and reasonable inferences, context, and the use of references (see Appendix 1-B for definitions of these criteria). These hypotheses can be considered expert opinion according to WAC 365-195-905 in which expert opinion is defined as a "Statement of a qualified scientific expert based on his or her best professional judgment and experience in the pertinent scientific discipline. The opinion may or may not be based on site-specific information." To be considered best available science according to the WAC, an expert opinion must meet three of the six characteristics listed in the table in Appendix 1-B: logical conclusions and reasonable inferences, context, and references.

Logical conclusions and reasonable inferences are defined as "The conclusions presented are based on reasonable assumptions supported by other studies and consistent with the general theory underlying the assumptions. The conclusions are logically and reasonably derived from the assumptions and supported by the data presented. Any gaps in information and inconsistencies with other pertinent scientific information are adequately explained."

Context is defined as "The information is placed in proper context. The assumptions, analytical techniques, data, and conclusions are appropriately framed with respect to the prevailing body of pertinent scientific knowledge."

References are defined as "The assumptions, analytical techniques, and conclusions are well referenced with citations to relevant, credible literature and other pertinent existing information."

The statements that are hypotheses in this document meet these criteria because they are presented with a clear and logical train of thought and the conclusions are based on reasonable assumptions supported by other credible studies that are relevant. They are placed in context and referenced.

In addition, the definition of *synthesis* in Webster's 7th Collegiate Dictionary is "deductive reasoning" and "the combining of often diverse conceptions into a coherent whole." The statements that present hypotheses and assumptions are based on deductive reasoning.

There are a few instances in the document where the authors of Volume 1 offer their observations based on their own professional experience. These are usually limited to statements relating to protection measures used to manage wetlands. Such statements are clearly labeled as those of the authors only.

1.2 Scope of Volume 1

The focus of this document is freshwater wetlands of Washington State. We have included information on wetlands in other regions and countries and on aquatic systems in general when more local information is lacking and the data are applicable to the wetlands in Washington. See the following section (1.3) for more discussion on this topic. Volume 1 does not address streams or riparian areas that are not wetlands. We do, however, summarize some of the literature related to buffers on streams where the information can be transferred to wetlands.

Marine and estuarine systems are discussed only in regard to wetland rating systems and wetland types for which specific management is needed. Marine and estuarine wetlands were excluded primarily to keep the scope of the project in the range of the available funding. Some recent scientific information on coastal and estuarine wetlands has been summarized by WDFW, Ecology, and other agencies through the Aquatic Habitat Guidelines Project, which is available on the internet (www.wa.gov/wdfw/hab/ahg).

There are several types of freshwater wetlands that are highlighted in the wetland rating systems (described in Volume 2) that are not specifically reviewed in this synthesis (e.g., bogs, interdunal wetlands, and vernal pools). These wetlands are subsets of wetlands in the different hydrogeomorphic (HGM) classes described in Chapter 2. At the level of detail provided in this document, general information summarized about wetlands also applies to these types of wetlands in whatever HGM class and region of the state is appropriate.

The effects of growing cranberries in wetlands are also not covered in this volume because of the time and funding constraints of the project. The limited area of the state that is affected by cranberry production was also a factor. In addition, information related to the effects of silviculture and forest practices on forested wetlands is not included because this subject is being addressed in another document currently being developed (Cooke in press).

In addition, the synthesis in Volume 1 is limited to information that has a practical application to the management and protection of wetlands. For the most part, available documents from the past ten years were used as the primary sources for this synthesis. It was assumed that this most recent literature would incorporate relevant science from the preceding years. Older documents were used in instances where they had not been superseded by more recent studies.

This volume DOES NOT contain agency recommendations or suggestions for implementation of any program to protect or manage wetlands. Any recommendations provided in Volume 1 (for instance, in the section of Chapters 5 and 6 addressing buffers and compensatory mitigation) are those that have been described in the literature. They are included here only as part of the synthesis of existing scientific information. Agency recommendations are provided in Volume 2.

1.3 Relevance of Scientific Information to Conditions in Washington

One of the tasks in reviewing scientific information was to determine what is relevant to wetlands found in the state of Washington. Determining the relevance of scientific information encompasses two aspects. The first is the degree to which general conclusions and principles developed from existing information can be used to predict what will happen in new or different situations. The conclusions of a scientific study done at one time in one wetland with specific characteristics may not be directly transferable to circumstances that develop in the future or at sites that have different characteristics or situations.

The first aspect also encompasses the concept that science doesn't often provide a "bright line." In other words, science rarely supplies us with precise solutions for protecting and managing natural resources. Very few experiments demonstrate true cause-and-effect relationships. For example, in reviewing the literature for this volume, we found few studies that actually documented the effectiveness of different ways for managing the wetland resource (such as the effectiveness of buffers of a specific width at protecting a specific wetland function). Rather, most studies, for example, discuss the impacts of human activities on wetlands. As a result, guidance on protection and management based on scientific information (as presented in Volume 2) is, to a large degree, extrapolation and synthesis of all the information collected.

The second aspect is the relevance of information collected in one region to the conditions found in another region. We have relied, whenever possible, on literature that was derived in the Pacific Northwest. However, in some cases, scientific information generated in other regions of the United States, and to a lesser extent from other countries, was used. Authors of this volume judged whether each "out-of-region" reference was applicable to Washington by extrapolating, interpreting, and synthesizing the information to determine how it pertains specifically to Washington.

We understand establishing what is relevant to Washington is a subjective decision; however, two criteria were used in the decision. First, an "out-of-region" reference was incorporated in the synthesis if the basic ecological principles on which it was based are relevant to most landscapes. Second, it was incorporated if the geomorphic setting of the wetland in a scientific report was similar to those found in the Pacific Northwest and no information specific to the region (that meets the criteria of BAS) was found in our search of the literature.

One of the basic assumptions in ecological and biological research is that environmental processes operate in a similar way if the basic conditions are similar. For example, water is expected to flow downhill whether it occurs in Minnesota or in Washington. Denitrifying bacteria are assumed to transform nitrate to nitrogen gas wherever they are found as long as the soils are anaerobic. The particular wildlife species that are closely associated with wetlands may differ regionally, but frequently fill the same habitat niches in Ohio or California as they do in Washington. Thus, much of the information on functions developed outside the region is transferable to Washington. Regional differences in functions occur when the basic conditions differ, and we have tried to point this out where possible.

As mentioned previously, the definition of *synthesis* in Webster's 7th Collegiate Dictionary is "deductive reasoning" and "the combining of often diverse conceptions into a coherent whole." This is the goal we have set for Volume 1. Part of the role of a synthesis, thus, is to summarize many studies and scientific articles; glean the general principles that apply in most areas as well as those that relate specifically to the state of Washington; and try to determine if they will apply to future conditions based on best professional judgment of the authors and the reviewers of the document.

1.4 Overview of Volume 1

Volume 1 is organized into seven chapters. The chapters share a common organization, beginning with a reader's guide that describes the topics covered in the chapter and how the chapter is organized. An introduction then provides general background information, definitions, and clarifications. Each chapter describes the sources of information used and how well the subject is documented in the literature, particularly for the Pacific Northwest. The chapters also note gaps where information on an issue could not be found. Key points are summarized at the end of major sections and conclusions provided at the end of each chapter.

A brief summary of the contents of each chapter that follows and the appendices is provided below. In this document, page numbers are assigned to each chapter individually and are not sequential. The first number represents the chapter and the second the page number in that chapter (e.g., [3-2] represents page 2 in Chapter 3).

Chapter 2 – Wetlands in Washington and How They Function

Chapter 2 summarizes the information on how wetlands are categorized and how wetlands function in Washington State. It describes how functions are defined and introduces the concept that the performance of functions is controlled by a number of environmental factors within the wetland boundary (site scale) as well as in the broader landscape (landscape scale). The chapter then describes how some of the key factors that control functions are used to classify wetlands into groups that perform functions in similar ways.

The chapter goes on to describe functions of freshwater wetlands in Washington. Where applicable, the chapter discusses the differences in functions among wetland classes and in various areas of the state. The major functions described are those that were defined for the Washington State wetland function assessment methods (Hruby et al. 1999, 2000).

Chapter 3 – Environmental Disturbances Caused by Different Human Activities and Uses of the Land

In Chapter 3 the discussion shifts from wetland functions and the environmental factors that control the performance of functions to the major disturbances caused by human activities that affect wetlands and their functions. In this context, a *disturbance* is an event that changes an environmental factor that controls wetland functions. Ten disturbances (listed below) are discussed.

- Changing the physical structure within a wetland (e.g., filling, removing vegetation, tilling soils, compacting soils)
- Changing the amount and velocity of water in wetlands (increasing or decreasing the amount)
- Changing the fluctuation of water levels (frequency, duration, amplitude, direction of flow)
- Changing the amount of sediment (increasing or decreasing the amount)
- Increasing the amount of nutrients
- Increasing the amount of toxic contaminants
- Changing the acidity (acidification)
- Increasing the concentration of salt (salinization)
- Fragmentation (decreasing area of habitat and its spatial configuration)
- Other disturbances (noise, etc.)

The chapter continues with separate sections for four of the major types of human land uses in Washington State (agriculture, urbanization, forest practices, and mining) and the types of disturbances they cause. For each of these four land uses, the ten types of disturbances that change the factors controlling wetland functions (listed above) are discussed where applicable.

Chapter 4 – Negative Impacts of Human Disturbances on the Functions of Wetlands

Chapter 4 integrates the concepts discussed in Chapter 2 and Chapter 3. In Chapter 4, ten sections, one for each of the disturbances listed above, summarize how these disturbances ultimately leads to impacts on hydrologic functions, functions that improve water quality, and habitat functions.

Chapter 5 – The Effectiveness of Wetland Management Tools

Chapter 5 presents a synthesis of what the current literature reports on four tools currently used to protect and manage wetlands and their functions: the definition of wetlands, wetland delineation methods, wetland ratings, and regulatory buffers. In the section on definitions, the issues of biological versus regulated wetlands, small wetlands, isolated wetlands, and Prior Converted Croplands that are wetlands are discussed. This chapter does not provide language or recommendations for regulations or policy—those are provided in the second, separate volume containing guidance for protecting and managing wetlands in Washington (Volume 2).

Chapter 6 – The Effectiveness of Wetland Mitigation

Chapter 6 discusses another commonly used tool for managing and protecting wetlands, compensatory wetland mitigation. This topic is discussed in its own chapter because of the large volume of information available on this subject. Topics covered in this chapter include:

- Evaluation of the success of compensatory mitigation
- Compliance of mitigation projects with permit requirements
- Types of compensatory mitigation
- Replacement ratios and replacement of wetland acreage
- Functions provided by compensatory mitigation projects
- Reproducibility of particular types of wetlands (bogs, fens, vernal pools, alkali wetlands, and mature forested wetlands)
- Suggestions from the literature for improving compensatory mitigation

Chapter 7 - Cumulative Impacts on Wetlands

Chapter 7 discusses different types of cumulative impacts, and the loss of wetland area as the most easily assessed indicator of cumulative impacts. It goes on to present some of the causes of cumulative impacts in Washington. These include:

- Case-by-case permitting as a cause of cumulative impacts
- Lack of consistent plans and regulations between jurisdictions as a possible cause of cumulative impacts
- Implementation of regulatory programs at the local level as a possible cause of cumulative impacts

The chapter ends with a discussion in which the types of cumulative impacts are compared to the protection measures commonly taken by local governments.

Glossary

The glossary provides definitions for some of the technical terms used throughout Volume 1. Other terms are defined in the context of the sentence in which they appear and may not be included in the glossary.

References

The references cited in the text are listed separately at the end of Volume 1. Some of these references represent reviews or syntheses in which a researcher describes trends observed from numerous studies conducted in previous years. In these cases, we cite only the review document and not all the citations in the review.

Citations from the review by Adamus et al. (2001), however, are an exception. Portions of Adamus et al. (2001), a review of current scientific literature on the impacts of human activities on wetlands and their functions, were adapted and included in Chapter 4 with permission from Dr. Adamus. The list of cited references at the end of the document does include the literature sources from those portions of Adamus et al. (2001) that were adapted.

Appendices

The appendices of Volume 1 are as follows:

- Appendix 1-A identifies the team guiding the production of Volume 1 (the Core Team)
- Appendix 1-B describes the characteristics of a valid scientific process and types of scientific information defined by the Washington Administrative Code (WAC 365-195-905)
- Appendix 1-C details the methods used in the literature review and production of Volume 1
- Appendix 1-D lists the reviewers who commented on the draft of Volume 1
- Appendix 2-A provides information about various terms and methods that have been used to organize and group information about wetlands, such as classification, characterization, and rating
- Appendix 2-B lists the species of wildlife associated with wetlands in Washington and Oregon from Johnson and O'Neil (2001)

1.5 Public Involvement and Review of Volume 1

1.5.1 The Process of Public Involvement

The process for public involvement of Volume 1 included meetings of two focus groups, numerous mailings and extensive peer and public review. Ecology compiled a mailing list of scientists with wetlands expertise, local government planners, and other groups and individuals from various existing mailing lists used for other wetland-related projects.

In October 2001, Ecology sent out a focus sheet describing the project and a cover sheet that solicited the recipient's participation in the project. This sheet included a tear-off card that could be used to request that the sender be retained on the mailing list. The mailing list was then edited based on the returned cards.

Meetings of focus groups were held in January 2002 in Moses Lake and Olympia to begin the process of gathering input from the public on the project. These meetings were attended by various members of the Core Team, local planners, other staff from local government, and other interested parties. The purpose of these meetings was to help focus the project so that the synthesis would meet the needs of our primary audience, local governments. The meetings gave opportunities to the Core Team to present information on the project and to listen to questions and concerns from the attendees. Lists of keywords to use for the search of the literature were revised based on input from the focus groups.

In June 2002, Ecology sent out a mailer with an update on the project to the entire mailing list. It discussed the status of the project, timelines, and other issues.

In November 2002, Ecology staff contacted selected experts in various disciplines to solicit their review. The list of peer reviewers was not intended to be inclusive of all experts. The purpose was to make sure that each of the major topics in Volume 1 was reviewed by one or more recognized experts in that discipline. These expert reviewers were selected from academia, public agencies and private consultants.

In February 2003, Ecology sent another mailing to all those on the list to determine who wanted to comment on the draft of Volume 1. In June 2003, Ecology distributed a notice by email to update the public on revised target dates for distribution of the draft document for peer and public review.

The draft was distributed for general review in September 2003. Over 170 paper copies as well as CDs were sent to reviewers. An undetermined number of reviewers downloaded the draft from the project's web site. The experts asked to review the document were provided the draft at the same time as the general public. Instructions for providing comments and a questionnaire were also distributed with the draft document.

Several mailings were distributed since the fall of 2003 informing those listed about the status of revisions to Volume 1 as well as progress on the completion of the draft of Volume 2. The Core Team decided that a draft of Volume 2, containing guidance on

protecting and managing, should be completed before Volume 1 was completed. The draft of Volume 2 was distributed for comment in August 2004, during which time the authors began writing responses to comments and revising Volume 1. The review process for Volume 2 is described in Chapter 1 of that document.

1.5.2 Responding to Comments and Reviewing Suggested Literature

Twenty-nine reviewers provided comments on the draft of Volume 1. The reviewer's comments varied from cursory to very detailed, approximately 900 comments were submitted.

Initially, the Core Team organized and reviewed the comments and developed responses to the most substantive comments as individual or synthesized comments. The responses were posted on the project's web site in the spring of 2004. In addition, Ecology posted a list of all the comments that were submitted, organized by chapter, section and page. After the draft of Volume 2 was completed, each of the original comments was addressed by the authors. Each comment and a response to it have now been posted on the project's web site at the address below. Comments are organized by chapter, except for the beginning section that contains answers to questions in a questionnaire distributed to reviewers with the draft document.

As a part of the questionnaire, the reviewers were asked to provide any additional references they felt were pertinent to the subjects discussed. In addition, those who suggested changes or additions to the text were asked to provide citations. As a result, reviewers submitted several hundred new references. The authors reviewed this list and rated each as high, medium, or low importance using the same criteria used in the original search (see Appendix 1-C). Attempts were made to obtain and review all citations rated as high or medium. The results of this process, whether the reference was or was not obtained and why, are documented in a table at the end of the document containing the responses to comments.

Volume 1 and the responses to comments are available online

Ecology has developed a web site for this project on the Shorelands and Environmental Assistance Program web site. The web site includes a project description, contact information, current status of the project, and copies of the updates that were sent. The web site also includes a copy of the final version of Volume 1, as well as Volume 2, along with two documents containing the comments received and the authors' responses, one for each document. http://www.ecy.wa.gov/programs/sea/bas_wetlands/index.html

1.6 Conclusions

Volume 1 provides a summary of relevant scientific information related to wetlands in the Pacific Northwest and their management. The document should be useful to all those who have an interest in the protection and management of wetlands including agency staff, consultants, interested organizations, and citizens. It should be particularly helpful to local governments that are required under the Growth Management Act, to include best available science when developing and revising regulations protecting critical areas including wetlands. Volume 1 has been reviewed by technical experts (peer reviewed) and other interested parties. The intention of the project and the review process was to produce a synthesis of the current science on wetlands in the state of Washington that is easily understood, yet thorough and scientifically rigorous.

Chapter 2

Wetlands in Washington and How They Function

2.1 Reader's Guide to This Chapter

Chapter 2 presents information on wetlands in Washington and how they function. It introduces the ecological principles that help us understand the impacts of decisions we make about wetlands. It then expands on the newer ecological concept that the performance of functions is controlled by a number of environmental factors within the wetland boundary (site scale) as well as in the broader landscape (landscape scale). The chapter then describes these controls relative to regions and wetland types (classification of wetlands) in Washington before turning to detailed descriptions of the functions performed by the wetlands east and west of the Cascade Mountains and in different wetland classes.

To protect and manage wetlands, an understanding of wetland functions must be supplemented by knowledge of how these functions are affected by human activities. Chapter 3, therefore, goes on to describe how various land uses and activities disturb the environment, for example by causing excess nutrients, increased runoff and fluctuating water levels, and reduction in habitat. These disturbances in turn affect the environmental factors that control wetland functions. Chapter 3 describes what the literature says about the disturbances created by different land uses, while Chapter 4 goes into detail regarding how each disturbance affects particular wetland functions, including the organisms that use wetlands.

2.1.1 Chapter Contents

Major sections of this chapter and the topics they cover include:

Section 2.2, Basic Ecological Principles Useful in Managing Wetlands and in Understanding the Impacts of Human Activities describes five basic ecological principles that are useful in managing wetlands as identified by the Ecological Society of America. The principles include time, place, species, disturbance, and landscape.

Section 2.3, Introduction and Background on Wetland Functions describes the evolution of our understanding of wetland functions over the last few decades. It also defines the term *wetland functions.* The section describes how environmental processes at many geographic scales control the functions provided by wetlands. The section includes a diagram summarizing the environmental factors that control functions and how they interact with human disturbances. The difference between *functions* and *values* is also explained.

Section 2.4, Classification of Wetlands in Washington as a Key to Understanding their Functions begins by describing the common classification systems used to categorize wetlands. It discusses ecological regions (ecoregions) in Washington State and how wetlands across the

state are classified within the ecoregions into groups (classes and subclasses) that function in similar ways. The classes and subclasses of wetlands found in the state are described.

Section 2.5, Overview of Wetland Functions in Washington State introduces the functions of wetlands that are currently the focus of management efforts. These functions fall into three main categories: improving water quality, hydrologic functions, and providing habitat. Each category is described and the functions related to each are listed.

Section 2.6, How Wetlands Perform Functions in Washington State describes each of the wetland functions listed in Section 2.5. For each function, the text provides a general description of how the function is performed, and then goes into detail about how that function is performed by wetlands of various classes and in different areas of Washington.

Section 2.7, Chapter Summary and Conclusions summarizes the major concepts presented in the chapter.

2.1.2 Where to Find Summary Information and Conclusions

Each major section of this chapter concludes with a brief summary of the major points resulting from the literature review on that topic in a bullet list format. The reader is encouraged to remember that a review of the entire section preceding the summary is necessary for an in-depth understanding of the topic.

For summaries of the information presented in this chapter, see the following sections:

- Section 2.3.4
- Section 2.4.6
- Section 2.5.4
- Section 2.6.4

In addition, Section 2.7 provides a summary and conclusions about the overarching themes gleaned from the literature and presented in this chapter.

2.1.3 Sources and Gaps in Information

Our understanding of how wetlands function and the factors that control these functions has increased in the last two decades and much of this information has been published in the journal *Wetlands* (the journal of the Society of Wetland Scientists). Other journals that often carry papers on wetland functions include *Environmental Management*, *Restoration Ecology*, and the *Journal of the American Water Resources Association*.

Much of what we know about wetlands in Washington, their functions, and how functions are defined, is based on the collective expertise and judgment of teams of experts who developed the *Methods for Assessing Wetland Functions* (also known as the Washington State wetland function assessment methods of WFAM) (Hruby et al. 1999, Hruby et al. 2000) and who revised the

Washington State wetland rating systems (Hruby 2004a,b). These tools are methods that analyze the functions of wetlands in the state. This expert, regional information is critical because much of the knowledge in the scientific literature about wetland functions was developed outside the Pacific Northwest.

These tools can be considered a synthesis of the best available science for defining and understanding the functions performed by Washington's wetlands. The wetland scientists who developed these documents analyzed existing scientific information and extracted material that is relevant for Washington State. They also added their best professional experience, expertise, judgment, and field observations during development of these products. Existing scientific information is cited in these tools where it was judged relevant to Washington State.

The tools were developed using a formal process that was based on using consensus among wetland scientists in the region. The process included peer review and public comment. The documents resulting from the function assessment project and the rating system effort are cited in this synthesis as Hruby et al. (1999), Hruby et al. (2000), and Hruby (2004a,b). Information about these projects is also available at http://www.ecy.wa.gov/programs/sea/wetlan.html.

Major gaps in our knowledge of how wetlands in Washington function, however, still exist for the types of wetlands for which function assessment methods have not yet been developed. For example, there is little published information about the functions of "slope" wetlands and "flats" wetlands (see section 2.4.4 for a description of these wetland classes). There is also less published information on the wetlands in the arid region of the state.

2.2 Basic Ecological Principles Useful in Managing Wetlands and in Understanding the Impacts of Human Activities

Many decisions about the management and use of land are made with little attention to any of their ecological impacts. Thus, a better knowledge of the functioning of "ecosystems" is needed to broaden the scientific basis of decisions on using the land and managing it (Dale et al. 2000). In response to this need, the Ecological Society of America established a committee to examine the ways that land-use decisions are made and the ways that ecologists could help inform those decisions. The following discussion on the basic ecological principles that are useful in managing how we use the land (including wetlands) is derived from the report of the committee that was published in *Ecological Applications* (Dale, et al. 2000).

The committee identified five ecological principles that have implications for managing wetlands. The principles deal with time, place, species, disturbance, and landscape. Each is described briefly below and represents a summary of the information in Dale et al. (2000). (Note: the citations used by Dale et al. (2000) in developing these principles are not included in the summary.)

***Time Principle* - Ecological processes function at many time scales; some long, some short; and ecosystems change through time.** For example, activities in cells occur on the scale of microseconds to minutes, decomposition occurs over hours to decades, and soil formation occurs over decades and centuries. In addition, ecosystems can change from season to season, year to year, and decade to decade. Human activities that alter the species found in ecosystems or alter the biological, chemical, or geological cycles can change the pace or direction of these "natural" changes. Human activities have effects that can last decades or centuries.

***Species Principle* – Particular species and networks of interacting species have key, broad-scale effects on ecosystems**. Such "focal" species affect ecological systems in many ways. *Indicator species*, such as amphibians, help us understand the current condition of ecosystems. The status of indicator species helps us understand the status of larger groups of species, the status of key habitats, or as an indication of the action of some environmental stressor (disturbance). *Keystone species*, such as elephants, are those that have a greater effect on ecological processes than would be predicted from their abundance alone. *Ecological engineers*, such as beaver, alter habitat, and in doing so modify the survival and opportunities of many other species. *Umbrella species*, such as cougar, deer, or elk, either require large areas or use multiple habitats and thus overlap the habitat requirements of many other species. *Link species*, such as salmon, exert critical roles in the transfer of matter and energy across trophic levels or provide critical links in the transfer of energy in complex food webs.

***Place Principle* – Local climatic, hydrologic, edaphic (resulting from soils), and geomorphological factors as well as biotic interactions strongly affect ecological processes and the abundance and distribution of species at any one place**. Conditions in any one place reflect the variations that occur along gradients of elevation, longitude, latitude, and the many physical, chemical, and edaphic factors at a micro-scale. These factors provide the ecosystem with a particular appearance (e.g., a wetland formed in a glacial "kettlehole" is quite different from a wetland that formed in the "pothole" left behind in the basaltic surface of the Columbia Basin after the ice-age floods).

***Disturbance Principle* – The type, intensity, and duration of disturbances shape the characteristics of populations, communities, and ecosystems**. Disturbances are events that disrupt ecological systems. They may occur naturally (e.g., wildfires, storms, floods) or be caused by human actions (e.g., clearing land, building roads, altering stream channels). The effects of disturbances on ecological systems are controlled in large part by their intensity, duration, frequency, timing, and size and shape of area affected. Many ecosystems, such as Ponderosa pine forests, are maintained by a certain level and type of disturbance, such as fire. Changes in land use that alter the regime of natural disturbances or initiate new disturbances are likely to cause changes in species distributions, abundances, the composition of ecological communities and the functioning of the ecosystem.

***Landscape Principle* – The size, shape, and spatial relationships of land-cover types influence the dynamics of populations, communities, and ecosystems**. The spatial array of habitats and ecosystems make up the "landscape," and all ecological processes respond, at least in part, to this "landscape template." The kinds or organisms that exist and their interaction with ecosystem processes (e.g., decomposition, nutrient fluxes) are constrained by the sizes, shapes, and patterns of interspersion of habitat across a landscape. Human activities that decrease the size of habitat

patches or increase the distance between similar habitat patches can greatly reduce or eliminate populations of organisms.

These ecological principles underlie our understanding of how wetlands function and how they should be managed to protect their functions. They form the basis of the following discussion of how wetlands function, how human disturbances can impact those functions (Chapter 4), and how we should develop ways to protect and manage this resource (Volume 2).

2.3 Introduction and Background on Wetland Functions

2.3.1 An Evolving Understanding of Wetland Functions

The concept of wetland functions is relatively new in both the regulatory and scientific arenas. For many years wetlands were considered nuisances and wastelands (Washington State Department of Natural Resources 1998). The functions found within a wetland were not considered important enough to study and understand. Today, however, we know that the functions performed by wetlands are important and interacts with other aspects of the landscape around it. We have found that the structural components of a wetland and its surrounding landscape (such as plants, soils, rocks, water, and animals) interact with a variety of physical, chemical, and biological processes both within the wetland itself and the surrounding landscape. These interactions are called *functions*.

The concept of wetland functions has evolved since it was first introduced about four decades ago. Wetlands were first considered primarily to function as habitat for important species such as waterfowl. The factors that were thought to control how a wetland functions in this respect were the structural elements in a wetland. For example, how much open water did the wetland contain? What types of vegetation were found there? This interest in wetland structure led to the development of a classification system for wetlands in 1979 based on the vegetation and water regime (Cowardin et al. 1979). This system is still in use today. See Section 2.4.1 for more on this classification system.

It soon became apparent, however, that wetlands contribute more to the landscape than just habitat. During the 1980s much research was done on how wetlands filter pollutants and improve water quality. As a result, wetland engineers started to design and create wetlands specifically to treat wastewater (Hammer 1989). During the 80s wetlands were also recognized for their contribution to flood protection (Adamus et al. 1987).

The ongoing research in the 1980s also led to a realization that the functions performed within a wetland are controlled by a number of environmental factors both within and outside of the wetland. Climate was recognized as the major factor that affects how wetlands function at the largest geographic scale (Bailey 1995, Benda et al. 1998). Differences in temperature, rainfall, and seasonal and annual changes impact all aspects of interactions among organisms and their environment, including wetlands.

During the 1990's Brinson (1993b) and the National Academy of Sciences (National Research Council 1995) described and defined three other factors at a smaller geographic scale that can be considered primary controls of functions within a wetland:

- Geomorphic or topographic setting of the wetland
- Direct source of water to the wetland
- Hydrodynamics, or the direction of flow and strength of water movement within the wetland

More recently, however, scientists have become increasingly aware that functions performed by wetlands are also controlled by processes that occur at the scale of the watershed. There is currently an emphasis on trying to understand wetland functions in the context of how water, sediments, and nutrients move in a watershed (Bedford 1999). The surface geology and soils, the routing of water through the watershed, and the movement of sediments, large wood, nutrients, and other chemicals are all considered important factors in controlling how individual wetlands function (see Section 2.3.3).

2.3.2 How Wetland Functions Are Defined

The interactions that occur within a wetland occur at many scales as well, from the microscopic (such as bacterial decomposition of organic matter) to the continental (such as providing refuge and feeding for migrating waterfowl along the continental flyways). If every interaction that occurs within a wetland were identified as a separate function, the number of functions would be almost infinite. For example, the decomposition of organic matter by bacteria is a combination of many types of decomposition, one for each individual species of bacteria found in the wetland. Each bacterial species decomposes organic matter at a different rate and under different environmental conditions. Each of these could be considered a separate wetland function.

In contrast, a function can be a broad lumping of many environmental processes. For example, the "removal of imported elements and compounds" is a function identified in one method for assessing wetland functions (Brinson et al. 1995). At least a dozen nutrients and several hundred known contaminants can be found in surface waters. Therefore this function combines several hundred different processes of removal, one for each imported nutrient, contaminant, and other compound.

Wetland functions – The physical, biological, chemical, and geologic interactions among different components of the environment that occur within a wetland. There are many valuable functions that wetlands perform but these can be grouped into three categories – functions that improve water quality, functions that change the water regime in a watershed such as flood storage, and functions that provide habitat for plants and animals.

Furthermore, wetlands perform many types of functions, but not all wetlands perform the same functions, nor do similar wetlands provide the same functions to the same level of performance (Clairain 2002).

One of the initial tasks in defining functions, therefore, is to identify and group the processes and interactions that occur in wetlands into some manageable number of "functions." Most functions are generally grouped in terms of three broad categories (Adamus et al. 1991):

- Biogeochemical functions, which are related to trapping and transforming chemicals and include functions that improve water quality in the watershed
- Hydrologic functions, which are related to maintaining the water regime in a watershed and include such functions as reducing flooding
- Food web and habitat functions

Functions are subdivided into more specific groups by the environmental processes or interactions within the wetland that are related and are on a similar temporal and spatial scale. They are also grouped based on the needs for managing wetlands (Hruby 1999). For example, managers may need to know how well a wetland removes specific constituents that contribute to poor water quality such as sediment, nutrients, and toxic compounds, rather than having only a general assessment of the removal of elements and compounds that cause problems with water quality.

Table 2-1 gives examples of how the many different processes and interactions that occur in wetlands have been grouped under different names for various policy and regulatory purposes. They are organized into the three broad categories above (water quality improvement, hydrologic functions, and food webs and habitat).

The names of the categories to some degree reflect how broadly the function is defined. "The removal of all imported elements and compounds" is a broadly defined function, whereas "removing sediment" is a more narrowly defined function. Section 2.5 describes in more detail the functions that have been chosen for the Washington State wetland function assessment project and the Washington State wetland rating systems.

Table 2-1. Different ways of dividing wetland functions.

Wetland Evaluation Technique (WET) [a]	HGM Guidebook for Riverine Wetlands [b]	Mill Creek Special Area Management Plan (SAMP)[c]	Methods for Assessing Wetland Functions – Lowlands of Western WA[d]
Biogeochemical Functions Related to Improving Water Quality			
Nutrient Removal/ Transformation	Nutrient Cycling	Nutrient Uptake	Removing Nutrients
Sediment Stabilization	Removal of Imported Elements and Compounds	Sediment Stabilization	Removing Sediment
Sediment/Toxicant Retention	Retention of Particulates	Retention of Toxics	Removing Metals and Toxic Organic Compounds
Hydrologic Functions Related to Maintaining the Water Regime			
Floodflow Alteration	Dynamic Surface Water Storage	Floodflow Alteration	Reducing Peak Flows
Groundwater Recharge	Long-term Surface Water Storage	Groundwater Discharge	Decreasing Downstream Erosion
Groundwater Discharge	Energy Dissipation		Recharging Groundwater
	Subsurface Storage of Water		
	Moderation of Groundwater Flow or Discharge		
Functions Related to Maintaining Food Webs and Habitat			
Aquatic Diversity/ Abundance	Maintain Spatial Structure of Habitat	Habitat for Aquatic Species	General Habitat
Wildlife Diversity/ Abundance/ Migration Wintering	Maintain Interspersion and Connectivity	Habitat for Anadromous Fish	Habitat for Invertebrates
Production Export	Maintain Distribution and Abundance of Invertebrates	Habitat for Resident Fish	Habitat for Amphibians
	Maintain Distribution and Abundance of Vertebrates	Habitat for Migratory Birds	Habitat for Anadromous Fish
		Habitat for Resident Birds	Habitat for Resident Fish
		Habitat for Other Species	Habitat for Wetland-Associated Birds
			Habitat for Wetland-Associated Mammals

Sources:
[a] Adamus et al. (1987)
[b] Brinson et al. (1995)
[c] U.S. Army Corps of Engineers (2000)
[d] Hruby et al. (1999)

Relationship of functions to values

The scientific literature has in the past confused the terms wetland *functions* and wetland *values*. In fact, the term *functional values* was in common usage during the 1980s and early 1990s (e.g., Amman et al. 1986). The correct interpretation of the term *functional values* suggests that wetland values were functioning, which was not the intent of the phrase. As mentioned previously, wetland functions are the environmental processes that take place in a wetland. Society, however, does not necessarily attach the same value to all functions. Value is usually associated with goods and services that society recognizes, and not all environmental processes are recognized or valued. The National Research Council (1995) says the following about the differences between values and functions.

> *Because value is a societal perception, it often changes over time, even if wetland functions are constant. Value can change over time as economic development changes a region. The value of a wetland in maintaining water quality near a source of drinking water can be great even if the wetland is small (Kusler 1994). Some values can be mutually exclusive if they involve direct or indirect manipulation, exploitation, or management of wetlands. For example, production of fish for human consumption could conflict with the use of a wetland to improve water quality of water that contains toxins.*

There are three reasons for maintaining a clear distinction between functions and the services that wetlands provide (King et al. 2000). First, people can attach values to services, but usually cannot attach values to the underlying environmental functions and processes on which they depend. Second, the factors that affect the level of services a wetland provides are different from those that determine the levels of function. Third, different questions need to be addressed when considering values and functions. When assigning a relative value to a wetland, questions involving the importance and scarcity of the services need to be answered. Depending on the landscape context of the wetland, these may, or may not, be related to the levels of function in the wetland.

Generally, the important values of wetlands cannot be assessed or rated using the same methods as those used to assess functions (Hruby 1999). Analyzing values requires understanding a different set of factors than those used for functions (King et al. 2000).

2.3.3 Environmental Factors that Control Wetland Functions

"*Ecosystems are not defined so much by the objects they contain as by the processes that regulate them*" (Christiansen et al. 1989)

Functions of wetlands, as defined previously, represent interactions among the different components of the ecosystem and the landscape. Thus, functions can be influenced or controlled by changes to any one of these components. For example, a wetland may perform the function of providing overwintering habitat for coho, for which the presence of seasonal or permanent surface water is critical. This function will, therefore, change if the wetland is drained so no surface

water remains at any time. Changes in functions, however, can also be a result of alterations to the watershed outside the wetland boundary. For example, surface water in the wetland may also be eliminated if its water supply is diverted. Also if the gravel beds in which the coho spawn farther up in the watershed are disturbed, or if the flow in the stream is reduced to such an extent that the young can no longer swim to the wetland from the spawning areas, the wetland's support of coho overwintering habitat will be altered.

Likewise, the expression of one function in a wetland (such as habitat) can result in a change to the larger-scale environmental processes and the landscape. For example, if the conditions are right for beavers to settle in a wetland along a stream or river (i.e., the wetland functions as good habitat), the beavers will build a dam and create a ponded wetland. This will change the vegetation in the wetland and possibly alter other wetland functions such as improving water quality and storing flood waters. These changes may be important enough to change the water quality and the movement of water through that part of the watershed (a change in one of the primary controls of function).

Any factor that changes how well, or how much, a function is performed by a wetland can be considered a "control" of that function. Another term often used in the scientific literature is *driver*. The drivers of functions in wetlands determine how well the functions are performed. An action or occurrence that affects a control or driver is called a *disturbance* by ecologists (Dale et al. 2000). The type, intensity, and duration of disturbances can change the physical structure of the ecosystems and how they behave (ecosystem dynamics) (Dale et al. 2000).

Human activities create a disturbance that causes a "stress" on the ecosystem to which it responds. Scientists often use the term *stressor* to distinguish those disturbances that have a significant impact on an ecosystem from those that have little impact (see for example Adamus et al. 2001, Laursen et al. 2002).

In this document, however, we are not using the term *stressor*. All the disturbances discussed and reviewed here have documented negative impacts on wetlands and their functions. To avoid confusion, the term *disturbance* is used throughout this document.

Human uses of the land create a different set of disturbances than were present before human activities modified the land (Dale et al. 2000). The disturbances that are caused by human activities are discussed in Chapter 3, and the impacts these disturbances have on wetlands and their functions are described in Chapter 4.

The focus of research and management has been on functions and controls of functions that occur within the wetland itself and less on those that are a part of the landscape of the entire watershed. This has resulted from the fact that the need to define wetland functions has actually been driven by regulatory requirements and policy (Brinson et al. 1995, Clarain 2002). The policy has been to have a "no net loss of wetland area and function" at both the state and the national levels. However, this focus on functions confined to the wetland itself is changing. We are learning that managing wetlands requires an understanding of the "relationship of the individual wetlands to the landscape" (Bedford 1996) as well as the wetland itself.

A summary of the literature addressing the environmental factors that control wetland functions is presented below. First reviewed is the literature that addresses controls that occur at the scale of the wetland's contributing basin (that part of the landscape that contributes surface water to the wetland). The controls that are found within the boundary of the wetland (the site scale) are then described. The discussion includes a number of conceptual models that have been developed to help visualize and understand the complex interactions between wetland functions and environmental factors at different scales.

Terms used in this document to refer to environmental factors

Surface and subsurface water flows through the landscape within drainage systems. These drainage systems are often called basins, sub-basins, watersheds, or river basins depending on the size of the area. In this document, drainage systems are generally referred to using one of two terms:

- ***Watershed*** - A geographic area of land bounded by topographic high points in which water drains to a common destination.
- ***Contributing basin*** - The geographic area from which surface water drains to a particular wetland.

Environmental factors that affect wetland functions can occur at different geographic scales. In this document two scales are used.

- ***Landscape processes*** - Environmental factors that occur at larger geographic scales, such as basins, sub-basins, and watersheds. Processes are dynamic and usually represent the movement of a basic environmental characteristic, such as water, sediment, nutrients and chemicals, energy, or animals and plants. The interaction of landscape processes with the physical environment creates specific geographic locations where groundwater is recharged, flood waters are stored, stream water is oxygenated, pollutants are removed, and even wetlands are created.
- ***Site processes*** - Environmental factors that occur within the wetland itself or within its buffer. The interactions of site processes with landscape processes define how a wetland functions.

2.3.3.1 Environmental Controls of Functions at the Landscape Scale

Hydrogeologic Controls of Functions in Wetlands

Climate, geology, and the hydrologic characteristics in a watershed control how water, sediment, and nutrients move (Bedford 1999). Together, along with factors within the boundary of a wetland, these factors control the functions performed. Scientists call these large-scale, environmental factors the *hydrogeologic setting* of a wetland (Winter 1983, 1986, 1988, 1989, 1992, LaBaugh et al. 1987, Winter and Woo 1990). The following describes some models that have been developed to better understand these controls of wetland functions.

A hydrogeologic model created by Bedford (1996, 1999) concludes that wetlands develop and persist over time through the interaction of the hydrologic cycle with the landscape (Figure 2-1). This model views wetlands as part of an ecological system that is continuous with large-scale surface and groundwater systems. In this model, several geologic characteristics control the flow and chemistry of water, including the surface relief and slope of the land, the thickness and permeability of the soils, and the composition and hydraulic properties of the underlying geologic materials (Bedford 1999).

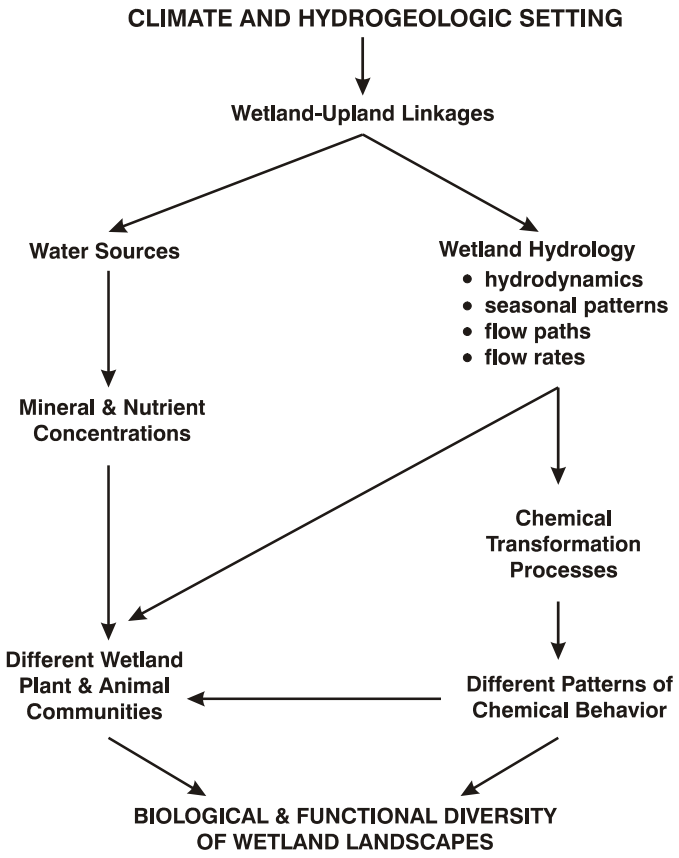


Figure 2-1. A model of the environmental factors that control wetland functions. (Bedford 1999; reprinted with permission)

In Bedford's hydrogeologic model, as in all the models discussed here, climate drives the large-scale water regime. Climate determines the precipitation and patterns of evapotranspiration that ultimately move surface and groundwater into and out of wetlands (see Figure 2-1). It also determines how sediments and chemicals (e.g., salts and nutrients) are eroded from bedrock and transported throughout the system.

A similar model to that of Bedford considers the contributing basin of a wetland in describing the factors that affect functions. This model, known as the "process-structure-function" model (Figure 2-2), was developed in conjunction with restoration plans for Northwest riverine systems. It is described in more detail in Beechie and Bolton (1999), Gersib (2001), and Stanley and Grigsby (2003). The model assumes that the biological, physical, and chemical characteristics (structure and functions) of aquatic systems including wetlands are determined by the interaction

of many processes operating at the larger scale of the landscape (Kaufman et al. 1997, Beechie and Bolton 1999). These processes include the movement of (Naiman et al. 1992):

- Water (surface and subsurface)
- Sediment
- Nutrients and other chemicals (salts, toxic contaminants)
- Large woody debris
- Energy (in the form of sunlight)

According to the "process-structure-function" model, the interactions of these processes with climate and geomorphology determine the structure within wetlands (e.g., substrate, plant communities). The wetland structure, in turn, is one factor that influences the type and performance of wetland functions.

For example, a wetland may produce large quantities of plant material and support the function of a rich food web. In order to provide this function, the wetland needs to have waters rich in nutrients coming into it, good exposure to sunlight, and a way for the production of plant material to leave the wetland into surrounding aquatic resources. The major controls for this function are the movement of water to and from the wetland, the movement of nutrients into and within the wetland, and an adequate source of energy.

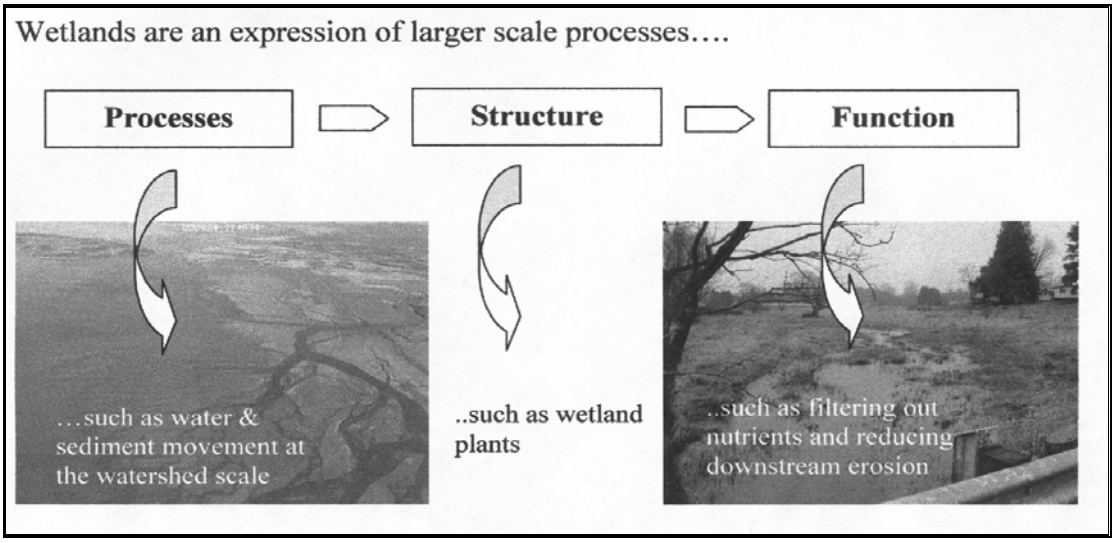


Figure 2-2. "Process-structure-function" model.

The "process-structure-function" model, like Bedford's, assumes that changes in land use affect processes such as the delivery of water, nutrients, sediment, and toxics to aquatic systems (Poiani et al. 1996, Mallin et al. 2000). These in turn affect structure and function within those aquatic systems.

Controls of the Habitat Provided by Wetlands

The abundance and richness of species within a wetland may be explained by the attributes of the surrounding landscape as well as by the characteristics found within the site itself (review in Dale et al. 2000). This is the landscape principle in ecology that was described in Section 2.2. The kinds of organisms that exist in a wetland and their interaction with landscape processes are constrained by the sizes, shapes, and patterns of interspersion of habitat across a landscape.

Understanding how animals and plants move between different habitats, and how the distribution of habitat "patches" affect the abundance of species, are the goals of a relatively new science called *landscape ecology*. The major result of recent research has been to highlight the fact that the distribution and abundance of species at an individual site, or "patch" is affected by the location, size, and shape of other patches of similar or different habitat in the surrounding landscape (Haila 2002, Manning et al. 2004). Some of the questions being asked in this research have been summarized by Bissonette and Storch (2002) and include:

- What is the relationship between species richness and the size of the patch of habitat?
- What is the relationship of species abundance to size of the patch of habitat?
- Are the interactions between different species modified as habitat is fragmented?
- Do the changes in the amount and quality of habitat along the edges of patches (edge habitat) change how an area functions as habitat?
- What are the relationships between relatively undisturbed corridors and the movement of species between habitat patches that have been separated by human activities?
- Do such connections increase species richness?

The research to date has highlighted the fact that there are no easy answers to these questions. The response of animals and plants to changes in patches, corridors, and distance between patches of the same habitat is very specific to the species involved (Haila 2002, Bissonette and Storch 2002, Haddad et al. 2003, Manning et al. 2004). For example, Haddad et al. (2003) studied ten different species living in the forests of South Carolina. Although the species were chosen because the authors thought they were likely to respond to the presence of corridors connecting patches of forest habitat, the abundance of only five of the ten species was positively correlated with presence of corridors. The abundance of the other five species was not correlated with the presence of corridors.

The study of patches and interaction between patches and species richness and abundance has taken on an increasing importance as human activities on the land have changed the distribution of habitats. The changes in habitat at the scale of the landscape caused by human activities are called *fragmentation*. The fragmentation of habitat consists of both reductions in the area of the original habitat and changes in the spatial configuration of what remains (Haila 2002). The results of current research on fragmentation have been difficult to interpret because much of it does not adequately separate the environmental factors that might cause differences in biodiversity (Haila 2002, Fahrig 2003, Manning et al. 2004). There is, however, one general conclusion that can be made from the current research. In reviewing over one hundred articles on

habitat fragmentation, Fahrig (2003) found that the loss of area available as habitat that results from human uses of the land has a large, consistently negative effect on the abundance and richness of species.

2.3.3.2 Environmental Controls of Functions at the Site Scale

The environmental factors at the large scale ultimately affect the environmental factors within the wetland itself (the site scale). As introduced earlier, Brinson (1993b) has developed a model that defines three factors that can be considered as primary controls of wetland functions at the site scale. Brinson's (1993b) model also uses characteristics of the landscape as factors that control functions in a wetland, but his model focuses primarily on the wetland itself relative to the two models discussed earlier (Bedford 1999). For example, Brinson's model emphasizes the shape and location of the wetland in the landscape and the type of water movement in the wetland that is dominant. The three factors defined by Brinson (1993b) are:

- The **geomorphic setting** (landscape position) of the wetland. Geomorphic setting is the topographic location of the wetland within the surrounding landscape and the geology that underlies it. In other words, is the wetland in a depression, on a slope, in a floodplain, or on the shores of a lake? The underlying geology also determines the soils present in the wetland, and this for example has an effect on the type and abundance of the plants found there.
- The **source of water** to the wetland. The sources of water can be simplified to precipitation, surface flow, shallow subsurface flow, and groundwater.
- The **hydrodynamics** of the wetland (the direction of flow and strength of water movement within the wetland). Hydrodynamics refers to the movement of water in the wetland and its capacity to do work. There are three qualitative categories of hydrodynamics: (1) vertical fluctuations of the water levels or water table, (2) unidirectional surface or near-surface flows that range from strong currents contained in channels to slow sheet flow down a slope, and (3) bidirectional flows resulting from tides or wind-driven currents in lakes.

In contrast, the "hydrogeologic" and "process-structure-function" models describe the surface and subsurface conditions across the landscape that control water processes within the wetland's contributing basin. The Brinson model (1993b) is the basis of the hydrogeomorphic (HGM) classification system which groups wetlands into similarly functioning groups. The classification system and an earlier classification, used for habitat mapping, are described in Section 2.4.1.

2.3.3.3 Summary of the Controls of Wetland Functions

To summarize the literature on the environmental factors that control functions, the authors of this synthesis have combined the terms and information used by several different authors to arrive at the list of factors in Table 2-2. These terms will be used in the following chapters because no standardized terms have been defined to describe all that happens at the different geographic, temporal, or spatial scales. In fact, the many articles that have been written on the subject of wetland functions and how they are controlled by environmental factors have engendered some

confusion in the terms used. For example, the term *process* has been used by different authors to describe a wide range of happenings that include the routing of water at a landscape scale as well as the chemical reactions by which bacteria change nitrate to nitrogen gas at the microscopic scale. Both of these factors are considered controls of functions.

The relationship between the environmental factors in Table 2-2 that control wetland functions and how they interact with human-caused disturbances is shown conceptually in Figure 2-3.

Table 2-2. Environmental factors that have been identified as controls of functions in wetlands. Most of the controls can occur at both the landscape scale and the site scale.

Environmental Factors that Control Functions in Wetlands	Scale at which the Control Occurs
Physical structure of wetlands (e.g., soils, vegetation, rocks)	Site
Biological structure of wetlands (e.g., physical structure of plants)	Site
Input of water (amount of water; maximum and minimum water levels)	Landscape and site
Fluctuations of water levels (frequency, amplitude, direction of flows)	Landscape and site
Input of sediment	Landscape and site
Input of nutrients	Landscape and site
Input of toxic contaminants	Landscape and site
Temperature	Landscape and site
Level of acid (pH)	Landscape and site
Concentration of salts	Mostly site
Size, connections, and distances of habitat patches in the surrounding landscape	Landscape
This table is a synthesis of the information presented by Winter (1983, 1986), LaBaugh et al. (1987), Winter and Woo (1990), Naiman et al. (1992), Brinson (1993a), Brinson et al. (1995), Bedford (1999), Beechie and Bolton (1999), Gersib (2001), Adamus et al. (2001), Stanley and Grigsby (2003).	

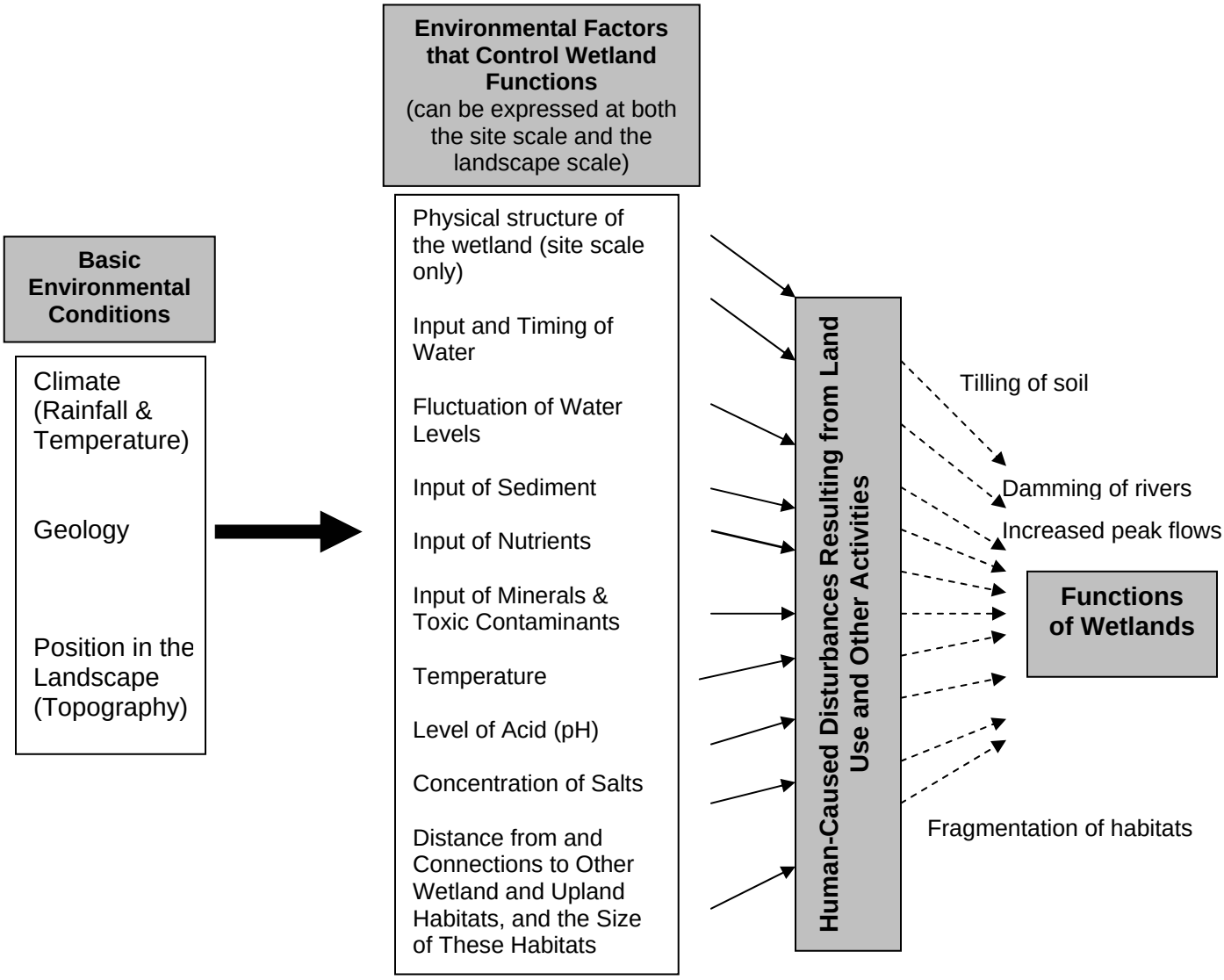


Figure 2-3. Diagram summarizing some major environmental factors that control functions of wetlands and how they interact with human-caused disturbances.

The basic environmental conditions establish and determine the factors that control the functions of wetlands. The controls can occur at both the landscape and site scales. Human activities cause disturbances that affect these controls in many different ways and thereby alter the performance of wetland functions. The figure gives some examples of the disturbances. This figure is a synthesis of the information presented by the same authors as listed in Table 2-2. The different models and information described above are the basis for Chapters 3 and 4 that describe the impacts of human activities on wetlands and their functions.

2.3.4 Summary of Key Points

- There are five basic ecological principles that are useful in managing wetlands. The principles deal with time, place, species, disturbance, and landscape.
- Wetland functions are the physical, biological, chemical, and geologic interactions among different components of the environment that occur within a wetland. There are many ways to define functions depending on specific needs for managing wetlands.
- Functions fall into three broad categories: biogeochemical, hydrologic, and maintenance of food webs and habitat.
- Society does not necessarily attach value, or equal value, to all functions.
- The functions that wetlands perform are controlled by environmental factors that occur in the broader landscape as well as within the wetland. The major controls of function are climate; geomorphology and soils; the source and quantity of water; the movement of water, nutrients, other chemicals, and sediments; energy in the form of sunlight; and biological interactions.
- The factors that control wetland functions interact with each other and there are many feedback loops. Environmental processes create the physical structure of the ecosystem and this in turn controls functions. Functions, in turn, can then modify the processes and structure as well.
- In order to gain a basic understanding of the ecological importance of functions provided by wetlands, they must be evaluated within the context of the landscape in which they exist.

2.4 Classification of Wetlands in Washington as a Key to Understanding Their Functions

This section presents a brief discussion of systems that scientists have developed to group or classify wetlands nationally and in Washington State in order to better assess how they function. It begins with an overview of two classification systems—the Cowardin classification, commonly used to inventory wetlands across the country, and the hydrogeomorphic or HGM classification, which is used to characterize how wetlands function. Understanding how wetlands are grouped and classified is a key to fully understanding how different types of wetlands in different areas provide different functions.

2.4.1 Commonly Used Classification Systems in Washington

2.4.1.1 The Cowardin Classification

The first commonly used classification system for wetlands was developed in 1979 by the U.S. Fish and Wildlife Service (Cowardin et al. 1979). The Cowardin classification system is hierarchical and includes several layers of detail for wetland classification that are based on:

- Water flow
- Substrate types
- Vegetation types
- Dominant plant species

The Cowardin classification system was developed to aid a national inventory of wetlands using aerial photographs (the U.S. Fish and Wildlife Service National Wetland Inventory or NWI). The wetlands in the state that can be identified from aerial photographs have been mapped using this classification system. The maps are available from the U.S. Fish and Wildlife Service in a digital form for GIS (http://www.nwi.fws.gov/). This information is a useful starting point for developing inventories of wetlands at the local level and looking at wetlands at the scale of watersheds and river basins.

> Methods for organizing our knowledge about wetlands have been called *classifications*, *categorizations*, *characterizations*, *ratings*, *assessments*, and *evaluations*. These groupings are meant to indicate the type of information a method provides. Unfortunately, the scientific community has been inconsistent in the use of these terms. Users of methods developed for analyzing wetlands should be aware of some of these problems with terminology. See Appendix 2-A for further discussion.

2.4.1.2 The Hydrogeomorphic Classification

Although the Cowardin classification is useful in developing wetland inventories from aerial photographs and incorporates some landscape factors, it was not designed to help understand how functions differ among wetlands. A more recent system of classification, called the *hydrogeomorphic (HGM) classification* (Brinson 1993b), was developed to specifically address differences in how various wetlands function. This classification method was chosen by the statewide wetland technical committee that guided the development of the Washington State wetland function assessment methods (Hruby et al. 1999).

As previously described in Section 2.3.3, the HGM classification is based on (Brinson 1993b):

- The position of the wetland in the landscape (geomorphic setting)
- The source of water for the wetland

- The flow and fluctuation of the water once in the wetland (hydrodynamics)

Classifying wetlands based on how they function narrows the focus of attention to a specific type of wetland. It also focuses on the functions that wetlands within that type are most likely to perform and the environmental factors that most likely control how wetlands of that type function.

The HGM classification also uses the concept of grouping wetlands by geographic units (domains and regions) in which some of the controls of functions that occur at the landscape scale are similar. The assumption is that many of the functions performed by wetlands are also similar.

The highest category in the HGM classification (called *class*) is defined nationally (Table 2-3) and is based on the geomorphic setting of the wetland (Brinson 1993b, Smith et al. 1995). Not all geographic units (domains and regions) contain all the wetland classes possible.

Within a region, wetland classes can be further divided by local experts into wetland subclasses and sub-subclasses (sometimes called *families* of wetlands) based on other geomorphic or hydrologic characteristics. The wetland experts in each region can, therefore, tailor the classification to address differences in the performance of functions by different wetland types in their region (Smith et al. 1995).

Geographic areas to which this classification system is applied in Washington and a description of the HGM classes in the state are described in Section 2.4.4.

Table 2-3. Characteristics of wetland classes in the hydrogeomorphic classification (from Brinson 1993a).

Hydrogeomorphic Class (Geomorphic Setting)	Dominant Source of Water	Dominant Hydrodynamics (Movement of Water)
Riverine	Overbank flow from a channel, or hyporheic (underground) flow in floodplain	One direction, horizontal
Depressional	Surface runoff, or the "daylighting" of groundwater	Vertical
Slope	"Daylighting" of groundwater on slopes	One direction, horizontal
Lacustrine (Lake) Fringe	Lake water	Two directions, horizontal
Flats	Precipitation	Vertical
Tidal Fringe	Overbank flow from estuary	Two directions, horizontal

2.4.1.3 Other Classifications Used in Washington

There have been several other classifications developed in Washington to group wetlands for the purpose of inventories and identifying different types of habitats. Kunze (1994) developed a classification of native, low elevation, freshwater wetlands in western Washington that is based on the dominant plant species found in the wetland. The purpose of this classification was to distinguish "natural heritage resources," whose identification was mandated by state law.

In eastern Washington, Kovalchik and Clausnitzer (2004) developed a classification of Aquatic, Riparian, and Wetland sites in the national forests that is also based on the dominant vegetation. The purpose of this classification was to describe the general geographic, topographic, edaphic (resulting from soils), functional, and floristic features of aquatic, riparian and wetland ecosystems. In addition, they developed it to describe successional trends in these ecosystems. Lastly it provides information on the values of the resources and opportunities for management (Kovalchik and Clausnitzer 2004).

2.4.2 Geographical Differences in Wetland Functions

Because hydrogeologic settings and the controls of functions vary across the landscape, it is important to identify the geographic areas in which these factors are similar. This allows the grouping of wetlands that function similarly.

For example, two conferences on wetland functions in the mid-1980s highlighted some of the differences between wetlands on the West Coast and those in the rest of the country (Horner 1986). Specifically, wetlands on the West Coast are different for the following reasons (Zedler 1985 as cited in Horner 1986):

- Drainage areas to West Coast wetlands are often smaller than those on the East Coast
- The coastal plain, with some exceptions, is not as large on the West Coast
- Soils in the West Coast region are often high in clay
- Conditions in a watershed are often highly erosive on the West Coast because of the steep topography
- Precipitation varies more seasonally on the West Coast than east of the Rocky Mountains

Even within Washington, the diverse areas of the state support many kinds of wetlands that vary in functions. For example, vernal pools on the scablands differ greatly from the floodplain marshes along the Snoqualmie River, and wetlands that formed in the potholes created by glaciers have different functions from those found along the shores of salt lakes in the Grand Coulee (Hruby et al. 2000).

Through the Washington State wetland function assessment project, there has been a major effort over the last eight years to build on previous work and to develop methods for assessing how wetlands function in different regions of the state. The methods are based on a formal process of quantifying the collective judgment of a group of local experts. This approach provides a

scientific basis for rapid methods in the absence of rigorous, site-specific scientific studies (Hruby 1999).

A statewide technical committee was formed in 1994 to guide the technical components of the function assessment project. In addition, several assessment teams, composed of experts in different disciplines, developed methods for specific wetland types and areas of the state (Hruby et al. 1999, 2000). At present, methods for four wetland types in the lowlands of western Washington and three types in the Columbia Basin of eastern Washington have been completed. These documents are available on the project's web site (http://www.ecy.wa.gov/programs/sea/wfap/index.html).

Another major effort has just been completed to incorporate differences among geographic areas and wetland functions into the Washington State wetland rating systems for eastern and western Washington. The Washington State Department of Ecology has been coordinating this effort, and teams of regional wetland experts and local government staff have provided technical expertise in writing the documents.

The geographic regions where wetlands function in different ways that have been identified by these teams of regional experts are described in the next section.

2.4.3 Wetland Regions in Washington

Wetlands in Washington are grouped first into "domains" and "regions" based on climate and other landscape features, then into "classes" by geomorphic setting, and finally into "subclasses" and "families" by the sources of water for the wetland and how that water moves (Hruby et. al. 1999, 2000, Hruby 2004a,b). These are some of the primary controls of wetland functions as described earlier. This section focuses on the wetland domains and regions. Section 2.4.4 describes the wetland classes and Section 2.4.5 the subclasses for Washington State.

The wetlands in Washington were divided into two ecological domains, East and West, when the Washington State wetland rating systems were first developed (Ecology 1991, 1993). The teams of wetland experts who revised the rating systems have kept this division (Hruby 2004a,b). At this highest level, the domains are based on the national classification of the environment (called *ecoregions*) developed by federal agencies (Bailey 1995). Wetlands on the west side of the Cascade Crest fall within the domain called *Humid Temperate* and those on the east side are in the *Dry* domain.

The term *ecoregion* was coined by J.M. Crowley (1967) and popularized by Robert J. Bailey (1976) to define a classification of ecosystems in the United States. Ecoregions are generally considered to be regions where climatic conditions are similar. As a result, the ecosystems there, including wetlands, are relatively homogeneous (Omernik and Gallant 1986). The concept was developed to help resource managers better understand regional differences in the environmental factors that maintain ecosystems and the relative importance of different factors that can change ecosystems (Omernik and Gallant 1986). The local maps of the ecoregions and their definitions are continually being updated by the U.S. Environmental Protection Agency laboratory in Corvallis, Oregon. The latest maps of ecoregions are available on the web at http://www.epa.gov/bioindicators/html/ecoregions.html.

The wetland experts working on assessments of function in the state further divided the domains into smaller regions because the two domains are too coarse a division for understanding how wetlands function in the state in a more detailed way (Hruby et al. 1999, 2000). At present there are five regions in the state (Figure 2-4) including three regions in the eastern domain and two in the western domain:

- Eastern domain:
  - Montane
  - Columbia Basin
  - Lowlands of Eastern Washington
- Western domain:
  - Montane
  - Lowlands of Western Washington

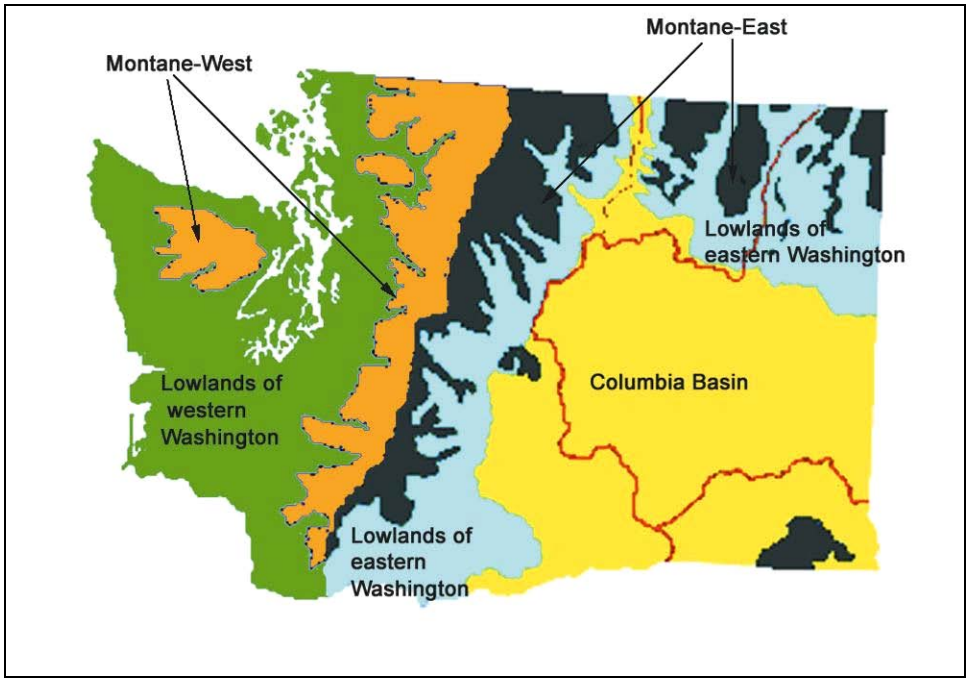


Figure 2-4. Regions in Washington used for classifying wetlands.

As mentioned previously, these regions of Washington are linked to the national classification of ecoregions developed by several federal agencies. The boundaries of the regions used in Washington, however, in some cases include parts of multiple ecoregions defined at the national level. The geographic extent of the Lowlands of Western Washington includes portions of three ecoregions within the Humid Temperate domain defined at the national level: the Coast Range, the Puget Lowlands, and the Willamette Valley (Hruby et al. 1999). Characteristics of these ecoregions are detailed in Omernik and Gallant (1986). The geographic extent of the Columbia Basin region, however, is the same as the Columbia Basin Ecoregion identified by Omernik and Gallant (1986).

At present, final definitions of regions have been developed only for the Lowlands of Western Washington and the Columbia Basin because these are the only two regions for which methods to assess wetland functions have been developed. The Montane regions (east and west of the Cascades) and the Lowlands of Eastern Washington have been defined with less detail because methods for assessing functions in these regions have not yet been developed. Generally the Montane regions include areas above 3,000 feet (915 m) elevation, and the Lowlands of Eastern Washington includes all other areas in the Dry domain, outside the Columbia Basin, and below 3,000 feet (915 m) elevation.

2.4.4 Description of the Wetland Classes for Washington

A brief description of wetlands in the different classes in Washington is given below. More detailed descriptions are available in Hruby et al. (1999, 2000).

2.4.4.1 Riverine Wetlands

The distinguishing characteristic of riverine wetlands in Washington is that they are frequently flooded by overbank flow from a stream or river (Hruby et al. 1999). Riverine wetlands are found in a valley or adjacent to a stream channel (Figure 2-5). They lie in the active floodplain of a river or stream and have important links to the water dynamics of the river or stream. The flooding waters are a major environmental factor that structures the environment in these wetlands and controls wetland functions. Riverine wetlands in some regions of Washington are defined by the frequency of overbank flooding (Hruby 2004a,b).



Figure 2-5. Riverine wetlands. Located in active floodplains where overbank flooding of the river or stream structures the wetland environment and controls its functions.

2.4.4.2 Depressional Wetlands

Depressional wetlands occur in topographic depressions that have closed contours on three sides (Figure 2-6). Elevations within the wetland are lower than in the surrounding landscape. The shapes of depressional wetlands vary, but in all cases the movement of surface water and shallow subsurface water is toward the lowest point in the depression. The depression may have an outlet, but the lowest point in the wetland is somewhere within the boundary, not at the outlet (Hruby et al. 1999).



Figure 2-6. Depressional wetlands. Located in topographic low areas that are closed on at least three sides (they may or may not have an outlet).

2.4.4.3 Slope Wetlands

Slope wetlands (Figure 2-7) occur on hill or valley slopes where groundwater surfaces and begins running along or immediately below the soil surface. They are usually found where the topography and local geologic conditions forces groundwater to the surface creating a zone of perennial or near-perennial moisture (Stein et al. 2004). Water in these wetlands flows only in one direction (down the slope) and the gradient is steep enough that the water is not impounded. The "downhill" side of the wetland is always the point of lowest elevation in the wetland (Hruby et al. 2000).



Figure 2-7. Slope wetlands. Located on slopes where groundwater daylights and runs at or just below the soil surface.

2.4.4.4 Lacustrine (Lake) Fringe Wetlands

Lacustrine fringe wetlands in Washington are found along the edges of deeper bodies of water such as lakes or reservoirs (Figure 2-8). These wetlands occur at the margin of topographic depressions in which surface water covers more than 20 acres (8 ha) and is deeper than 7 feet (2 m) in western Washington or 10 feet (3 m) in eastern Washington. The amount of open water and deep water also has to exceed 30% of the total area of wetland. The dominant surface water movement in lacustrine fringe wetlands has a horizontal component due to winds or currents, but there may also be a corresponding vertical component resulting from wind or seasonal water fluctuations (Hruby et al. 1999, 2000).

The definition of *lake fringe* is more specific than the definition of *lacustrine* used in the Cowardin classification described previously. The local teams of experts developing methods for assessing functions and the rating system decided to refine the definition of lacustrine to better reflect environmental conditions in the state.



Figure 2-8. Lacustrine fringe wetlands. Located along the edge of large bodies of water, such as lakes.

2.4.4.5 Flats Wetlands

Flats wetlands are rare in Washington. They occur in topographically flat areas that are hydrologically isolated from surrounding groundwater or surface water. The main source of water in these wetlands is precipitation. They receive virtually no groundwater discharge or surface runoff from areas outside the wetland boundary. This characteristic distinguishes them from depressional and slope wetlands (Hruby et al. 1999).

2.4.4.6 Tidal Fringe Wetlands

Tidal fringe wetlands occur along the coasts and in river mouths to the extent of tidal influence. The dominant source of water is from the ocean or a river that empties into the ocean; therefore these wetlands can be fresh or saline. The unifying characteristic of this class is the hydrodynamics. All tidal fringe wetlands have water flows dominated by tidal influences and water depths controlled by tidal cycles (Hruby et al. 1999). This document does not address tidal fringe wetlands.

2.4.5 Subclasses of Wetlands in Washington

Developing the HGM classification for Washington is an ongoing process, and not all subclasses for wetlands in the different regions have been defined. The wetland subclasses and families that have been defined in the four regions of Washington (as of February 2005) are listed in Table 2-4.

Although the HGM classification for wetlands in the state is not yet complete, the categories listed in Table 2-4 provide a useful tool to help separate wetlands into different types.

Table 2-4. Subclasses and families of wetlands in different regions of Washington State. (Hruby et al. 1999, 2000)

Class	Subclasses and Families by Region			
	Lowlands of Western WA	**Lowlands of Eastern WA**	**Columbia Basin**	**Montane (East and West)**
Riverine	• Impounding • Flow-through	ND	ND	ND
Depressional	• Outflow • Closed	ND	• Alkali • Freshwater • Long-duration • Short-duration	ND
Slope	ND	ND	ND	ND
Flats	ND	Probably does not occur in the region.	Probably does not occur in the region.	ND
Lacustrine (Lake) Fringe	ND	ND	ND	ND
Tidal Fringe	• Salt Water • Fresh Water	Does not occur in the region.	Does not occur in the region.	Does not occur in the region.
ND = Subclasses in the region have not yet been defined.				

2.4.6 Summary of Key Points

- The physical structure and functions of wetlands vary by region. The diverse regions of Washington support many kinds of wetlands that provide different functions. These differences are documented in the wetland function assessment methods and rating systems for Washington State.
- Wetlands in Washington are grouped first into domains and regions based on climate, then by geomorphic setting, and finally by the sources of water for the wetland and how that water moves. This is called the hydrogeomorphic (HGM) method for classifying wetlands.
- Hydrogeomorphic classes in Washington State include riverine, depressional, slope, lacustrine (lake) fringe, flats, and tidal fringe. Subclasses and families of wetlands are also defined by region (see Table 2-4).

2.5 Overview of Wetland Functions in Washington State

As described in the previous section, our current knowledge about wetland functions in different regions of Washington and among different HGM classes is based largely on the work of experts involved in developing the function assessment methods and ratings for wetlands in the state (Hruby et al. 1999, 2000, Hruby 2004a,b). Experts have developed methods to assess functions of riverine and depressional wetlands in several regions of the state. They have not discussed or identified the functions of freshwater wetlands in the flats, slope, tidal fringe, or lacustrine fringe classes, nor any functions of wetlands in the montane regions.

As mentioned in Section 2.3.2 there are many ways to group wetland functions. Functions that are currently defined for the state are listed on the following pages. The definitions are compiled from Hruby et al. (1999, 2000) and Hruby (2004a,b). Not all wetlands in a region, class, or subclass perform all of these functions. A more detailed description of each function is given in Section 2.6. As noted previously, functions are coarsely grouped into three main categories, those that improve water quality, those related to water regime in a watershed, and those that pertain to wildlife habitat.

> The functions selected for the Washington State wetland function assessment methods and the rating systems are narrowly defined to provide a level of specificity that is important to managing wetlands by decision-makers. The list of functions defined here does not represent all the functions performed by wetlands in the state. It does, however, represent the functions that were determined to be valuable by the experts that developed them and that need to be considered when managing wetlands (Hruby et al. 1999, 2000, Hruby 2004a, b).

2.5.1 Functions Related to Improving Water Quality

Removing Sediment: This function is defined in terms of the processes and characteristics that retain sediment within a wetland and prevent its downstream movement. A wetland performs this function if there is a net annual decrease of sediment load to downstream surface waters.

Removing Nutrients/Phosphorus: This function is defined in terms of the processes and characteristics within a wetland that remove phosphorus present in surface waters and prevent its movement into surface waters and groundwater.

Removing Nutrients/Nitrogen: This function is defined in terms of the processes and characteristics within a wetland that remove dissolved nitrogen present in surface waters or groundwater and prevent its further movement into surface waters or groundwater.

Removing Metals and Toxic Organic Compounds: This function is defined in terms of the processes and characteristics within a wetland that retain toxic metals and toxic organic compounds coming into the wetland and prevent their movement into surface waters and groundwater.

Removing Pathogens: This function can be defined in terms of the processes and characteristics within a wetland that retain or kill pathogenic organisms such as viruses and bacteria that can cause diseases in humans. This function was originally excluded from the water quality functions identified by the expert teams who developed the assessment methods and revised the rating system. They judged that the characteristics that determine this function are the same as those for removing sediment and removing toxic compounds. It has been added to the list of functions because reviewers of this document suggested it and it is a commonly recognized function (Kadlec and Knight 1996).

2.5.2 Functions Related to Maintaining the Water Regime in a Watershed (Hydrologic Functions)

Reducing Peak Flows: This function is defined in terms of the processes and characteristics within a wetland by which the peak flow in a watershed can be reduced during a major storm or snowmelt (i.e., events that would otherwise cause flooding).

Reducing Erosion: This function is defined in terms of the processes and characteristics within a wetland that detain high flows during storms and reduce the duration of erosive flows, thus decreasing downstream erosion in streams. This definition was developed for riverine and depressional wetlands. Wetlands along the shores of lakes (Jude and Pappas 1992) also protect resources from erosion but in a different way. For wetlands classed as lacustrine fringe, the function can be called "dissipation of erosive forces." This is defined as the processes by which wetlands reduce wave and current energies, thus reducing erosion of shorelines.

Recharging Groundwater: This function is defined in terms of the processes and characteristics within a wetland that allow surface water to infiltrate into the groundwater system.

2.5.3 Functions Related to Habitat

General Habitat: This function is defined in terms of the processes and characteristics within a wetland that indicate a general suitability and opportunity as habitat for a broad range of species. A suitable habitat for a suite of different fauna can be provided by a broad range of structures, vegetation, and interspersion of habitat types within the wetland and the upland habitats contiguous to a wetland. Characteristics in a wetland can be quite different and continue to provide highly suitable conditions for a range of species.

Habitat for Invertebrates: This function is defined in terms of the processes and characteristics within a wetland that help maintain a high number of invertebrate species.

Habitat for Amphibians: This function is defined in terms of the processes and characteristics within a wetland that contribute to the feeding, breeding, or refuge needs of amphibian species.

Habitat for Anadromous Fish: This function is defined in terms of the processes and characteristics within a wetland that contribute to the feeding, breeding, or refuge needs of anadromous fish species.

Habitat for Resident Fish: This function is defined in terms of the processes and characteristics within a wetland that contribute to the feeding, breeding, or refuge needs of resident native fish.

Habitat for Wetland-Associated Birds (called *Aquatic Birds* in the methods for eastern Washington): This function is defined in terms of the processes and characteristics within a wetland that provides habitats or life resources for species of wetland-associated birds. Wetland-associated bird species are those that depend on aspects of the wetland for some part of their life needs: food, shelter, breeding, or resting.

Habitat for Wetland-Associated Mammals (called *Aquatic Mammals* in the methods for eastern Washington): This function is defined in terms of the processes and characteristics within a wetland that support one or more life requirements of aquatic or semi-aquatic mammals.

Richness of Native Plants: This function is defined in terms of the degree to which the wetland provides a habitat for many different native plant species.

Supporting Food Webs (also called *Primary Production and Export* in the methods for western Washington): This function is defined in terms of the processes and characteristics within a wetland that support complex food webs within the wetland and surrounding resources through the export and assimilation of the primary productivity of the wetland. The function combines three major environmental processes: primary production, secondary production, and export of production.

2.5.4 Summary of Key Points

- Wetland functions are currently defined for Washington State in a relatively narrow manner to facilitate better wetland management and regulation by decision makers.
- Wetland functions defined in Washington fall into three general groups: functions related to improving water quality, functions related to the water regime in a watershed (hydrologic functions), and functions related to habitat.
- Not all wetlands in a region, class, or subclass perform all functions.

2.6 How Wetlands Perform Functions in Washington State

Table 2-5 summarizes the information on the functions that are, or are not, performed by the different freshwater wetland classes in Washington State. The following sections synthesize information available about each function and how the different wetland types in the state perform that function.

Table 2-5. Functions potentially performed by wetlands in different HGM classes in Washington. Data compiled from Hruby et al. (1999, 2000), Hruby (2004a, b).

Functions	Riverine	Depressional	Slope	Lacustrine Fringe	Flats
Improving Water Quality					
Removing Nutrients	P	P	P	P	P
Removing Sediment	P	P	P	P	NS
Removing Metals/Toxic Organic Compounds	P	P	P	P	P
Removing Pathogens	P	P	P	P	P
Hydrologic					
Reducing Peak Flows	P	P	N	N	NS
Decreasing Downstream Erosion/Dissipating Erosive Forces	P	P	P	P	NS
Recharging Groundwater	P	P	N	N	NS
Food Webs and Habitat					
General Habitat	P	P	P	P	P
Habitat for Invertebrates	P	P	P	P	P
Habitat for Amphibians	P	P	P	P	P
Habitat for Anadromous Fish	P	P	N	P	N
Habitat for Resident Fish	P	P	N	P	N
Habitat for Wetland-Associated Birds	P	P	NS	P	P
Habitat for Wetland-Associated Mammals	P	P	NS	P	P
Plant Richness	P	P	P	P	P
Support Food Webs	P	P	P	P	P

Key to symbols used in table:
P = Functions are performed
N = Functions are not performed
NS = (not significant) Functions are performed to a minor degree, but probably not at levels that are of importance to society.

2.6.1 Functions that Improve Water Quality

Wetlands greatly influence the quality of water in a watershed by removing many different types of contaminants. They help improve water quality, including that of drinking water, by intercepting surface runoff and removing or retaining inorganic nutrients, processing organic wastes, removing pathogens and reducing suspended sediments before they reach open water. The dominant processes for removing contaminants in wetlands are settling, chemical reactions in and with the soils, and biotransformations (reviewed in Hammer 1989, Moshiri 1993, Kadlec and Knight 1996).

Table 2-6 summarizes some of the major groups of contaminants that can enter wetlands and the primary mechanisms by which they are removed. The following sections discuss in more detail each of the major functions by which wetlands improve water quality.

Table 2-6. Primary mechanisms for removing contaminants in wetlands. Extracted from Hammer 1989, Moshiri 1993, Kadlec and Knight 1996.

Contaminant	Physical	Chemical	Biological
Sediment and other solids	Settling, Filtration		
Oxygen demand	Settling	Oxidation	Biodegradation
Hydrocarbons	Diffusion, Volatilization, Settling	Photochemical oxidation	Biodegradation, Evapotranspiration
Nitrogen compounds			Denitrification
Phosphorus compounds	Settling	Precipitation, Adsorption	
Metals	Settling	Precipitation, Adsorption, Ion Exchange,	Biotransformation
Pathogens	Residence time	UV radiation	Die-off, Other microbes

2.6.1.1 Removing Sediment

Sediment may enter wetlands in direct runoff from surrounding areas, as windblown dust, or in streams or rivers that flow through the wetland. Sediments deposited in wetlands are removed from surface flows, thereby improving water quality down-gradient. A wetland, however, will perform this function only if surface water contaminated with sediment actually enters the wetland.

Some general properties may be applied to all wetlands with respect to their ability to remove sediments (Phipps 1986). Within a given wetland, the deposition of sediment depends on several factors including (Phipps 1986, Johnston 1991, Fennessy et al. 1994, Gilliam 1994, Kadlec and Knight 1996):

- Residence time of the water that allows sediments to settle
- Wind and wave action that re-suspend sediments
- Size and amount of incoming sediment
- Vegetation

Generally, a high residence time for the water that allows settling and the filtration by vegetation are the major processes by which sediment is removed from surface water (Fennessy et al. 1994). Filtration is the physical adhesion and cohesion of sediment facilitated by vegetation (Adamus et al. 1991). The size of the particles that settle out is directly related to the increase in settling time achieved in the wetland (Adamus et al. 1991).

Typically a wetland with vegetation traps 80% to 90% of sediment from runoff entering the wetland (Johnston 1991, Gilliam 1994). Other studies have found that wetlands with open, deep, water may be as effective, or more effective, than vegetation in trapping sediments (Fennessy et al. 1994) because the residence time increased.

Wetlands can be more important for removing excessive amounts of sediments compared to other components of the landscape (Adamus et al. 1991). Another way to consider the importance of wetlands for removing sediments in a watershed is to analyze how much wetland area is needed to effectively remove sediments. Fennessy et al. (1994) report the following from their review of the literature:

- Watersheds in Wisconsin with only 5% of their area in wetlands trapped up to 70% of the sediment in the system
- In a North Carolina watershed, more than 20% of the total sediment deposition occurred in wetlands that represented only 11% of the area

The importance of any wetland for improving water quality depends, however, on the amount of sediment pollution in the watershed. Watersheds in which human activities loosen the topsoil (agriculture, development, and logging) are prone to have high sediment loadings. Wetlands in these watersheds are very important for maintaining water quality (National Research Council 1995).

Removal of Sediment by Wetlands of Various Classes and in Different Domains and Regions

The way wetlands remove sediment is not judged to be different in the two major domains of the state (the east side and the west side of the Cascades) (Hruby et al. 1999, 2000). However, the processes by which wetlands in Washington remove sediments differ somewhat among the different wetland classes as described below.

Wetlands in the Flats Class

Wetlands in the flats class, in general, do not remove sediment because by definition their major source of water is precipitation that falls within the wetland itself (Brinson 1993b). There is no opportunity for sediment-laden water to enter the wetland. All other types of wetlands perform this function to some degree because they receive surface water from outside their boundaries, and the surface water is never completely free of sediments.

Wetlands in the Depressional Class

Depressional wetlands that hold back all the surface water coming in (that is, those without a surface outlet) trap all the sediment they receive. Such wetlands are very effective at this aspect of water quality improvement wherever they are found in Washington (Hruby et al. 1999, 2000).

The removal of sediment in depressional wetlands with an outflow depends on how effectively they slow the water and allow settling, as well as the density of the vegetation that filters the incoming water. The same processes are present in depressional wetlands of both eastern and western Washington (Hruby et al. 1999, 2000).

Wetlands in the Lacustrine Fringe Class

Wetlands along the shores of lakes (lacustrine fringe) trap and retain suspended sediment by anchoring the shoreline, reducing resuspension of bottom mud by wind mixing, and slowing water velocities (Adamus et al. 1991). Even aquatic bed vegetation, which typically provides less resistance to water flow than emergent or woody plants, may reduce water movement enough to induce settling (Adamus et al. 1991).

Wetlands of this class have not yet been subjected to the thorough analysis required for developing a function assessment method. More definitive conclusions about Washington wetlands are, therefore, not available. However, no evidence has been reported that would negate the observations made in lacustrine wetlands in other parts of the U.S. that were reviewed by Adamus et al. (1991).

Wetlands in the Slope Class

Slope wetlands by definition (Brinson 1993b) do not impound surface water. The removal of sediment through settling is therefore not a factor in this class of wetlands.

Unpublished data collected during the calibration of the eastern Washington wetland rating system, however, suggest that slope wetlands may still play a role in removing sediment. For

example, slope wetlands in eastern Washington have vegetation that is usually thicker than the vegetation in the surrounding uplands (Figure 2-9). This vegetation acts like a filter to trap sediments coming from further upslope because it provides more resistance to the water flowing down the hillside (Hruby 2004a).



Figure 2-9. Slope wetland in the Columbia Basin that formed at a break in the slope. It has dense emergent plants that can trap sediment coming from the upslope areas.

Slope wetlands in western Washington have not yet been analyzed in terms of their potential to remove sediments, and it is not possible to report if similar processes and structure are found there. Models for assessing slope wetlands have, however, been developed for the Willamette Valley in Oregon. Two characteristics of slope wetlands identified there that contributed to the retention of sediments were the amount of ground covered by vegetation and the relative area of the wetland covered in hummocks (Adamus and Field 2001).

Wetlands in the Riverine Class

The removal of sediment in riverine wetlands is a somewhat different process. The vegetation and depressions within these wetlands trap sediment, but sediments are eroded by floods that recur every few years. The function of riverine wetlands is to stabilize sediment during the period between floods (Adamus et al. 1991). Wetlands are an integral part of the cycle of erosion and deposition in floodplains.

Phipps (1986) stated that the efficiency of sediment trapping by riverine wetlands in the Pacific Northwest has not been measured. This conclusion is still valid today, since no studies were found that quantified this function. The process of trapping sediments is still judged to be an important function on a watershed scale in Washington State (Hruby et al. 1999) and was

modeled during the development of function assessment methods. The characteristics of riverine wetlands that were judged important in removing sediments were as follows (Hruby et al. 1999):

- How much the stream or river meanders through the wetland
- How wide the wetland is relative to the width of the stream
- How much of the wetland is covered in vegetation that can act as a filter
- The amount of constriction in the outlet (if the wetland has an outlet)

2.6.1.2 Removing Phosphorus

Phosphorus can enter wetlands with suspended solids or as dissolved phosphorus. It is usually transported attached to particles rather than dissolved in the water (Raisin and Mitchell 1995). The major processes by which wetlands keep phosphorus from going farther downstream are (Mitsch and Gosselink 2000):

- The trapping of sediment on which phosphorus is adsorbed
- The removal of dissolved phosphorus by adsorption to soils that are high in clay content or organic matter
- Precipitation with calcium to form calcium phosphate

Wetlands that are effective at trapping sediments, therefore, are also effective at removing phosphorus. The discussion in Section 2.6.1.1 on the classes of wetlands that are effective at removing sediments also applies to removing phosphorus (Hruby et al. 1999).

The adsorption of phosphorus on soils is not permanent. Certain conditions during periods of extensive anoxia (lack of oxygen) may release phosphorus into the overlying waters (Adamus et al. 1991, Reddy and Gale 1994). In general, however, wetlands are a sink for phosphorus in watersheds (Adamus et al. 1991).

Other data also shows that phosphorus retention in wetlands is highly variable. Whigham et al. (1988) concluded that wetlands where waters had extensive contact with vegetation and/or organic litter were the most effective at phosphorus removal. Forested wetlands were only effective during flood events (when there was contact between waters and vegetation and more sediment deposition occurred). They found open water, lacustrine systems to be the least effective at phosphorus removal.

Johnston et al. (1997) observed that a wetland may remove phosphorus from incoming waters during one part of the year but at other times of year it may add phosphorus to water leaving the wetland. They hypothesized that the release of phosphorus from a wetland is due to the leaching of phosphorus from dying wetland vegetation.

The different pathways by which phosphorus can be trapped or released in wetlands are summarized in the quotation from a North Carolina State University web site in the box on the following page. Other sources that describe the many different ways phosphorus can be

adsorbed, de-sorbed, precipitated and bound to soils depending on pH, alkalinity and hardness of the water are Kadlec and Knight (1996), Richardson and Vepraska (2001) and Wetzel (2001).

Mechanisms of phosphorus removal

The following discussion from North Carolina State University summarizes the scientific literature on the ways in which wetlands remove and process phosphorus. (North Carolina State University undated).

Phosphorus removal from water in wetlands occurs through adsorption by aluminum and iron oxides and hydroxides; precipitation of aluminum, iron, and calcium phosphates; and burial of phosphorus adsorbed to sediments or organic matter (Walbridge 1993, Johnston 1991, Richardson 1985). Wetland soils can, however, reach a state of phosphorus saturation, after which phosphorus may be released from the system (Richardson 1985). Phosphorus export from wetlands is seasonal, occurring in late summer, early fall and winter as organic matter decomposes and phosphorus is released into surface water.

Dissolved phosphorus is processed by wetland soil microorganisms, plants, and geochemical mechanisms (Walbridge 1993). Microbial removal of phosphorus from wetland soil or water is rapid and highly efficient; however, following cell death, the phosphorus is released again. Similarly, for plants, litter decomposition causes a release of phosphorus. Burial of litter in peat can, however, provide long term removal of phosphorus. Harvesting of plant biomass is needed to maximize biotic phosphorus removal from the wetland system.

The potential for long-term storage of phosphorus through adsorption to wetland soil is greater than the maximum rates of phosphorus accumulation possible in plant biomass (Walbridge 1993, Johnston 1991). In alkaline wetlands, such as found in the West, phosphorus precipitates with calcium as calcium phosphate (Novotony and Olem 1994, Walbridge 1993). However, the presence of aluminum is the significant predictor of dissolved phosphorus sorption and removal from water in most wetland systems (Reddy and Gale 1994, Walbridge 1993, Richardson 1985). The capacity for phosphorus adsorption by a wetland, however, can be saturated in a few years if it has low amounts of aluminum and iron or calcium (Richardson 1985).

Wetlands along rivers have a high capacity for phosphorus adsorption because as clay is deposited in the floodplain, aluminum (Al) and iron (Fe) in the clay accumulate as well (Gambrell and Trace 1994). Thus floodplains tend to be important sites for phosphorus removal from the water column, beyond that removed as sediments are deposited (Walbridge 1993).

Removal of Phosphorous by Wetlands of Various Classes and in Different Domains and Regions

The way wetlands remove phosphorus is considered to be similar in the two domains of the state (the east and west sides of the Cascades). Firstly, wetlands that are effective at trapping sediments are also effective at removing phosphorus regardless of their location (Hruby et al. 1999, 2000). Wetlands of all types in both domains have the potential of trapping sediments and therefore removing any phosphorus adhered to it. This conclusion is based on data showing that most of the phosphorus entering a wetland is bound to sediment (Dortch 1996, Mitsch et al. 1995, Mitsch and Gosselink 2000).

Secondly, phosphorus entering a wetland in a dissolved form can also be retained because it binds to clay and organic soils (see box on the previous page). The HGM classification, however, does not separate wetland types by soil content (Brinson 1993b), so the presence of clay or organic soils is not specific to a particular wetland class or region. As a result it is not possible to differentiate this function between wetland types. In the absence of research to the contrary, it can be hypothesized that wetlands in all domains and regions of the state and in all wetland classes have the potential to remove phosphorus if they contain organic or clay soils that can bind phosphorus.

2.6.1.3 Removing Nitrogen

Wetlands in general act as sinks for nitrogen under both nutrient-enriched and un-enriched conditions (Adamus et al. 1991, Jansson et al. 1994). Nitrogen enters a wetland in the form of ammonium from animal wastes in runoff, as nitrate/nitrite from fertilizers in runoff and groundwater, or from air pollution (Adamus et al. 1991).

The efficiency of nitrogen removal is greater with longer retention times of the water, earlier plant community stages, and lower loading rates (Dorge 1984 as reported in Adamus et al. 1991). Wetlands are far more efficient at removing nitrogen from up-basin loading than either rivers or streams (Saunders and Kalff 2001), even though soluble nitrogen may be flushed out of wetlands at times of high flow (Johnston et al. 1990).

The major biochemical processes by which wetlands remove nitrogen are nitrification and denitrification. These respectively occur in alternating conditions where oxygen is present (aerobic) and oxygen is absent (anaerobic) (Johnston et al. 1990, Mitsch and Gosselink 2000, Vought et al. 1995, Saunders and Kalff 2001). Denitrification transforms the majority of nitrogen entering wetlands into nitrogen gas, causing between 70% and 90% to be removed from the aquatic system (Reilly 1991, Gilliam 1994).

In aerobic substrates, the bacteria *Nitrosomonas* can oxidize ammonium to nitrite. The bacteria *Nitrobacter* oxidizes nitrite to nitrate. This process is called nitrification (Mitsch and Gosselink 2000).

Nitrogen is completely removed from the aquatic system only by anaerobic bacteria that reduce nitrate to gaseous nitrogen during denitrification. The gaseous nitrogen volatilizes, and the nitrogen is eliminated as a water pollutant. Thus, the alternating reduced and oxidized conditions (anaerobic and aerobic respectively) of wetlands complete the nitrogen cycle and maximize

denitrification rates (Johnston 1991). First the aerobic bacteria change ammonium and organic nitrogen (decomposing plants and animals) to nitrate and nitrite, and then the anaerobic bacteria change the nitrate and nitrite to nitrogen gas.

Plants or microorganisms can use nitrate and ammonium for growth. Plant growth, however, does not really remove the nitrogen from the aquatic system because it becomes available again with the death of the plants or microorganisms that absorbed the nutrients (Adamus et al. 1991).

Nitrogen Removal by Wetlands of Various Classes and in Different Domains and Regions

The way wetlands are judged to remove nitrogen is similar east and west of the Cascades (Hruby et al. 1999, 2000, Hruby 2004a,b). Furthermore, the HGM classification does not separate wetland classes by the amount of oxygen in the soils (Brinson 1993b). The presence of alternating cycles of anaerobic and aerobic conditions is not specific to wetland types or regions. Therefore, it is not possible to differentiate this function between wetland types and regions.

Whether a specific wetland removes nitrogen or does not depends on the conditions found within the wetland, not on the type of wetland or its position in the landscape. The conditions that promote removal of nitrogen in wetlands of the state are seasonal inundation or saturation (Hruby et al. 1999, 2000). This indicates the soils alternate between aerobic conditions (when dry) and anaerobic conditions (when wet), and provides the optimal conditions for the gasification of nitrogen as described above.

2.6.1.4 Removing Metals and Toxic Organic Contaminants

The major physical, biological, and chemical processes by which wetlands reduce the amount of toxic materials moving into down-gradient waters are through sedimentation, adsorption, precipitation, oxidation, bio-degradation, and plant uptake (Adamus et al. 1991, Kadlec and Knight 1996, ITRC 2003).

- **Sedimentation** is a major process by which wetlands remove toxic compounds because some toxic compounds are bound to sediments or form insoluble compounds that settle out. For example, most heavy metals in urban runoff are adsorbed to sediment particles and are buried in sediment deposits within wetland soils (Newton 1989). Arsenic, Cadmium, Copper, Iron, Lead, Nickel, Silver, and Zinc are all metals that can be trapped through sedimentation (review in ITRC 2003). Thus, wetlands that are effective at removing sediments are also effective at trapping many toxic metals.

- **Adsorption** of the contaminants to the wetland soil is promoted by soils high in clay or organic matter (Adamus et al. 1991, Mitsch and Gosselink 2000). For example, wetlands can remove toxic metals from surface and groundwater if they contain clays, peat, aluminum, iron, and/or calcium (Gambrell and Trace 1994). Metals entering wetlands will bind to the negatively ionized surface of clay particles, or precipitate as inorganic compounds (metal oxides, hydroxides, and carbonates, depending on pH), or form a complex with humic materials (Gambrell and Trace 1994).

- **Chemical precipitation** is promoted by wetland areas that are inundated and remain aerobic, as well as those with pH values below 5 (Mengel and Kirkby 1982). Also, precipitation of dissolved iron is common in wetlands where anaerobic groundwater containing reduced iron compounds surfaces. In the aerobic surface environment the iron compounds oxidize into insoluble forms and precipitate out from solution. During this process metals and other compounds bind to the iron, and co-precipitate with the iron hydroxides (Kadlec and Knight 1996, Wetzel 2001).

- **Photochemical oxidation** is a pathway by which organic contaminants can be broken down into less toxic compounds through the action of sunlight (Kadlec and Knight 1996).

- **Biodegradation** is similar to oxidation, but in this case bacteria and other microbes break down organic contaminants. Degradation occurs under both aerobic and anaerobic conditions depending on the chemical structure of the contaminant (Kadlec and Knight 1996, ITRC 2003).

- **Plant uptake** of toxic compounds is maximized when there is significant wetland coverage by emergent plants (Kulzer 1990).

Removal of Toxic Contaminants by Wetlands of Various Classes and in Different Domains and Regions

Wetlands on the east and west sides of the Cascades were judged to function similarly in removing toxic contaminants (Hruby et al. 1999, 2000, Hruby 2004a,b). There may be some differences based on wetland class because some of the characteristics (such as effectiveness at trapping sediment) that are important for removing toxic compounds are dependent on the wetland class. Other differences do not depend on wetland class. In Washington, the experts who developed assessment methods judged that wetlands that remove sediments effectively are also effective at removing toxic compounds (Hruby et al. 1999, 2000).

The HGM classification, however, does not separate wetland types by the soils present or by how well they trap sediments (Brinson 1993b). The presence of clays, organic soils, aluminum, iron, or calcium in the soils is not specific to any wetland type. In the absence of research to the contrary, it can be assumed that wetlands in all regions of the state and in all wetland classes have the potential to remove toxic metals and organic compounds if they have the appropriate conditions that allow contaminants to sediment out, adsorb to soils, precipitate, biodegrade, or oxidize.

Wetlands with Clay Soils in Washington

As mentioned above, wetlands with clay soils can remove toxic contaminants because of the chemical properties of this type of soil. The term “clay” however, is applied both to materials having a particle size of less than 2 micrometers (25,400 micrometers = 1 inch) and to the family of minerals that has similar chemical compositions and common characteristics of crystal structure (Velde 1995). In Washington we find soils that are called “clays” that fit both aspects of the definition. In reviewing the descriptions of soils in the county soil surveys (e.g., Pringle 1990), there are three types of clay soils described in Washington.

- Those that consist of very finely ground rock formed by glaciers (called clays based on the size of the particles)
- Those that were deposited in lakes and the ocean (called clays either because of size or mineral composition)
- Those derived from the weathering of rocks in place (called clays based on mineral composition)

The scientific literature on the chemical properties of clays in relation to the adsorption of metals and organic pesticides, however, is based on the clays that are defined by their mineral composition and that are derived from weathered rocks such as bentonite, montmorillonite, and kaolinite (Fushiwaki and Urano 2001).

There is little information on the chemical properties of clays derived from glacial activity or aquatic sediments. County soil surveys (e.g., Debose and Klugland 1983) indicate that glaciers have played an important role in forming clays in western and northeastern Washington. Lacustrine (lake) and marine clays are also common in Whatcom County (Natural Resources Conservation Service 1992). These clays may contain chemically reactive minerals but it was not possible to confirm this assumption. Information from the soil survey of Whatcom County (Table J2 on the chemical properties of soils, released November 18, 2002), however, suggests that the clay soils of marine origin have a high cation exchange. This would indicate a high potential to bind metal and organic contaminants.

Wetlands with Volcanic Ash

Washington is relatively unique in the U.S. because it contains extensive areas where soils developed in volcanic ash (called Andisols). In addition, wetlands in the Columbia Basin often have a very fine layer of volcanic ash near the surface from the Mt. St. Helens eruption in 1980 (observations made by the technical team during the calibration of the methods for assessing wetland functions, Hruby et al. 2000).

In general, the cation exchange capacity of volcanically derived soils is high, due to a high surface area of the mineral and organic compounds (McSweeney 2004). Furthermore, volcanic ash that is washed or deposited into wet areas is in time transformed into bentonite clays (Bohor et al. 1976, Bohor et al. 1979). Thus, the ash found in wetland soils of Washington can be hypothesized to perform as clays to remove toxic compounds.

Wetlands with Organic Soils

Soils with a high content of organic matter have a high cation exchange capacity, and they are thus able to bind contaminants (Kadlec and Knight 1996). This is because the break down of plant material produces organic colloids that form complexes with contaminants (McSweeney 2004). Wetlands with organic soils such as peat bogs and fens in Washington State have the necessary soil conditions by definition (high content of organic matter) to react with and adsorb toxic contaminants.

Wetlands in the Depressional Class

A number of the characteristics that enhance the removal of toxic compounds are present more often in depressional wetlands, although all depressional wetlands do not have these characteristics. A higher number of depressional wetlands have slower moving water and finer sediments compared to riverine or slope wetlands (Brinson 1993b). Wetlands in which water moves slowly are better at removing toxics than those in which water moves rapidly. Slow moving water allows more time for chemical processes to occur before the water moves out of the wetland. This promotes the settling of fine sediments and the formation of organic soils (North Carolina State University 2002).

Depressional wetlands in the state more often have organic soils than wetlands in the other classes (observation is based on unpublished data collected by Ecology during the calibration of the Washington State wetland function assessment methods and the wetland rating systems 1998-2004). Depressional wetlands, therefore, can be assumed to usually have a higher potential to remove toxic compounds than wetlands in the other classes.

2.6.1.5 Removing Pathogens

Surface runoff coming into wetlands often contains large quantities of bacteria, particularly coliform bacteria and pathogens such as *Salmonella* (Hemond and Benoit 1988). Probably the most important mechanism for removing pathogenic bacteria from surface water is detention which is a function of residence time (reviews in Hammer 1989, Kadlec and Knight 1996).

Detention of the water in wetlands results in a natural die-off, and therefore removal from the water column, because many pathogenic bacteria cannot survive for long periods outside their host organism (Hemond and Benoit 1988). In addition, protozoa and other micro-organisms often found in wetlands actively feed on bacteria and can speed up the process of die-off (Hemond and Benoit 1988).

Removal of Pathogens by Wetlands of Various Classes and in Different Domains and Regions

The HGM classification does not separate wetland classes by their retention time or their populations of protozoa and other micro-organisms. Since these are the two major factors that account for the die-off of pathogens, it is not possible to differentiate how wetlands perform this function based on regional and hydrogeomorphic differences. Whether a specific wetland removes pathogens depends on the conditions found within the wetland, not on the type of wetland or its position in the landscape.

2.6.2 Functions Related to Maintaining the Water Regime in a Drainage Basin (Hydrologic Functions)

Wetlands play an important role in the water regime of watersheds (Mitch and Gosselink 2000, Bullock and Acreman 2003). Sipple (2002) provides a good summary of their role:

Because of their low topographic position relative to uplands (e.g., isolated depressions, floodplains), wetlands store and slowly release surface water, rain, snowmelt, groundwater and flood waters. Trees and other wetland vegetation also impede the movement of flood waters and distribute them more slowly over floodplains. This combined water storage and slowing action lowers flood heights and reduces erosion downstream and on adjacent lands. It also helps reduce floods and prevents water logging of agricultural lands. Wetlands within and downstream of urban areas are particularly valuable in this regard, counteracting the greatly increased rate and volume of surface-water runoff from pavement and buildings.

Because of their position on the landscape, wetlands at the margins of lakes, rivers, bays, and the ocean help protect shorelines and stream banks against erosion. Wetland plants hold the soil in place with their roots, absorb the energy of waves, and break up the flow of stream or river currents. The ability of wetlands to control erosion is so valuable that some states (e.g., Florida) are restoring wetlands in coastal areas to buffer the storm surges from hurricanes and tropical storms by dissipating wave energy before it impacts roads, houses, and other man-made structures.

The information available, however, indicates that the role of a wetland in the hydrologic cycle of a watershed is highly varied and depends on many factors. Bullock and Acreman (2003) reviewed 169 publications that report the results of scientific studies that quantified the hydrologic functions of wetlands. Their review confirms that wetlands exert a strong influence on the hydrologic cycle, but the actual functions performed by individual wetlands vary greatly. In many cases wetlands reduce floods and recharge groundwater while in other cases they may exacerbate floods or cause a net loss of groundwater (Bullock and Acreman 2003).

The following sections describe the characteristics of wetlands that reduce peak flow, reduce erosion, and recharge groundwater in Washington as determined by the teams of experts developing the methods for assessing functions and the rating system.

2.6.2.1 Reducing Peak Flows

Surface water that may otherwise cause flooding is stored to a greater degree in wetlands than typically occurs in terrestrial environments (Adamus et al. 1991). As a result, peak flows in streams and rivers are directly related to the total area of wetlands in the watershed, or to the area of wetlands in the headwaters of the system (National Research Council 1995). Wetlands reduce peak flows in streams and rivers by slowing and storing water in overbank areas and by holding back runoff that would otherwise flow directly downstream and cause more severe flooding (Reinelt and Horner 1995).

The function of reducing peak flows as defined in Washington State also includes the process of "floodflow desynchronization" (Hruby et al. 1999). This is a process that occurs at a larger, landscape scale. Desynchronization occurs when floodwaters are stored in many wetlands within the watershed. The release of water from these wetlands is staggered and gradual, resulting in more persistent flows but much lower peak flows (Adamus et al. 1991).

The characteristics of a wetland that indicate a potential to reduce peak flows include (Hruby et al. 1999, Mitsch and Gosselink 2000):

- The volume of water storage (depth of water stored multiplied by wetland area)
- The *live storage*, which is the storage above the bottom of the outlet
- Proximity of the wetland to flood waters
- Location of the wetland (e.g., along a river, lake, or stream)
- The amount of storage in the wetland relative to the volume of the flooding waters
- Lack of other upstream storage areas such as ponds, lakes, and reservoirs

Reduction in Peak Flows by Wetlands of Various Classes and in Different Domains and Regions

The importance of wetlands in reducing peak flows and how they perform this function differ in eastern and western Washington. This is a result of differences in the patterns of precipitation and snowmelt between the two areas (Hruby et al. 1999, 2000). The processes by which wetlands in Washington reduce peak flows also vary among wetland classes.

Wetlands of Western Washington

In **depressional wetlands of western Washington**, the characteristics within a wetland that reduce peak flows are the short-term storage capabilities of the wetland and the relative amount of flow captured from the upgradient contributing basin (Hruby et al. 1999). Short-term storage is often called *live storage* by hydrologists. It is the amount of water stored above the level of the outlet (if the wetland has one). Water stored below the outlet is called *dead storage* and was not considered to be important in reducing peak flows in western Washington (Hruby et al. 1999). The dead storage is usually filled by the time a flood event occurs and thus is not available to capture storm flows. Since most flooding events occur later in the fall, winter, and early spring, reductions in peak flow will occur only when a depressional wetland has some live-storage as well (Adamus et al. 1991, Hruby et al. 1999).

The expert teams who developed assessment methods for the state determined that the same assumption applies to the storage within the interstices of the soil (spaces between soil particles). Wetland soils in western Washington are usually saturated by the time most flood events occur, and storage in the soils was not judged to be important in reducing peak flows (Hruby et al. 1999) although it has been suggested as an important characteristic in other parts of the nation (Adamus et al. 1991).

Depressional wetlands with no outlet store all surface waters coming into them and therefore have the highest potential to reduce peak flows (Hruby et al. 1999).

In **riverine wetlands of western Washington**, the major characteristic judged to reduce peak flows is the storage provided by overbank areas (Hruby et al. 1999). As floodwaters rise, the waters overtop the banks of the river and fill the adjacent areas, many of which are riverine wetlands. The presence of a wide surface with an elevation at or near that of the river bank is the most important factor in reducing peak flows. As the flood waters overtop the banks they are

slowed down and the height of the flooding is reduced because the excess water is stored in these wetlands longer than the duration of the peak flows (Adamus et al. 1991, Hruby et al. 1999).

The **lacustrine fringe, flats, and slope classes of western Washington** have not been analyzed relative to reducing peak flows. The information available suggests wetlands in the flats and slope class do not play a major role in this function. Wetlands in the flats class by definition do not receive any runoff from surrounding areas (Brinson 1993b). Their effectiveness at reducing peak flows is to store only the precipitation that falls within their boundaries.

Wetlands in the slope class do not provide storage because by definition they do not impound any surface water (Brinson 1993b). Water flows to the lowest point on the slope and is then discharged. In fact, some studies show that slope wetlands may increase peak flows relative to surrounding uplands because their surface is saturated and rainfall in the wetland does not infiltrate (Bullock and Acreman 2003). The one role slope wetlands may play is to reduce the velocity of surface runoff by way of the thick vegetation often growing there (see Figure 2-9 for an illustration). The importance of vegetation on slopes in reducing flows has been well documented in studies of logging, though not specifically for slope wetlands (Lewis et al. 2001). It can be assumed that vegetation in slope wetlands plays the same role as vegetation in forested areas in reducing velocities of surface runoff (Hruby 2004a,b).

Wetlands of Eastern Washington

In **depressional wetlands of eastern Washington**, the characteristics within the wetland that reduce peak flows are the total storage capacity of the wetland and the relative amount of flow it captures from the upgradient contributing basin (Hruby et al. 2000).

The events that cause flooding in eastern Washington are different than in the western part of the state. Summer thunderstorms can cause flooding at times when most depressional wetlands are dry. As a result, the entire storage capacity of the wetland is available rather than just the live storage (Hruby et al. 2000). Depressional wetlands with no outlet store all surface waters coming into them and therefore have the greatest potential to reduce peak flows.

Riverine wetlands in eastern Washington are judged to function in a fashion similar to those on the west side (Hruby 2004a). Although function assessment methods have not been developed, the field work undertaken in calibrating the revised wetland rating system suggests that the major characteristic that reduces peak flows is also the storage provided by overbank areas (Hruby 2004a). See the previous discussion of riverine wetlands in western Washington for a more detailed description of storage by overbank areas.

Wetlands in **the lacustrine fringe and slope class** have not been analyzed in eastern Washington for their ability to reduce peak flows. The information collected during the calibration of the eastern Washington rating system, however, suggests wetlands in these two classes provide this function but not at the same levels as riverine or depressional wetlands (Hruby 2004a). Wetlands along the shores of lakes and reservoirs in eastern Washington tend to be small relative to the area of the lake (based on unpublished data, Hruby 2004a). They have some capacity to store water as the water levels in a lake rise, but the extra amount stored is often very small compared to the storage in the lake itself.

Furthermore, many lakes and reservoirs in this region have controlled and manipulated outlets. This means that the reduction in peak flows is directly controlled by humans and not by ecological processes. It is not possible, therefore, to assess how well these wetlands function to reduce peak flows based on their characteristics without an understanding of the protocols used to regulate the water levels in each reservoir.

By definition, wetlands in the slope class do not provide storage because any water flows to the lowest point and then is discharged (Brinson 1993b). However, their frequently dense vegetation reduces the velocity of surface runoff (see Figure 2-9) and thus can reduce the velocity of water somewhat. A wetland with dense vegetation will intercept more runoff and be more capable of reducing runoff velocity (and thus peak flows) than a wetland with less dense vegetation (Richardson and McCarthy 1994).

The importance of vegetation on slopes in reducing flows has been well documented in studies of logging (Lewis et al. 2001) though not specifically for slope wetlands. In eastern Washington the assumption is that vegetation in slope wetlands plays the same role as vegetation in forested areas in reducing peak flows (Hruby 2004a).

2.6.2.2 Reducing Erosion

The major process by which wetlands reduce downstream erosion is by slowing the velocity of water flowing downstream (Reinelt and Horner 1995, Adamus et al. 1991). The reduction in velocity depends on (Adamus et al. 1991):

- Channel constrictions that slow the flow of water
- Frictional resistance of the bottom
- Frictional resistance of vegetation

Jadhav and Buchberger (1995) state that the drag induced by plant stems increases with water velocity. This means that the relative reduction in velocity caused by plants increases as the speed of the water increases.

Reduction of Erosion by Wetlands of Various Classes and in Different Domains and Regions

The ways by which wetlands decrease erosion are somewhat different east and west of the Cascades. This is a result of the differences in the patterns of precipitation and snowmelt between the two areas (Hruby et al. 1999, 2000). The processes by which wetlands in Washington reduce erosion can also differ among wetland classes, as described below.

Wetlands of Western Washington

In **depressional wetlands of western Washington**, several characteristics were judged to influence a wetland's function in reducing water velocities (Hruby et al. 1999):

- Short-term storage capabilities of the wetland
- Characteristics of its outlet

- Amount of woody vegetation present
- Relative amount of flow captured from the upgradient contributing basin

Depressional wetlands with no outlet store all surface waters flowing into them. They have the greatest potential, therefore, to decrease erosion because no water leaves the wetland that could cause erosion (Hruby et al. 1999).

In **riverine wetlands of western Washington**, the major characteristic that reduces erosion is the amount of woody vegetation present that can provide a barrier to water flows (Hruby et al. 1999). As flood waters overtop the river banks, they are slowed down. The width of the wetland relative to the channel indicates how well the wetland can reduce velocity; the wider the wetland, the more water can spread out, becoming shallower and slowing down (Hruby et al. 1999).

Methods for assessing functions have not been developed for the **lacustrine fringe, flats, and slope classes in western Washington** and there is little information available on how these types of wetlands may perform this function. Wetlands in the flats class, however, are not expected to play a major role in this function. By definition, they do not receive any runoff from surrounding areas and therefore do not intercept waters that can cause erosion (Brinson 1993b).

Wetlands in the slope class, however, may decrease erosion to some degree because they often have thick vegetation relative to the surrounding uplands that reduces the velocity of surface runoff. Jadhav and Buchberger (1995) state that under dynamic conditions (high flows such as those found on slopes during storms) velocity is reduced by the drag induced by plant stems. Wetland detention time is therefore increased with vegetation density.

It can also be hypothesized that wetlands along the shores of lakes in western Washington (lacustrine fringe) may reduce erosion along the shore because of the vegetation they support. This would both anchor the shoreline and dissipate erosive forces (Adamus et al. 1991). Wetlands that have extensive, persistent (especially woody) vegetation provide protection from waves and currents associated with large storms and snowmelt that would otherwise penetrate deep into the shoreline (Adamus et al. 1991).

Wetlands of Eastern Washington

In **depressional wetlands of eastern Washington**, the characteristics within the wetland that decrease erosion are the total storage capacity of the wetland and the relative amount of flow captured from the upgradient contributing basin (Hruby et al. 2000). The events that cause erosion in eastern Washington are different than in the western part of the state. Summer thunderstorms can cause highly erosive flows at times when most depressional wetlands are dry (Hruby et al. 2000). As a result, the entire storage capacity of the wetland is usually available to reduce water velocities rather than just the live storage. Depressional wetlands with no outlet store all surface waters coming into them and therefore have the most potential to decrease erosive flows.

Riverine wetlands in eastern Washington function in a similar fashion to those on the west side (Hruby 2004a). Although experts have not developed function assessments, the field work

undertaken in calibrating the revised wetland rating system suggests that woody vegetation within the wetland is key in reducing erosive flows by slowing velocities during floods.

Function assessment methods for the **lacustrine fringe and slope classes** have also not been developed in eastern Washington. There is therefore no clear understanding of how they function to decrease erosion. It can be hypothesized, however, that wetlands of both classes can function to reduce erosion to some degree in a manner similar to these types of wetlands in western Washington (see discussion above).

2.6.2.3 Recharging Groundwater

The recharge of groundwater is the movement of surface water, usually downward, into the ground. In wetlands, the function is described in terms of the wetland structures and processes that allow surface water to infiltrate into the groundwater system. Adamus et al. (1991) and the expert teams developing the Washington State wetland function assessment methods (Hruby et al. 1999, 2000) concluded that the movement of water into the ground depends primarily on:

- The elevation of the wetland relative to the groundwater
- The mass and pressure of water ("pressure head") in the wetland
- The physical characteristics and frictional resistance of the sediments and strata underlying the wetland (hydraulic conductivity)

If the surface of the water in a wetland is groundwater, or the primary source of water to the wetland is groundwater (e.g., a seep), the wetland cannot recharge that groundwater. By definition, recharge occurs only if water from surface runoff infiltrates into groundwater.

The information available on the potential for wetlands to recharge groundwater is contradictory. In a review of scientific studies that quantified the hydrologic functions of wetlands, Bullock and Acreman (2003) found 32 studies that documented that recharge occurs and 18 studies where no recharge was found. Adamus et al. (1991) conclude, from an extensive review of the literature, that four site-specific conditions determine how well a wetland performs this function:

- Groundwater flow rates under the wetland (linked to hydraulic conductivity)
- The storage capacity of the wetland (linked to the pressure head of water)
- Water movement within the wetland (linked to elevation relative to groundwater and hydraulic head)
- Evapotranspiration (linked to "pressure head" of water in the wetland)

These conclusions about these site-specific conditions were more recently confirmed by Hunt et al. (1996).

Adamus et al. (1991) were unable to find any patterns among wetland types or regions of the country. They also concluded that "for recharge, adjacent undeveloped uplands are usually, but not always, more important than wetlands." This conclusion was confirmed by Bullock and Acreman (2003).

Groundwater Recharge by Wetlands of Various Classes and in Different Regions

The characteristics within a wetland that result in the recharge of groundwater are the same for wetlands in both the eastern and western parts of the state. The potential for recharge in a wetland occurs when wetlands hold back precipitation and surface flows to create ponded areas. This ponded water then infiltrates into the groundwater system because of the "head" or pressure created by the depth of water on the surface. If the hydraulic head created by upslope groundwater is greater than the hydraulic head created by the ponded water, recharge will not occur (Adamus et al. 1991).

Groundwater recharge occurs only in a subset of **depressional wetlands** and some **riverine wetlands** that impound and hold surface water. Wetland types that do not impound surface water do not have the potential to recharge groundwater (Hruby et al. 1999, 2000, Hruby 2004a,b).

A new perspective on the function of supporting baseflow

One aspect of groundwater recharge that is often attributed to wetlands in Washington is called *baseflow support*. Wetlands are assumed to augment base flows in streams during the drier seasons because of the water they store. The information available, however, indicates this assumption is not valid in most cases, and in fact wetlands may reduce baseflow because of water lost through evapotranspiration. In a review of scientific studies that quantified the hydrologic functions of wetlands, Bullock and Acreman (2003) found that 49 out of 75 studies (2/3) conclude that wetlands reduce the flow of water downstream during dry periods. Only 16 studies conclude that wetlands sustain low flows and ten studies found that wetlands had no impact on low flows.

In Washington, the teams of experts that developed the methods for assessing functions and the rating systems concurred with the majority of studies (Hruby et al. 1999, 2000, Hruby 2004a,b). Surface outflow from wetlands was not judged to be an important factor in maintaining low flows in streams in Washington State. A wetland may be in a location where groundwater is discharged, but the source of this groundwater is not within the wetland itself. Thus, the discharge is not a function of the wetland; rather it is, as reported by Adamus et al. (1991), a function of the entire groundwater system.

Given the highly seasonal rainfall patterns in the region, the teams also judged that most surface water will be discharged into streams before the late summer when low flows as biologically the most critical. Water stored in the soils of wetlands was not considered to be a factor because of the types of soils present. Wetlands on alluvial soils would not hold water long enough into the dry season to support baseflow because they are so permeable (review in Bullock and Acreman 2003). On the other hand, wetlands with organic and peat soils would hold water and not release very much of it because the hydraulic conductivity is generally very low. The hydraulic conductivity of water in peat soils ranges between 0.000001 cm/sec to as high as 0.001 cm/sec (less than 3 ft per day) (Reeve et al. 2000) depending on the structure of the peat or the mineral soil.

2.6.3 Functions Related to Habitat

This section focuses on three aspects of wetlands as habitat:

- Structures and processes found within wetlands that make them an important habitat feature of the landscape
- The number and types of vertebrate species using wetlands in the Pacific Northwest
- Important features of wetlands that meet the habitat requirements of some groups of species that are closely associated with wetlands and that were modeled in the Washington State wetland function assessment methods

The discussion is not subdivided by wetland class or domain and region of the state because habitat requirements differ widely for various species. Furthermore, habitat requirements for a single species may even differ between locations (Adamus et al. 1991). Therefore, this literature review does not attempt to identify all the life requirements of all wildlife species that use wetlands in Washington. The intent of this synthesis is to identify some of the basic structures and processes in wetlands that are important habitat features.

2.6.3.1 The Use of Wetlands by Species of Wildlife

Animals use wetlands to varying degrees depending upon the species involved. Some live in wetlands for their entire lives; others require wetland habitat for at least part of their life cycles; still others use wetlands much less frequently, generally for feeding (Johnson and O'Neil 2001). Thus, species using wetlands are often grouped by their dependency on the habitat provided by wetlands, but unfortunately there is no consistency in the terms used to describe the dependency.

For example, Adamus et al. (1991) grouped species into two categories. *Wetland-dependent species* are those that: "(a) normally use wetlands exclusively for food and cover throughout most of their U.S. range and spend most of their lifetime within wetlands, or (b) would be extirpated from a large region if all wetlands were to be filled." The latter case includes species that may use wetlands for only part of their life cycles such as amphibians and many insects. The larvae of amphibians and many insects are aquatic even though the adults migrate out of the wetlands. The species are still considered to be wetland dependent because they could not survive without the presence of wetlands. *Wetland users* are those species that use wetlands for occasionally obtaining some life requirements such as sources of drinking water, winter cover (e.g., white-tailed deer and ring-necked pheasants), or dispersal centers within urban areas (e.g., opossum) (Adamus et al. 1991).

Adamus et al. (1991) also state the following about how species use wetlands:

> *The degree of dependence by any given species on wetlands often varies greatly depending on the abundance and distribution of wetlands and on suitable alternative habitats within the region. For example, urban wetlands and riparian wetlands in the arid Southwest support species that, in other parts of their ranges, are much less likely to inhabit wetlands.*

The Washington State wetland function assessment method uses the terms *wetland dependent* for western Washington (Hruby 1999) and *wetland associated* for eastern Washington (Hruby 2000). More recently, Johnson and O'Neil (2001) have developed a grouping based on three categories that are specific to wildlife in Washington and Oregon that is based on the consensus of numerous experts in the region. These authors use the terms *closely associated*, *generally associated*, and *present* when describing the relationship between species and wetlands, and these are defined as follows:

- *Closely Associated* – A species is widely known to depend on a habitat for part or all of its life history requirements. Identifying this association implies that the species has an essential need for this habitat for its maintenance and viability.

- *Generally Associated* – A species exhibits a high degree of adaptability and may be supported by a number of habitats. In other words, the habitat plays a supportive role for its maintenance and viability.

- *Present* – A species demonstrates occasional use of a habitat. The habitat provides marginal support to the species for its maintenance and viability.

2.6.3.2 Characteristics that Make Wetlands Important as Habitat

Wetlands are among the most productive ecosystems in the world, comparable to rain forests and coral reefs (Mitsch and Gosselink 2000, Sipple 2002). As a result, wetlands support numerous species from all of the major groups of organisms—from microbes to mammals (Sipple 2002). The support they provide for these organisms includes sources of food, shelter, and refuge. All of these aspects are generalized by the term *habitat*.

General reviews of wetlands as habitat (Adamus et al. 1991, Mitsch and Gosselink 2000) conclude that physical and chemical characteristics (factors that control the suitability of a wetland as habitat) determine what plants and animals inhabit various wetlands, including:

- Climate
- Topography (landscape shape)
- Geology
- Nutrients
- Hydrologic regime (quantity and movement of water)

In addition, some of the larger organisms such as beaver and muskrats manipulate wetlands to create habitat suitable for themselves and other organisms, such as fish, amphibians, waterfowl, insects, and other mammals (Mitsch and Gosselink 2000).

Four general ecological features contribute to species richness and abundance in a landscape (Knutson and Naef 1997):

- Structural complexity
- Connectivity with other ecosystems
- Abundant food source and available water
- Moist and moderate microclimate

Wetlands have all of these attributes, especially wetlands that are linked to riparian areas and floodplains. The following sections describe each of these features in more detail.

Structural Complexity

Structural complexity is a term used to represent the variety of environmental characteristics that increase the number of niches for wildlife (Knutson and Naef 1997). These characteristics can include biological features such as a high richness of plant species or physical features such as open water, rocks, and mudflats. The interspersion in wetlands between open water and vegetation, or between types of vegetation, is important because the edges created between these elements (see Figure 2-10) increase the number of niches present (Adamus et al. 1991). Wetlands also often contain different vegetation communities within their boundaries that add structure (and therefore niches). For example, a higher interspersion of plant types in wetlands is likely to support a higher diversity of invertebrates (Dvorak and Best 1982, Lodge 1985).



Figure 2-10. Features of wetlands that increase structural complexity. This wetland has open water and plants of different heights and different types (woody, herbaceous, aquatic bed) as well as snags and woody debris.

Riparian wetland systems in the semi-arid West often provide the only structurally complex habitat in regions dominated by open land or land cleared for agriculture (Adamus et al. 1991). This has also been found to be true in the semi-arid areas of eastern Washington, especially in the areas where rainfall is less than 12 inches per year (Hruby et al. 2000). Figure 2-11 shows a wetland with high structural complexity in the semi-arid terrestrial environment of eastern Washington that otherwise does not have much complexity.



Figure 2-11. Depressional wetland in the Columbia Basin. A structurally complex ecosystem in a terrestrial environment with low complexity. The average annual rainfall at this site is 8 inches per year.

Connectivity to Other Natural Resources

Many wetlands are linked to other aquatic or terrestrial resources by surface water, riparian corridors, or by relatively undisturbed vegetated corridors. Riverine wetlands form part of riparian corridors, depressional wetlands may be part of a small stream system or may be linked by surface water, and lacustrine fringe wetlands are connected to adjacent lakes. The role that corridors play in maintaining biodiversity, however, is very complex. For some species corridors are essential to maintain populations and genetic exchange (Kauffman et al. 2001, Haila 2002, Fahrig 2003). In other cases they may reduce populations of some species because they facilitate the movement of predators or invasive species (review in Fahrig 2003). See Chapters 3 and 4 for further discussion of habitat connectivity and corridors to both aquatic and terrestrial habitats.

Abundant Food Sources

The wet and moist microclimate of wetlands and their rich soils lead to the enhanced growth of plants. Wetlands are known for their high primary productivity (production of plant material) and the subsequent movement of this "food" to adjacent aquatic ecosystems (Mitsch and Gosselink 2000).

"Wetlands can be thought of as biological supermarkets" (Sipple 2002). For example, the number of invertebrates in small seasonal wetlands can exceed 700,000 animals per square meter (Leeper and Taylor 1998). Many of these invertebrates serve as food for larger predatory amphibians, reptiles, fish, birds, and mammals (Wissinger 1999).

Moist and Moderate Microclimate

The presence of water and thick vegetation in wetlands results in a microclimate that is generally more moist and that has milder temperature extremes than the surrounding areas. These conditions provide a habitat that is desirable to many species, particularly amphibians, ungulates, and other large mammals during hot, dry summers and severe winters (Knutsen and Naef 1997).

2.6.3.3 Use of Wetlands by Vertebrates in Washington

Wetlands in the state have been shown to be critical in maintaining regional biodiversity. Although wetlands represent only 2.1% of the area of the state (Dahl 1990), over two-thirds of all terrestrial vertebrate species in Washington can be considered "wetland users" (Knutson and Naef 1997, Kaufmann et al. 2001). A comprehensive review of wildlife in Washington and Oregon (Johnson and O'Neil 2001) provides a compilation of all wildlife species found in Washington and the different habitats in which they are found. Of the 32 types of habitat identified in the review, four are specific to wetlands. Table 2-7 lists the four types of wetland habitats identified in the compilation and the number of wildlife species found in each type. Appendix 2-B lists all the species found in each type of wetland as compiled in the review.

Table 2-7. Number of wildlife species by type of wetland habitat and by their association. From O'Neil and Johnson 2001. See Appendix 2-B for definitions of the types of wetlands.

Habitat Type	Total	Closely Associated	Associated	Present	Unsure
Herbaceous wetland	228	105	90	31	2
Westside Riparian-Wetlands	256	74	145	35	2
Montane Coniferous Wetlands	148	17	101	28	2
Eastside Riparian-Wetlands	271	81	149	36	5

Reptiles and Amphibians

There are 59 species of reptiles and amphibians in Washington and Oregon. Two species of reptiles, the western pond turtle (*Clemmys marmorata marmorata*) and the painted turtle (*Chrysemys picta*), are wetland dependent. Many more species of reptiles are wetland users. On the other hand, all but one species of amphibians are wetland dependent and require an aquatic habitat for part of their life cycle (Kauffman et al. 2001). Figure 2-12 shows how many of the 59 species of reptiles and amphibians in the two states are found in three of the four types of wetland habitat.

In Figures 2-12 to 2-14 the data are from (Kauffman et al. 2001). The lists of actual species in each type of habitat and the definitions of each type of habitat are summarized in Appendix 2-B.

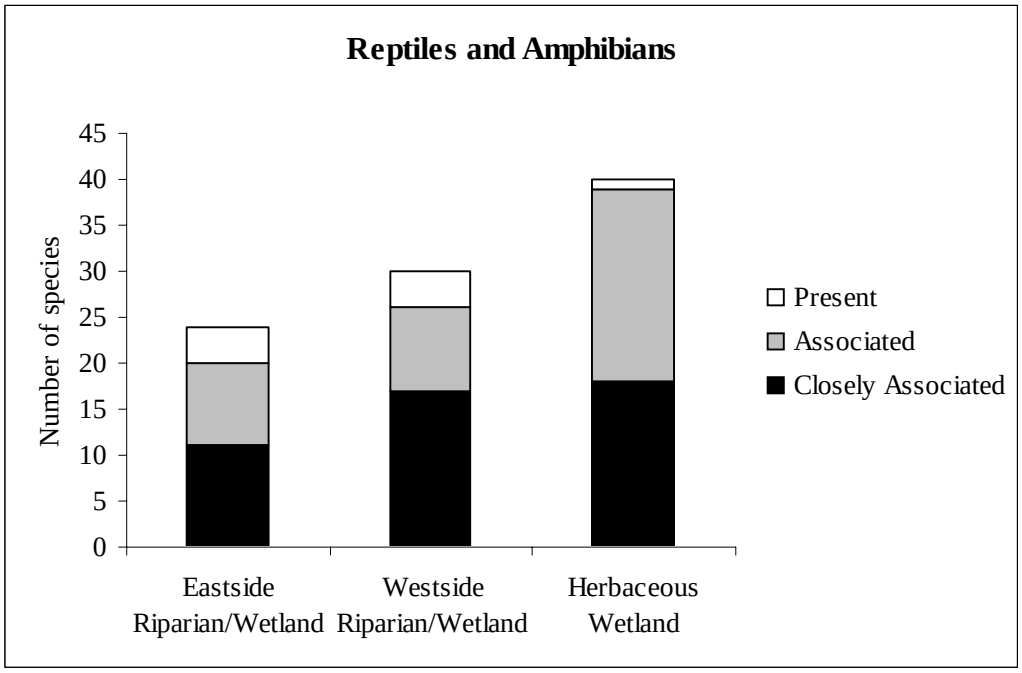


Figure 2-12. The number of reptile and amphibian species found in wetlands in Washington and Oregon. (from Kauffman et al. 2001)

Birds

Overall, 266 (72%) of the 367 species of birds in Oregon and Washington use freshwater, riparian, and wetland habitats. More striking, 204 (77%) of the 266 species of inland birds that breed in the two states do so in wetland environments (Kauffman et al. 2001). Figure 2-13 shows the number of bird species that use three types of wetlands in the region.

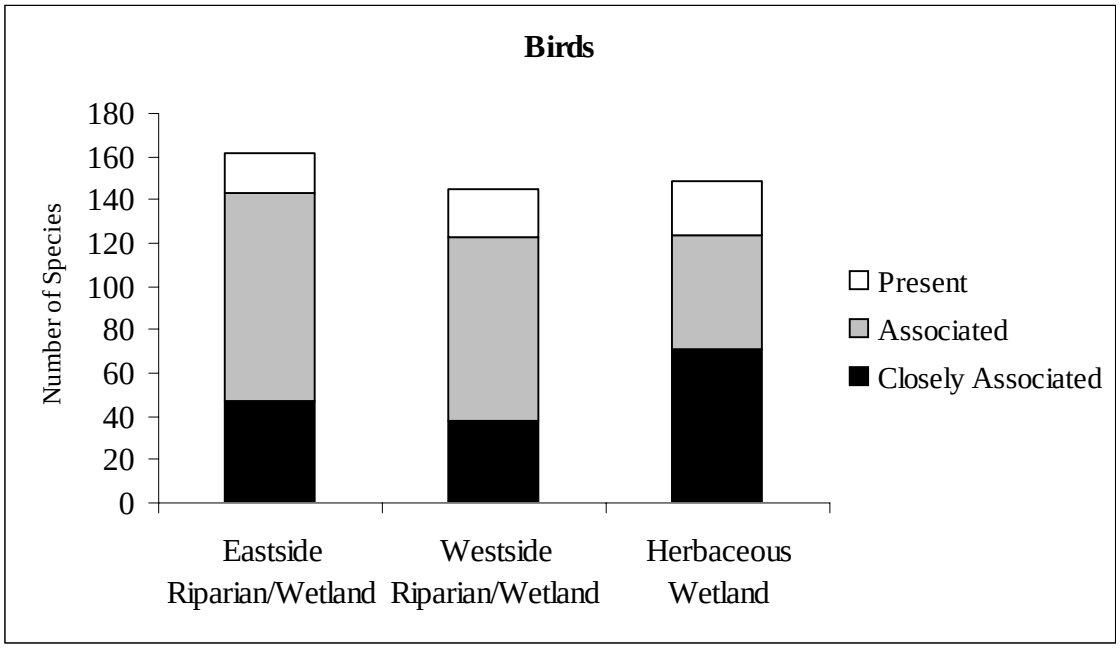


Figure 2-13. The number of bird species found in wetlands in Washington and Oregon (from Kauffman et al. 2001).

Mammals

Ninety-five of the 147 mammal species (65%) in the two states use the riparian/wetland ecosystem (Kauffman et al. 2001). All the "furbearers" (e.g., mink, otter, beaver, raccoon, etc.) use these habitats, and all but one of the big game animals (deer, elk, moose, etc. with the exception of bighorn sheep) rely on these areas for part of their habitat requirements. Figure 2-14 shows the number and degree of association of mammals to the three types of wetland habitats considered in Kauffman et al. (2001).

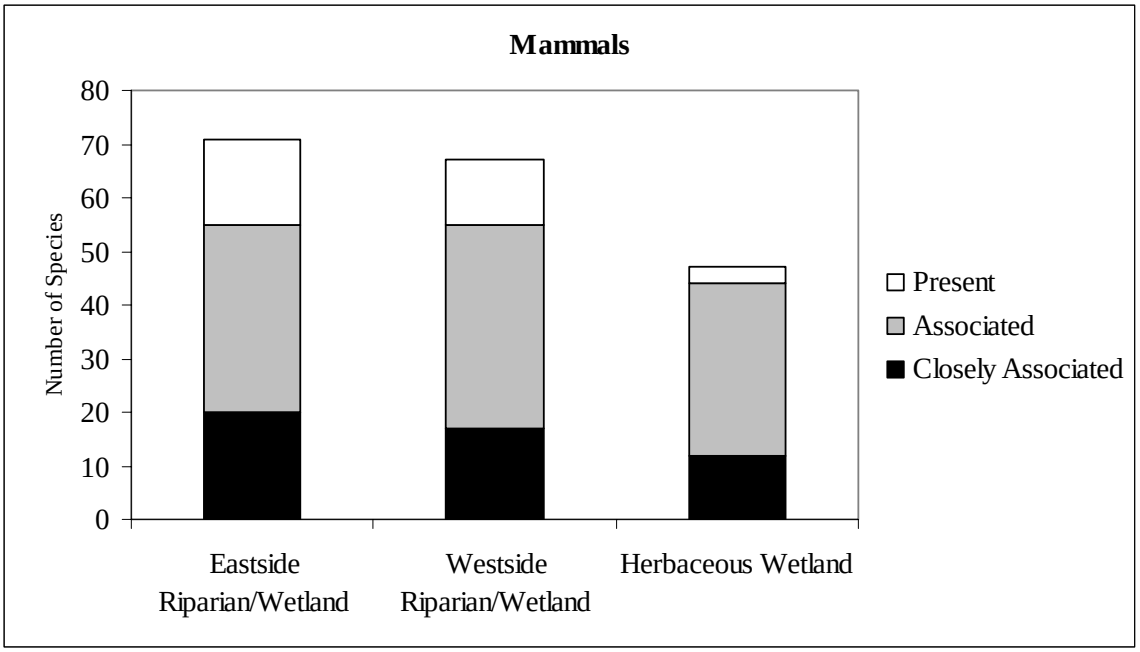


Figure 2-14. The number of mammal species found in wetlands in Washington and Oregon (from Kauffman et al. 2001).

2.6.3.4 Habitat Requirements of Some Wetland-Dependent Species in Washington

Invertebrates

Invertebrates have evolved unique adaptations enabling them to occupy most wetland habitats and most parts of the food web. In fact, wetland invertebrates can be distinguished from terrestrial and aquatic species at multiple taxonomic levels (family and genus) (Wissinger 1999). Wetlands are dominated by invertebrate families that are uniquely adapted to shallow and often fluctuating water levels (Wissinger 1999).

Wetland invertebrates are considered pivotal components of the food webs in wetlands (Mitsch and Gosselink 2000). As filter feeders, shredders, and scrapers, insects convert microorganisms and vegetation into biomass, providing much of the food for animals higher in the food web (secondary and tertiary consumers). Research focusing on aquatic invertebrates in wetlands indicates the importance of invertebrates in energy and the transfer of nutrients within aquatic

ecosystems (Rosenberg and Danks 1987, Wissinger 1999). Invertebrates have adapted to processing the plant material produced in wetlands of every type and geomorphic setting. They are considered a major link in the movement of energy in the food web of wetlands (review in Wissinger 1999).

The abundance of invertebrates in wetlands can be extremely large. Leeper and Taylor (1998) measured annual densities in excess of 700,000 organisms per square meter in shallow depressional wetlands of South Carolina.

Factors found to influence the distribution, richness, and abundance of invertebrates in wetlands include the following:

- **Water interspersed with stands of emergent vegetation** in wetlands result in high species richness of invertebrates (Voigts 1976).
- **Decaying wood** provides an important habitat for invertebrates (Maser et al. 1988).
- A **mix of plant assemblages** exhibits greater richness of invertebrate species than a single assemblage (Andrews and Hasler 1943, Dvorak and Best 1982, Lodge 1985, Balla and Davis 1995). Furthermore, the density of invertebrates varies considerably among species of submerged aquatic plants (Murkin and Batt 1987), and different invertebrate species are found on different plant species (Cyr and Downing 1988). Vegetation is a major factor shaping wetland invertebrate communities (Krieger 1992, Wissinger et al. 1999).
- **Permanent flowing water** is a habitat feature that supports a unique assemblage of invertebrate species (Needham and Needham 1962, Wiggins et al. 1980, Rolauffs et al. 2001). Furthermore, the invertebrates in flowing permanent channels are an important resource for many other aquatic species such as fish (Needham and Needham 1962).
- **Marked seasonal changes in water regime** in wetlands result in higher richness of invertebrate species compared to wetlands with little water level fluctuation (Balla and Davis 1995).
- **Water regime** in wetlands is an important factor for individual species of invertebrates. Factors associated with water regime include: permanence of surface water, predictability of drying and filling, seasonal timing of drying and filling, duration of dry and wet phases, and the harshness during dry and wet phases(temperature, salinity, oxygen levels) (reviewed in Wissinger 1999).

Not much is known about invertebrate distributions in different soil surfaces within a wetland. However, data from rivers, streams, and lakes show that the local invertebrate species have preferences for specific surfaces (Gorman and Karr 1978, Dougherty and Morgan 1991). In streams it is well known that the composition of midges (chironomids) is strongly affected by characteristics of the sediment surface (McGarrigle 1980, Minshall 1984).

Amphibians

Amphibians are a vertebrate group that, in the Pacific Northwest, includes wetland-breeding frogs and salamanders. Both the richness and abundance of amphibians in wetlands indicate that they

are important in wetland food webs (Leonard et al. 1993, Hruby et al. 1999). Some native species only breed for a short time in wetlands and then live in uplands as adults. Other species are found in or close to wetlands throughout the year. However, the eggs and larvae of all wetland-breeding species require water for development (Hruby et al. 1999).

Other information known about amphibians in wetlands includes the following.

- The **presence of buffers and undisturbed uplands and forest cover** leading to other wetlands or to upland habitat is critical. Relatively undisturbed migration routes between a wetland and upland feeding and hibernation sites are important for many amphibian species (Heusser 1968, Berven and Grudzien 1990, Beebee 1996). Moreover, dispersal routes for recolonization are critical when populations are eliminated by random processes including drought (Pounds and Crump 1994), disease (Bradford 1991), or pollution (K. Richter, PhD. personal communications 2000), or when populations produce insufficient offspring to permanently occupy a site (Gill 1978a, 1978b, Sinsch 1992). Finally, inbreeding is minimized when the amphibians within a wetland are members of a population that extends across several wetlands (Gulve 1991, 1994, Pechmann and Wilbur 1994).

- **Conditions in the buffers** of a wetland are especially important in providing cover to amphibian females and to newly metamorphosed animals. Female red-legged frogs (*Rana aurora*), Northwestern salamanders (*Ambystoma gracile*) (K. Richter, PhD. personal communication, 2000), and long-toed salamanders (*A. macrodactylum*) (Beneski et al. 1986, Leonard and Richter 1994) generally wait in buffers near wetlands until environmental and biological conditions are favorable to spawning. They then enter wetlands during one or a few nights to spawn, thereafter quickly retreating to the cover provided by buffers. Buffers are important to the tiger salamander (*A. tigrinum,* a species found in eastern Washington) seeking shelter in rodent burrows during the first days following emigration from ponds in which they are born (Loredo et al. 1996).

- Most species of amphibians select **areas with interspersed vegetation and exposed water** in which to lay eggs (K. Richter, PhD. personal communication 2000). Most species of amphibians generally avoid both exposed water and densely vegetated sites, instead selecting habitats with an interspersion of both features (Strijbosch 1979, Ildos and Ancona 1994).

- **Stable water levels** provide optimum habitat conditions for amphibians from spawning through hatching. Water level fluctuations are known to have a significant influence on amphibians (Richter 1996, 1997). Most species of amphibians in temperate climates minimize exposure of eggs to fluctuating depths and temperatures by both spawning at mid-depth and by submerging eggs below the surface (Richter 1997). Amphibian egg development also depends on permanent or partial submergence. In most Puget Sound species stable water levels occurs from mid-December through mid-May. Although mean water level fluctuations exceeding approximately 8 inches (20 cm) have been correlated to decreased amphibian richness in wetlands , experiments by Azous and Richter (1995) suggest that extended drops of more than approximately 3 inches (7 cm) from the time of egg laying through hatching may harm the Northwestern salamander.

- **Vegetation structure**, particularly plant shape and stem diameter, rather than the species of the plant has been suggested to be most important to salamanders. Wetland surveys and controlled field studies of several Northwest salamanders confirm that distinct stem widths are preferred (Richter 1997).

Anadromous Fish

Anadromous fish are those that spend all or part of their adult lives in salt water and return to freshwater streams and rivers to spawn. There are 12 species of anadromous fish in the Pacific Northwest (PSMFC 2001), but not all are regular users of wetlands.

The Pacific Northwest salmonids (species of the genus *Oncorhynchus*) have recently been the focus of much research because of the status of some species as threatened or endangered. The most common anadromous species that uses wetlands is the coho salmon (*Oncorhynchus kisutch*). Other anadromous fish noted in wetlands found in side channels, or old oxbows, of rivers and streams (off-channel wetlands) include cutthroat trout (*O. clarki*) and steelhead (*O. mykiss*) (Peterson 1982).

It is not the intent of this review to summarize all the information available on the habitat needs of salmonids. Some of the most important habitat structures in wetlands that have been found to be important for anadromous fish are summarized below:

- The **presence of ponded or impounded surface water** that is either seasonal or permanent is critical. "Slope" wetlands in Washington are the only class of wetlands that do not have the potential to provide habitat for anadromous fish because, by definition (Brinson et al. 1995) they do not have ponded or impounded surface water that is either seasonal or permanent.

- A wetland must have a **surface water connection** to a salmon-bearing stream or river if fish are to enter or exit the wetland (Hruby et al. 1999).

- **Interspersion between land and water** in a wetland is important because the contact zones between exposed water and vegetation provide protection from wind, waves, and predators, and may provide natural territorial boundaries (Golet and Larson 1974).

- Anadromous fish need a certain **water depth** for optimum habitat conditions. Narver (1978) observed juvenile coho moving into areas with water depth over approximately 18 inches (45 cm) and lower velocities (6 inches [15 cm] per second) when temperatures decline below approximately 41^{o}F (7^{o}C). Beaver ponds and off-channel areas with similar depths also provide habitat (Reeves et al. 1989). Survival and growth of overwintering fish may be maximized in systems that contain both shallow pools and deeper ones (Peterson 1982).

- **Cover** provided by wetlands is important for salmonids**.** Overhanging vegetation provides both temperature control and protection from predation. McMahon (1983) reported the need for streamside vegetation for shading. Small coho juveniles tend to be harassed, chased, and nipped by larger juveniles unless they stay near the bottom, obscured by rocks

or logs (Groot and Margolis 1991). Cover for salmonids in wetlands can be provided by (Giger 1973):

- Overhanging vegetation
- Submerged vegetation
- Submerged objects such as logs and rocks
- Floating debris
- Deep water
- Turbulence
- Turbidity (the assumption seems to be that cloudy water reduces the visibility of fish in open water where birds may prey on them)

Resident Fish

Fish that do not migrate out of wetlands are considered "resident fish." Many different fish species use wetlands and it is not practical to list all that occur in Washington's wetlands.

Before the late 1800s, the only resident freshwater game fish living in Washington State were trout, char, whitefish, burbot, and squawfish. Since then there has been a widespread and often indiscriminate introduction of game species from other parts of the nation (Washington State Department of Fish and Wildlife 1999b).

Some of the characteristics in wetlands that provide habitat for resident fish include the following.

- Resident fish, like anadromous fish, need a **range of water depths** for different parts of their life cycles (Hruby et al. 1999). Shallow waters provide refuge for young fish, while the deeper waters provide refuge for the larger adults. Varying water depths also provide different potential food sources since they are host to different populations of plants and invertebrates (see the earlier discussion of invertebrate habitat). Olympic mud-minnows rear in wetlands with water only a few inches deep in floodplains (R. Ziegler, Washington State Department of Fish and Wildlife, personal communications 2003).
- **Shorelines between exposed water and vegetation** provide protection from wind, waves, and predators, and may provide natural territorial boundaries (Golet and Larson 1974).
- **Overhanging vegetation** provides both temperature control and protection from predation (McMahon 1983).
- **Large woody debris** plays an important role in the Pacific Northwest, creating and enhancing fish habitat (Bisson et al. 1987).

Birds That Are Closely Associated With Wetlands

Bird species that are *closely associated* with wetlands are those that depend on part or all of its life requirements; these include food, shelter, breeding, or resting. Kauffman et al. (2001)

reviewed the literature and found a very high richness and abundance of birds in wetlands of the Pacific Northwest. They found that:

> *All 23 species of waterfowl that breed regularly in the western U.S. south of Alaska do so in riparian and wetland environments. Similarly, all 14 western species of waders, a group consisting of cranes, rails, herons, and ibises, depend on riparian and wetland habitats for most of their life cycles. Shorebirds, which include stilts and avocets, sandpipers, and plovers are typically dependent on freshwater, riparian, and wetland habitats. Interior wetlands (i.e., east of the Cascades) also provide crucial stopover habitat for 37 species during migration.*

A review of the specific habitat requirements of all birds using wetlands is beyond the scope of this document. General characteristics of wetlands and their buffers that provide good habitat for wetland-dependent birds include the following:

- The **condition of the wetland buffer** is an important characteristic for bird habitat. Trees and shrubs provide screening for birds, as well as providing additional habitat in the buffer itself (Johnson and Jones 1977, Milligan 1985).

- The **width of the buffer** as well as its condition is important (see Chapter 5 for a more detailed discussion of the use of buffers by birds).

- **Snags** are a source of cavities and perches for wetland-associated birds. Several species of birds use already existing cavities for nesting and/or refuge locations. Dead wood attracts invertebrates and other organisms of decay, which in turn provide a food source for many species of birds (Davis et al. 1983).

- Some bird species may require **several habitat types** such as open water and grasslands in close proximity to aid their movements from one type to another (Gibbs et al. 1991, Hunter 1996).

- **Embayments and peninsulas** in a wetland with open water provide "micro-habitats" for certain species that require hiding cover or those seeking security within a more enclosed system (U.S. Department of the Interior 1978).

- The **proximity of a wetland to open water or large fields** increases its utility to migrant and wintering waterfowl. If there is strong connectivity between relatively undisturbed aquatic areas, the suitability of a wetland as waterfowl habitat increases (Gibbs et al. 1991).

- **Open water of varying depths** provides greater diversity of foraging habitat for a greater variety of water birds (U.S. Department of the Interior 1978).

- A **full canopy can limit access** to open water in a wetland because birds have difficulty flying in and out. This may be best illustrated by great blue herons (*Ardea herodias*), which will be reluctant to fly down to a body of water if the tree canopy above is totally closed because rapid escape may be difficult or impossible (U.S. Department of the Interior 1978).

Mammals That Are Closely Associated With Wetlands

For the purpose of this review it is not practical to synthesize the specific habitat requirements of all mammal species using wetlands. The richness of mammal species using wetlands can be very high. Kauffman et al. (2001) report that 79 mammal species east of the Cascades and 69 on the west side use riparian wetlands. The wetlands associated with stream corridors characteristically have greater species richness than upland sites and provide habitat for some species that are not found elsewhere. About half of the species using riparian wetlands in the Pacific Northwest breed and feed in them (Kauffman et al. 2001.)

The following bullets summarize some general information about the characteristics of wetlands that provide good habitat for four mammal species that were modeled as wetland dependent in the Washington State methods for assessing functions (Hruby et al. 1999). These species include the beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), river otter (*Lutra canadensis*), and mink (*Mustela vison*).

- Wetlands with a **relatively undisturbed buffer** are important to these four species (and others) because the buffers:
  - Minimize disturbance (Allen and Hoffman 1984, Burgess 1978)
  - Provide habitat for prey species and food sources for mammals (Allen 1983, Dunstone 1978, Brenner 1962)
  - Provide cover from predators (Melquist et al. 1981)
  - Allow den sites for resting and reproduction (Allen 1983)
- Beavers prefer a **seasonally stable water level** (Slough and Sadleir 1977). Large fluctuations in water levels may also affect the suitability of a wetland for muskrats (Errington 1963). Wetlands subject to heavy spring runoff or flash floods that rapidly raise the water level may cause flooding of burrows (Errington 1963).
- For beavers and muskrats, **water depth must be of sufficient depth. For beavers the water must be deep enough** to accommodate lodges and bank dens and to allow free movement from the lodge to food caches during the winter. For example, freezing of the food cache is a limiting factor on beaver and muskrat survival in the Columbia Basin (J.Tabor, Washington State Department of Fish and Wildlife, personal communication 2000). Freezing of a pond to the bottom can be disastrous to muskrat populations (Schmitke 1971). Deep water will also provide protection from predators (Easter-Pilcher 1987). In the Columbia Basin beavers and muskrats need at least 4 feet (1.3 m) of permanent water to allow access to food caches during the winter when the surface is frozen (Hruby et al. 2000).
- **Vegetated corridors** leading to and from wetlands are considered an important feature in assessing the suitability of a wetland as habitat for wetland dependent mammals (Hruby et al. 2000). Dispersal is a fundamental process in regulating populations among these and other mammals (Kauffman et al. 2001).

- Muskrats and beavers use **persistent emergent cover** for security and feeding (Errington 1963). Allen (1983) believes that beavers prefer herbaceous vegetation over woody vegetation during all seasons, if available.

- **Interspersion of vegetation and open water** is an important characteristic of wetlands as habitat for mammals. High interspersion rates increase the abundance of prey for mink and river otter (i.e., muskrats, water birds, fish) (King 1983). Food abundance and availability appeared to have the greatest influence on habitat use by river otter in Idaho in studies by Melquist and Hornocker (1983). Classic studies of muskrats by Dozier (1953) and Errington (1937) indicate that optimum muskrat habitat is 66% to 80% of the wetland in emergent vegetation with the remainder in open water.

2.6.3.5 Habitat for Plants

Relatively few plant species of the thousands on Earth have adapted to the harsh conditions in wetlands. Major stressors are lack of oxygen, salt, and water level fluctuations in an environment that is neither fully aquatic nor terrestrial (Mitsch and Gosselink 2000). These strong selective pressures have produced a group of plant species that is unique to wetlands and whose maintenance has become an issue in regional biodiversity (Gibbs 2000). Furthermore, wetlands can provide habitat for a wide range of other plant species when conditions are not as harsh. Of the 2969 plant species found in Washington, 1515 (or 51%) have been found in wetlands (FEMAT 1993).

All wetlands provide the four basic requirements for plant growth (space, water, light, and nutrients) to some degree. Differences can be found among wetlands in the number of plant species they contain. Recent research has been focused on the characteristics of wetlands that affect plant richness, as summarized below:

- **Specific water regimes**, such as permanent inundation, seasonal flooding, or saturation, result in unique plant communities (Mitsch and Gosselink 2000).

- The **duration of individual flooding events** is important in separating plant communities because the duration affects germination of seeds in different ways (Casanova and Brock 2000).

- The **water regime** in a wetland can either limit the number of species present or enhance it, depending on types of water level fluctuations and physical energy of the water regime (Mitsch and Gosselink 2000).

- Plant richness in a wetland generally follows the ecological theory that maximum richness occurs at **intermediate levels of environmental stress** (Johnson and Leopold 1994). For example, water level fluctuation is an environmental stress (Mitsch and Gosselink 2000). Wetlands with large water level fluctuations, therefore, would be expected to have fewer plant species than those with moderate water level fluctuations. On the other hand, wetlands with very small water level fluctuations (low stress) would also be expected to have fewer plant species.

- Wetlands with **different water depths** tend to have higher richness than those with fewer (Hruby et al. 1999). Observations show that the distribution of species within a wetland is primarily a function of water depths (Spence 1982 as cited in van der Valk et al. 1994).

- The **proximity of other wetlands** as a source of seed (Brock et al 1994, Brown 1998).

2.6.3.6 Supporting Food Webs (Primary Production and Export)

Wetlands are known for their high primary productivity (i.e., production of plant material) and the subsequent export of this organic matter to adjacent aquatic resources. The exported organic matter provides an important source of food for most downstream aquatic ecosystems (Mitsch and Gosselink 2000).

Plant material produced in wetlands breaks down into smaller and smaller particles and becomes increasingly nutritious due to the activity of bacteria, fungi, and protozoa (Sipple 2002). This decomposed plant material, including the various microbes that colonize it, feeds many small aquatic invertebrates and small fish. These invertebrates and fish then serve as food for larger predatory amphibians, reptiles, fish, birds, and mammals (Sipple 2002).

The following summarizes general characteristics of wetlands that have high production and provide excellent support for aquatic food webs.

- In general, wetlands **where water flows through the system** have higher levels of primary production and export than those where water is impounded without leaving (Mitsch and Gosselink 2000).

- The **water level fluctuation** as well as movement of water mentioned above through the wetland and its **soils** is one of the most important determinants of primary productivity (Mitsch and Gosselink 2000).

- Performance of this function requires both that **organic material** is produced and that a mechanism is available to move the organic matter to adjacent or contiguous aquatic resources (Hruby et al. 1999).

2.6.4 Summary of Key Points

- The residence time of water in the wetland and filtering by wetland vegetation are major processes influencing removal of sediments, phosphorus, and toxics from surface water. Wetland vegetation typically removes 80% to 90% of sediment from runoff. Wetlands with seasonal inundation or saturation have conditions that promote removal of nitrogen from surface runoff. In order for a wetland to provide functions that improve water quality, however, surface water containing pollutants must first enter the wetland.

- The capacity of a wetland to store surface water affects its ability to reduce peak flows, as do the amount of flow from the upper watershed that enters the wetland and the amount of woody vegetation present. Reducing peak flows helps to decrease downstream erosion.

- Only wetland types that impound surface water have the potential to provide groundwater recharge.
- Wildlife species can be *wetland dependent* or *wetland users*. Wetland-dependent species (such as amphibians) require a wetland for at least part of their life cycles. Wetland users (such as deer) come to wetlands for such needs as water or cover.
- The characteristics of wetlands that provide habitat depend on species and life stage. Characteristics that are important for many species include vegetation structure, water depth, water level fluctuation, buffers, snags, and connections to other habitats and wetlands in the landscape.
- Wetlands have high productivity of plant material. Decomposed plant material can be exported downstream, providing food for insects, fish, and other organisms in the food web.

2.7 Chapter Summary and Conclusions

The functions of wetlands are things that wetlands "do." They represent the many interactions possible among the different components of the environment found in wetlands. There are many interactions that occur in wetlands and they occur at many scales. In general, however, functions are grouped into three broad categories: 1) biogeochemical interactions, 2) hydrologic interactions, and 3) interactions that maintain food webs and habitats for plants and animals.

The primary factors that control wetland function are climate, geomorphology, the source of water, and the movement of water. These factors affect wetland functions directly or through a series of secondary factors including nutrients, salts, toxic contaminants, soils, temperature, and the connections created between different patches of habitat. The factors that control wetland functions interact with each other and there are many feedback loops. A number of conceptual models have been developed to help visualize and understand the complexity of the interactions between environmental factors, environmental processes, and wetland function.

The major environmental factors of geomorphology, source of water, and the movement of water are the basic characteristics used to classify wetlands in Washington into groups of wetlands that have similar functions. These groups can be expected to perform these functions in similar ways. Freshwater wetlands in Washington are divided, based on how they function, into two domains, five regions, and six classes.

The environmental factors that control the structure and functions of a wetland occur at both the landscape scale and the site scale. For example, riverine wetlands will be affected to a great degree by processes operating at the scale of the entire watershed of the river. Depressional wetlands will be subject to processes that occur only within the basin that contributes surface or groundwater to the wetland.

The most important factors that control functions at an individual site may occur somewhere else in the landscape. Information about factors that control functions at the larger scale is still evolving. The importance of the environmental factors that occur at the larger, landscape scale,

however, should not be minimized for lack of information. Ongoing research is continually strengthening our understanding of these critical factors.

The links between wetland functions and the landscape have been well described by the National Academy of Sciences (National Research Council 1995):

> *Individual wetlands function to a large degree through interaction with the adjacent portions of the landscape and with other wetlands. For example, wetlands whose principal source of water is groundwater depend on that water infiltrating in the surrounding uplands. If these uplands are paved, clear-cut, or farmed, the amount of water recharge is significantly reduced and the wetland may dry up or become smaller. No single wetland or aquatic site could support anadromous fish. The connections between individual wetlands, aquatic systems, and terrestrial systems are critical to the support of many species. Furthermore, flood control and pollution control are determined by the number, position, and extent of wetlands within watersheds. Thus, the landscape gives proper context for the understanding of some wetland functions.*

An understanding of wetland functions for the purposes of managing and protecting them will require knowledge of how the major controls of functions change or are impacted by humans at all scales. We need to understand how climate, topography, and the movement of water, nutrients, sediment, etc. are affected by human activities in the entire watershed, as well as in the immediate vicinity of the wetland. Chapter 3 describes the environmental disturbances caused by different human uses of the land. Chapter 4 then carries this information forward to discuss how the disturbances caused by human activities affect specific functions of wetlands.

Chapter 3

Environmental Disturbances Caused by Human Activities and Uses of the Land

3.1 Reader's Guide to this Chapter

In Chapter 3, the discussion shifts from wetland functions and the environmental factors that control the performance of functions to the major disturbances created by human activities and uses of the land and water. In this context, a *disturbance* is an event that changes an environmental factor that controls wetland functions.

3.1.1 Chapter Contents

Major sections of this chapter and the topics they cover include:

Section 3.2, Introduction to Human-Caused Disturbances provides an overview of how human land uses change the dynamics and structure of the ecosystems by creating various types of disturbances. The section provides a general overview of how human activities affect the movement and quality of water and connections between habitats across the landscape.

The chapter continues with separate sections for four of the major types of human land uses in Washington State (agriculture, urbanization, logging, and mining) and how they cause disturbances. The different uses of the land by humans are divided into these four categories because most of the literature found discusses the disturbances and impacts of human activities in these terms.

Each major land use is addressed in a separate section, as follows:

Section 3.3, Disturbances Caused by Agriculture, discusses the changes in the physical structure of wetlands such as conversion to fields or pasture, changes in water regime such as changes to the amount and fluctuation of water, and the input of nutrients, salt, sediment and contaminants caused by agriculture.

Section 3.4, Disturbances Caused by Urbanization, discusses the changes urbanization has made, causing a loss of wetlands as well as changes to the water regime in watersheds. It describes how this land use has resulted in sedimentation, increase in nutrients, input of contaminants, and fragmentation of habitat.

Section 3.5, Disturbances Caused by Forest Practices, refers the reader, after a brief summary, to another synthesis that summarizes the literature on the disturbances created by logging.

Section 3.6, Disturbances Caused by Mining, discusses the increased level of heavy metals and acidity in surface waters that results from mining.

Section 3.7, Chapter Summary and Conclusions, ties together the major concepts presented in the chapter in a tabular form. Also, the disturbances caused by each of the four land uses are summarized.

3.1.2 Where to Find Summary Information and Conclusions

Each major section of this chapter concludes with a brief summary of the major points resulting from the literature review on that topic in a bulleted list. The reader is encouraged to remember that a review of the entire section preceding the summary is necessary for an in-depth understanding of the topic.

For summaries of the information presented in this chapter, see the following sections:

- Section 3.2.6
- Section 3.3.11
- Section 3.4.9

As previously mentioned, Section 3.7 provides a summary and conclusions about the main themes synthesized from the literature and presented in this chapter.

3.1.3 Sources and Gaps in Information

There is abundant data on some of the topics related to wetlands and the effects of land uses on water quantity, water quality, and some habitat issues. For example, the Puget Sound Wetlands and Stormwater Management Research Program was one important source of scientific information on how changes in land uses affect the physical, chemical, and biological factors that control wetland functions in the lowlands of Puget Sound. The research program has published numerous articles in scientific journals and has summarized much of the information developed in a book by Azous and Horner (2001).

In contrast, information on the effects of agricultural practices in the Pacific Northwest, especially in eastern Washington, is limited. Most studies originate from the prairie pothole region of the United States, the high mountain West, or California. The literature related to agriculture from outside the Pacific Northwest region has been included in this synthesis when it was judged to be relevant to Washington.

No scientific studies were found that examined the question of whether some wetlands in eastern Washington existed before the onset of irrigation projects. Research has been conducted by Adamus on irrigated agricultural lands from the high basin country of Colorado (Adamus 1993), but may not be germane to eastern Washington because soils and the surface geology are different. However, this study is included in the section on the influence of irrigation on wetlands because it discusses some of the issues that are relevant to the Columbia Basin.

3.2 Introduction to Human-Caused Disturbances

Human activities on the land increasingly represent a fundamental source of change in the global environment (Dale et al. 2000). Alterations to land use and land cover can often change the environmental factors that control functions within a wetland. Modifications in the environment that cause changes in how ecosystems function are called *disturbances*. Pickett and White (1985) define *disturbance* as "any relative discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment."

Disturbances to ecosystems are commonly viewed negatively as a disruption of equilibrium in an ecosystem. A growing science based on non-equilibrium theory, however, indicates that disturbances are an essential ecological process. They are necessary at some level of intensity and periodicity for the long-term maintenance of most, if not all, ecosystems (Averill et al. 2003). Disturbance occurs as a continuum from frequent intervals of low intensity to infrequent occurrences of high intensity (Pickett and White 1985). The average frequency of a given disturbance is inversely proportional to its intensity (Waldrop 1992). Large, intense, disturbances are rare and small ones frequent. Ecosystems have evolved in response to specific regimes of disturbances that have recurred over millions of years (Averill et al. 2003).

The disturbances caused by humans, however, often differ from those that occur naturally. They occur at different scales, different intensities, and different geographic locations (Dale et al. 2000). As a result ecosystems tend to respond in unexpected ways to human activities and many functions that ecosystems provide change or are diminished. Scientists sometimes use the term *stressor* to distinguish those disturbances that have a major impact on an ecosystem from those that maintain the usual structure and function of an ecosystem (see for example Adamus et al. 2001, Laursen et al. 2002). For the purposes of this discussion, however, only the term *disturbance* is used to simplify the discussion. All the disturbances discussed herein are stressors considered to have major impacts on ecosystems, and they are not the ones that maintain the existing structure and functioning in an ecosystem.

3.2.1 The Link between Wetland Functions, Human Land Uses, and Changes in Wetlands

In terms of wetlands and their functions, a disturbance can be considered as a condition or event that changes one of the environmental factors that control wetland functions. For example, nutrients are a factor that controls wetland functions. If nutrients from residential lawns flow to a depressional wetland that has limited nutrients, such as a bog, the excess nutrients can change the dominant plants in the bog and its habitat structure. In this case, the addition of nutrients that are in excess of those found in the absence of human activities is a disturbance on the functions of the wetland.

This example illustrates how changes in land use can influence large-scale environmental processes, resulting in disturbances to the factors that control wetland functions. It also illustrates how the topics discussed in Chapters 2, 3, and 4 of this volume are linked:

- The movement of nutrients throughout a basin, as described in the example, is one of several environmental factors that control wetland functions. These factors and the way in which they control wetland functions are the subject of Chapter 2.
- The maintenance of residential lawns is an example of a human activity that may affect the movement of nutrients in a basin. The application of excess nutrients (fertilizer) creates a disturbance when the nutrients flow from the lawn into a bog. This chapter (Chapter 3) describes how different kinds of human activities and uses of the land create environmental disturbances.
- When the excess nutrients reach the bog, they cause a change in its plant community and its habitat structure because the plant communities are adapted to a low-nutrient, acidic environment. Chapter 4 describes how disturbances caused by human land uses result in changes to wetland functions.

Figure 3-1 reviews the connection between the factors that control wetland functions, human-caused disturbances, and the functions of wetlands.

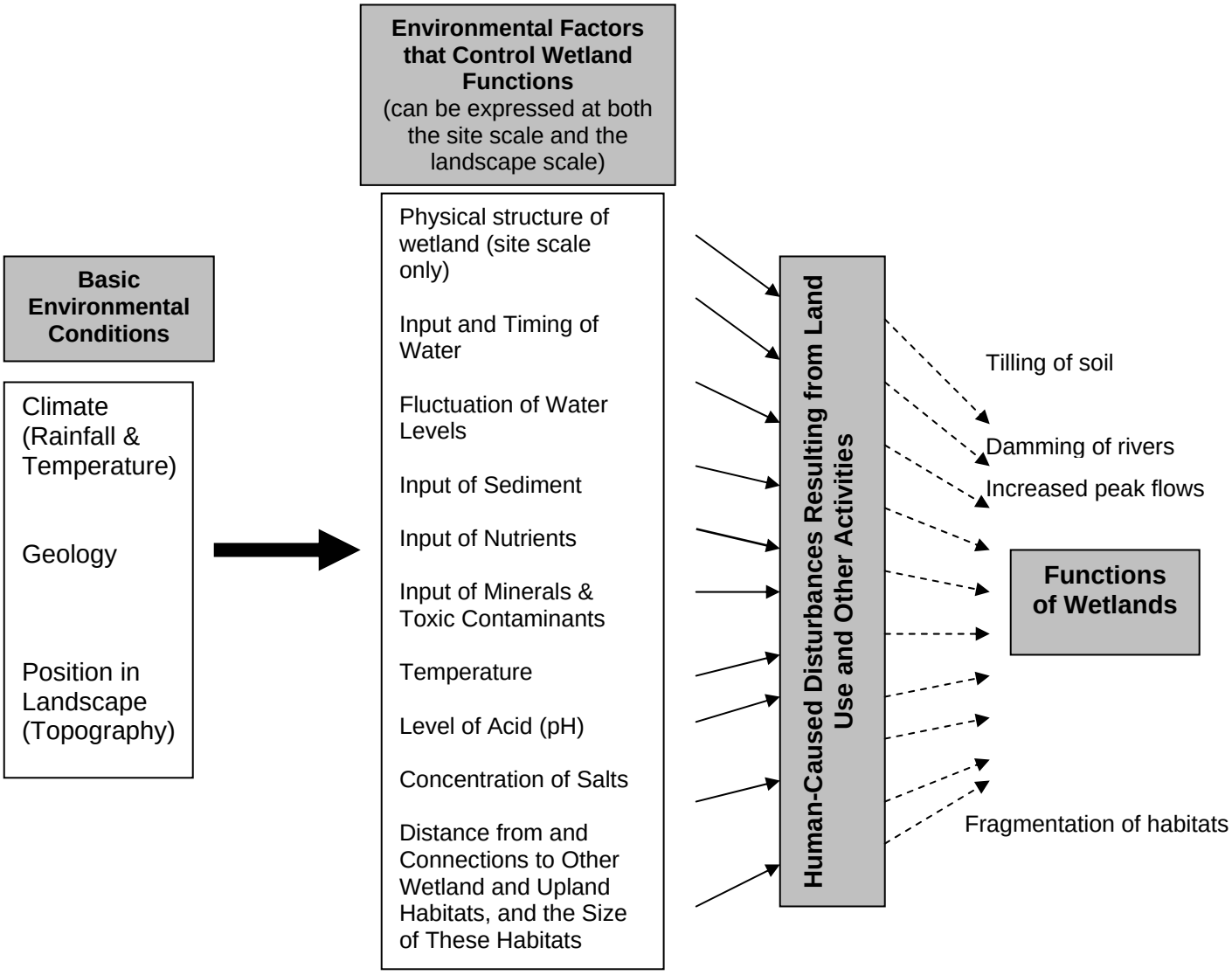


Figure 3-1. Diagram summarizing some major environmental factors that control functions of wetlands and how they interact with human-caused disturbances.

The basic environmental conditions establish and determine the factors that control the functions of wetlands. The controls can occur at both the landscape and site scales. Human activities cause disturbances that affect these controls in many different ways and thereby alter the performance of wetland functions. The figure gives some examples of the disturbances. This figure is the same as that in Chapter 2, Figure 2-3.

3.2.2 Types of Disturbances Resulting from Human Land Uses

Many different types of disturbances have been identified in the literature. For the purposes of organizing the information in this chapter, the list developed by Adamus et al. (2001) and shown in Table 3-1 is used because it was developed specifically to address impacts to wetland functions. Table 3-1 lists the types of disturbances that can impact wetlands and the scale at which the disturbances can occur. Many disturbances

that result from human uses of the land can occur over large areas such as basins and sub-basins (called the landscape scale), as well as in the wetland itself and in its immediate vicinity (called the site scale).

Table 3-1. Summary of human-caused disturbances and the scale at which they can occur.

Disturbance	Scale of Disturbance
Changing the physical structure within a wetland (e.g., filling, removing vegetation, tilling soils, compacting soils)	Site
Changing the amount and velocity of water (either increasing or decreasing)	Landscape and site
Changing the fluctuation of water levels (frequency, duration, amplitude, direction of flow)	Landscape and site
Changing the amount of sediment (increasing or decreasing the amount)	Landscape and site
Increasing the amount of nutrients	Landscape and site
Increasing the amount of toxic contaminants	Landscape and site
Changing the temperature	Mostly site
Changing the acidity (acidification)	Landscape and site
Increasing the concentration of salt (salinization)	Mostly site
Fragmentation (decreasing area of habitat and its spatial configuration)	Landscape
Other disturbances (noise, etc.)	Landscape and site
This table is a synthesis of the information presented by Adamus et al. (2001) and in the literature review done for this document.	

3.2.3 Disturbances to the Movement of Water at the Landscape Scale

The movement and sources of water in the landscape are two critical factors controlling how wetlands function. Many human land uses change the movement and sources of water, thereby creating a disturbance that affects the performance of functions in wetlands. The following provides some background on how human activities result in disturbances to the movement and sources of water.

The literature is quite clear that the frequency, timing, and duration of water in the landscape determine the presence of a wetland and the functions that it provides (see Chapter 2). How water enters a wetland, how long it is present, and the depths to which it is impounded all influence the functions that a wetland can provide or perform (Brinson 1993a, Mitsch and Gosselink 2000).

Surface and subsurface water flows through the landscape within "drainage systems." These drainage systems are often called basins, sub-basins, watersheds, or river basins depending on the size of the area. In this document, drainage systems are generally referred to using one of two terms:

- ***Watershed*** - A geographic area of land bounded by topographic high points in which water drains to a common destination.

- ***Contributing basin*** - The geographic area from which surface water drains to a particular wetland.

Booth (1991) succinctly summarizes the concept of a drainage system as follows:

> *Drainage systems consist of all of the elements of the landscape through which or over which water travels. These elements include the soils and the vegetation that grows on it, the geologic materials underlying that soil, the stream channels that carry water on the surface, and the zones where water is held in the soil and moves beneath the surface. Also included are any constructed elements, including pipes and culverts, cleared and compacted land surfaces, pavement and other impervious surfaces that are not able to absorb water at all.*

The movement and routing of water above and below the surface is the primary force in transporting nutrients, sediment, salts, and contaminants, and this in turn affects the functions provided by wetlands (Naiman et al. 1992). Water moves (or carries) sediment, nutrients, and energy throughout a watershed (Naiman et al. 1992). Changes in the amount of water, as well as in the frequency and fluctuations of water volumes, can alter how sediments, nutrients, and toxic contaminants come into a wetland. Changes in the movement of water resulting from human activities at the scale of the landscape can therefore have severe impacts on wetland functions throughout a watershed.

The following subsections provide background on how water moves in undisturbed landscapes as well as those that have been changed by human activities. The purpose of this discussion is to provide a context for understanding how human activities and uses of the land create the disturbances discussed later in the chapter.

Terms used to describe water regimes: hydrology vs. hydroperiod vs. hydrologic

Hydrology and hydroperiod are often used interchangeably to mean how water moves. *Hydrology*, as defined by Webster, is "the scientific study of the properties, distribution, and effects of water in the atmosphere, on the earth's surface, and in soil and rocks." The term hydrology means the study of how water moves.

Hydroperiod (not defined by Webster) is commonly used to refer more precisely to the periodicity of water; the timing (seasonal or otherwise) and duration of water's presence or absence within a particular aquatic feature, such as a wetland. It is "the seasonal occurrence of flooding and/or soil saturation, encompassing the depth, frequency, duration and seasonal pattern of inundation" (Azous et al. 2001). Mitsch and Gosselink (2000) define hydroperiod as "the seasonal pattern of the water level of a wetland . . . a hydrologic signature of each wetland type." Hydroperiod, in this context, refers to seasonal changes in wetland water level conditions caused by regular annual changes in water availability. This should be differentiated from the water level fluctuations driven by single or serial storm events.

Hydrologic is an adjective derived from the word "hydrology." It refers to the properties, distribution, and effects of water. Thus a term such as "hydrologic processes" refers to the environmental processes that involve the properties, distribution, and effects of water.

In this document, "hydroperiod" is used to refer to the pattern of water movement in a particular wetland or type of wetland. The term "hydrology" has been retained when direct quotes from sources use that term even if it has been misused. "Hydrologic" is used when an adjective is needed to describe the patterns of water movement.

3.2.3.1 Movement of Water in Undisturbed Landscapes

In undisturbed conditions, very little of the precipitation falling on the ground ends up in surface runoff, even in areas of high annual rainfall such as the Pacific Northwest. Areas with natural vegetation provide high rates of interception, infiltration, and evapotranspiration (Ziemer and Lisle 1998). The water either drips off leaves to the soil below; flows down the stems, leaves, and bark to the soil; or evaporates into the air, never reaching the ground.

Water that infiltrates into permeable surfaces either moves downgradient as shallow groundwater, infiltrates into a deeper water table, or is taken up by plant roots and transpired back into the atmosphere. Shallow groundwater flows downgradient through the pore spaces in the soils until it surfaces in a stream, wetland, or swale, sometimes in the form of a seep or spring.

Precipitation falling onto naturally impervious surfaces (e.g., bedrock), however, flows along the surface. Precipitation also flows along the surface if the soils become saturated and cannot hold any more water.

3.2.3.2 Movement of Water in Disturbed Landscapes

Human activities on the land change the movement of water across and through the landscape such that there are significant changes in runoff patterns and hydroperiods in a watershed (Booth 1991, Vought et al. 1995, Azous and Horner 2001). Surface runoff, rather than infiltration, comes to dominate water flows, as shown conceptually in Figure 3-2. The movement of water in a landscape can be altered by any of the following conditions:

- Removal of vegetation
- Compaction of soil (through grazing, earthwork, lawns, or playfields)
- Reduction in size of soil particles or the spaces between particles (through tilling or grading)
- Reduction in the organisms that aerate the soil
- Placement of drain tiles, ditching, road cuts, utility lines
- Construction of impervious surfaces
- Construction of dams and reservoirs

These conditions result from human land uses such as agricultural conversion, urbanization, and forest practices (Dunne and Leopold 1978, Booth 1991, Euliss and Mushet 1996). The disturbances from specific land uses to the movement of water and its sources are described later in this chapter. Information on the resulting impacts on wetland functions is synthesized in Chapter 4.

Removing vegetation allows precipitation to reach the soil surface faster, and therefore soil saturation occurs more rapidly. As soils become saturated, additional precipitation accumulates more rapidly on the surface and moves as sheet or surface flows. When soils are compacted, the precipitation cannot enter the soils readily and surface water accumulates more rapidly. Loss of permeability in the soil can persist even after compacted soils become vegetated as urban lawns, playfields, and in some agricultural conditions (Dunne and Leopold 1978).

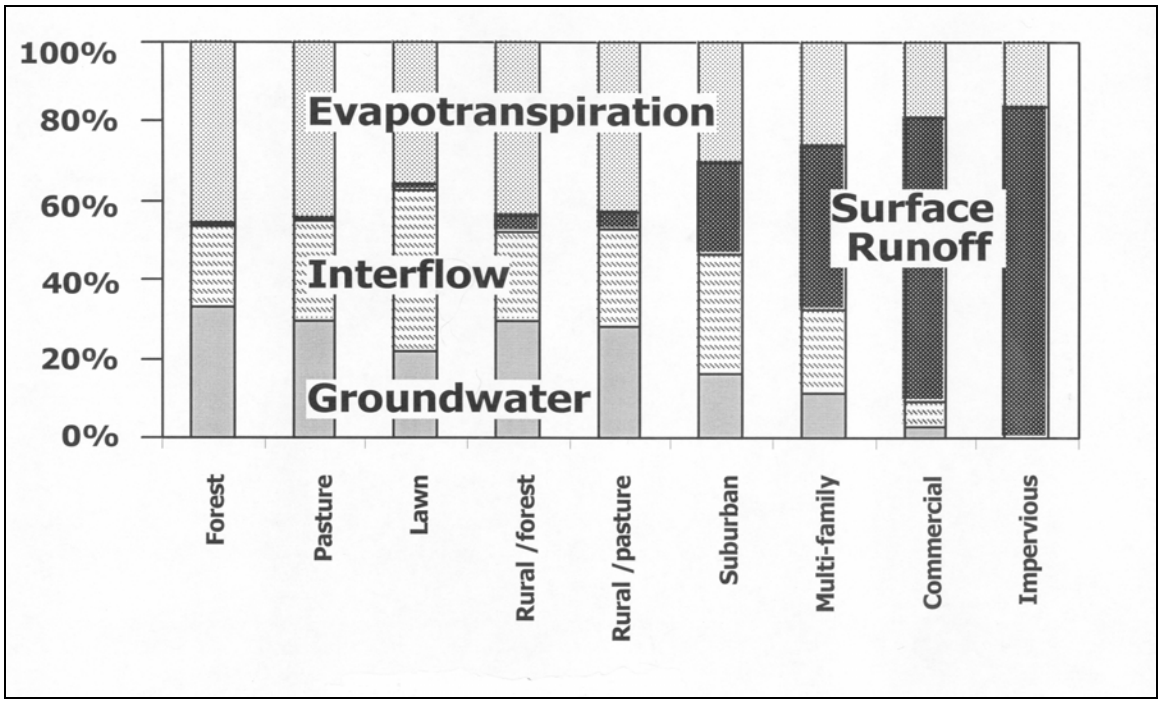


Figure 3-2. Changes in the proportion of groundwater, interflow, evapotranspiration, and surface runoff with different types of land cover in western Washington (Beyerlein 1999; reprinted with permission).

Under any of these conditions, runoff essentially becomes surface flow. Water flowing along the surface carries sediment and any other dissolved or adsorbed materials downgradient more rapidly than if the water is allowed to infiltrate in undisturbed soils (Ziemer and Lisle 1998). Studies in the Puget Sound region found that peak flows increase during storms as a result of urban development, but that the annual mean flow decreases (Konrad 2000).

In general, alteration of water flow in uplands results in a "shortening" of the path that water would naturally follow on its route through a watershed. It reduces the residence time of water in the ground and in bodies of surface water, such as streams or wetlands, within the watershed. On the other hand the construction of dams and weirs has resulted in the retention of water and a reduction in water velocity once the water reaches a stream or river.

Changing the water flow in uplands also results in increased rates and volumes of stormwater and changes the timing of stormwater entering aquatic systems. This can have numerous effects on aquatic systems as described in Section 3.4.2 on the effects of urbanization. For example, these changes circumvent or reduce:

- The removal of nutrients, pathogens, and toxics in the soil
- The filtering of sediment from surface flows through vegetated buffers and wetlands
- The reduction of downstream peak flows

3.2.3.3 The Role Of Impervious Surface In Changing Water Regimes

According to research throughout the country and in the Pacific Northwest described below, the degree of alteration in hydrologic processes and the subsequent impacts to aquatic habitats (including wetlands) is governed by the percent of impervious area and the percent of forested cover within a watershed. When soil is covered with impervious surfaces there is no opportunity for infiltration. All precipitation that falls on an impervious surface becomes surface water which flows downgradient.

Research in western Washington generally indicates that increases in the amount of impervious cover within a watershed can result in significant impacts to the habitat structure and function of freshwater aquatic systems (Azous and Horner 2001). Reinelt and Taylor (2001) discovered that 20% impervious cover in upstream development increased the peak and volume of stormwater runoff to the point that it began to dominate the hydroperiod of downstream wetlands. However, some scientists have concluded that trying to identify a specific threshold may not be accurate. As stated by Dr. Richard Horner "We are thoroughly convinced that there is no threshold; deterioration begins immediately and progresses at a rapid rate as soon as any amount of urban development begins" (Horner, University of Washington, personal communication 2004).

Defining and assessing impervious surface

The term *impervious surface* as used in the literature and in this document means more than just a hard impermeable surface such as an asphalt parking lot. There are many actions humans take that reduce the permeability of soils, and these are included in the calculations of "percent impermeable surface." For example, compacted soils found in lawns and landscaped areas function just as impervious surfaces do during storm events (May 1996).

Total impervious area (TIA) is sometimes challenging to assess without high-resolution aerial photographs and accurate GIS mapping capabilities (especially in watersheds with extensive forested coverage). Reinartz and Warne (1993) found that using road density as an indicator of basin impervious area resulted in findings nearly identical to those resulting from estimation of imperviousness from aerial photographs.

Reinelt and Taylor (2001) concluded that removing as little as 3.5% of the forested cover in a rural, low-density residential area resulted in changes in the pattern of water movement in the basin. Looking at percent forested cover in the Puget Sound Basin; Booth et al. (2002) have determined that natural hydrologic processes are maintained if 65% of a watershed remains in a forested condition. Because each watershed has different physical, chemical, and biological characteristics and patterns of impervious cover, the threshold at which aquatic resources experience significant effects will vary.

Table 3-2 summarizes additional findings on the effects of impervious cover on various biological characteristics of aquatic resources. As noted previously, specific impacts to wetland functions are described in Chapter 4.

Table 3-2. Summary of findings on the impacts of impervious cover.

Reference	Impacts to:	Key Finding
Booth (1991)	Fish habitat; channel stability	Channel stability and fish habitat quality declined rapidly with over 10% impervious cover
Taylor (1993)	Wetland plants and amphibians	Mean annual water level fluctuations are inversely correlated to density of plants and amphibians. Sharp declines occur when impervious cover exceeds 10%
Steedman (1988)	Invertebrates	Negative correlation between biologic integrity and increasing development at 209 streams. Degradation started at 10% impervious cover

3.2.3.4 The Role Of Dams In Changing Water Regimes

The construction and operation of dams affects the movement of water across large areas of the landscape. Regardless of their purpose, all dams trap particles to some degree and most alter the flood peaks and seasonal distribution of flows (Kondolf 1997). Dams disrupt the continuity of processes that occur at the landscape scale. Areas where water flowed fast may now have slow water movement and vice-versa (Kondolf 1997). In cases where water is transferred for irrigation or other purposes the reductions in discharge may greatly influence the hydrophysical conditions in the floodplain (Fjellheim and Raddum 1996).

There are four major aspects of changes to water regimes that result from the construction of dams (Bunn and Arthington 2002). These are:

- Reduction of the variability in flows
- Loss of some seasonal fluctuation in the wet/dry cycle
- Erratic daily patterns in the flow below hydroelectric dams
- Conversion of river and floodplain water regime (and habitat) to a lake water regime

Thus dams can change the water regime in a riverine and floodplain system to one that was not there previously, nor that could have been easily created by non-human factors.

For example, there are 211 major dams in the Columbia River Basin, 34 of which are on the main stems of the Columbia and Snake Rivers. The water levels in the reservoirs behind the dams operated by the Army Corps of Engineers rise and fall on a schedule unrelated to natural fluctuations. Levels in reservoirs may drop suddenly on a daily basis. The 211 dams also significantly reduce and slow the movement of water (Northwest Environmental Advocates, http://www.advocates-nwea.org/programs/U.html, accessed October 7, 2004).

3.2.4 Disturbances to the Quality of Water at the Landscape Scale

Two principal mechanisms have been documented to describe how land uses in a watershed change water quality in that watershed:

- Changes in hydroperiod increase erosion and sedimentation (Booth 1991, Booth and Reinelt 1993, Horner et al. 1996)
- Human uses of the land generate pollutants that are then transported into aquatic systems (Reinelt and Horner 1995)

Larger volumes of water, moving at faster rates, scour channels and cause rills in unvegetated soils. Moving water picks up and transports sediment and the pollutants associated with sediment particles. In addition, research shows that water flowing across the ground surface tends to pick up and convey dissolved nutrients and toxics directly into receiving waters (Young et al. 1980, Emmett et al. 1994, Gilliam 1994, Brenner 1995, Reinelt and Horner 1995, Vought et al. 1995, Crosbie and Chow 1999, Sheridan et al. 1999, Azous and Horner 2001).

Pollution conveyed by surface runoff (called *non-point-source pollution* by the U.S. Environmental Protection Agency) has been identified as the dominant source of pollutants in surface water. Non-point-source pollution is not discharged from the "end of a pipe" such as a large factory. Instead it is caused by sediment, metals, excess nutrients, and bacteria from a variety of dispersed sources (Reinelt and Horner 1995) such as stormwater, contaminated runoff from urban settings, agricultural runoff, and construction runoff (Baker 1992). These pollutants can have numerous impacts on wetlands and their functions as described in Chapter 4.

3.2.5 Disturbances to Habitats at the Landscape Scale (Fragmentation)

Human activities within a landscape often break up environment into small patches of habitat that are separated by roads, buildings, or tilled fields. The breaking up of the environment into habitat "patches" separated by areas altered by human land uses is a disturbance that is called *fragmentation*. Habitat fragmentation consists of both the reduction in the area of the original habitat and a change in spatial configuration of what remains (Haila 2002).

Suburban and urban development, farmlands, roads, railroads, powerline corridors, and other land uses cause various kinds and degrees of fragmentation (Heinz Center for Science 2002). These are discussed in more detail in subsequent sections of this chapter. In addition, human activity can create landscapes that are less varied than the landscapes historically present. Particularly in the West, natural fires create a patchy landscape, where forest and grasslands are intermingled in a mosaic. Fire suppression and the large

fires that result after long periods of suppression can create broad expanses of very similar vegetation (Heinz Center for Science 2002).

All environments, with or without human activities, are fragmented to some degree and are subjected to continuous change due to "natural" causes. As a result, no straightforward standard is available for assessing human-caused fragmentation. Furthermore, different ecosystems and the species they support experience the effects of fragmentation in variable, even contradictory ways (Haila 2002). For example, the breaking up of a certain habitat into patches may increase the populations of certain species by keeping predators from moving between patches. Such patches, however, will reduce the populations of predators because their access to prey will be reduced (Fahrig 2003).

The effect of human-caused fragmentation needs to be considered at different spatial and temporal scales, and the relevant scales will vary across species, geographic regions, and types of environment (Haila 2002). The types of fragmentation caused by the major land uses is described in this chapter, and the impacts of fragmentation on the functions of wetlands are described in Chapter 4.

3.2.6 Summary of Key Points

- Many human land uses change the movement and sources of water in a watershed, thereby creating a disturbance that affects the performance of functions in wetlands.
- In general, alteration of water flow by human uses of the land results in a "shortening" of the path that water would follow on its route through a watershed. It reduces the residence time of water in the ground and in the bodies of surface water, such as streams or wetlands, within a watershed.
- Changes in the amount of water and the frequency and fluctuations in water volumes can also change how sediments, nutrients, and toxic contaminants come into a wetland.
- Research in western Washington generally indicates that increases in the amount of impervious cover within a watershed can result in significant impacts to the habitat structure and function of freshwater aquatic systems.
- Two principal mechanisms have been documented to describe how land uses in a watershed change the water quality in that watershed: (1) land uses increase erosion and sedimentation, and (2) human uses of the land generate pollutants that are then transported into aquatic systems.
- Human activities within a watershed often break up the nevis and habitats into small patches and this disturbance is called fragmentation.

3.3 Disturbances Caused by Agriculture

This section describes the types and severity of disturbances that can be caused by agricultural practices. As mentioned previously, these disturbances can, in turn, affect factors that control wetland functions and are discussed in Chapter 4.

Wetlands have historically been some of the first places on the landscape that were used for agriculture. In western Washington, sites with flat topography suitable for agriculture were often located in river or stream floodplains. Many areas of these floodplains were wetlands with high water tables that persisted late into the growing season. Most early descriptions of Northwest rivers tell of valleys so wet that trails followed 'the borders of mountains' (Sedell and Luchessa 1982). Much of the flooding was a result of beaver activity that modified the flood plain and created areas where sediments could accumulate. Because the bottom land had accumulated fine silts and organic matter of alluvial origin, the land was fertile and drained early in the development of Oregon and Washington (Sedell and Luchessa 1982).

Agricultural practices play a significant role in influencing water movement in many regions of Washington. However, much of the research on wetlands in Washington over the last 10 years has been on the effects of urbanization. Although some of the consequences and effects of agriculture and urbanization may be the same or similar, others may be quite different. For example, agricultural practices in some parts of the state such as the Columbia Basin may have resulted in the creation of wetlands, or the expansion of pre-existing wetlands through the introduction of water from irrigation (Foster et al. 1984).

Cranberry growing operations in Washington are a type of agricultural land use that affects wetlands. However, cranberry production is limited to very small areas along the southern Washington coast in Pacific and Grays Harbor counties. The types of impacts that occur from conversion of wetlands to cranberry production are very different from other types of agricultural impacts. Due to the limited area affected, and time and funding limitations, this synthesis does not attempt to address the effects of cranberry production on wetlands in the state.

3.3.1 Loss of Wetlands and Changes to the Physical Structure of Wetlands from Agricultural Practices

Agriculture disturbs the physical structure of wetlands directly through conversion of the wetland to fields or pasture that often leads to the elimination of wetlands themselves. Conversion activities include filling or tilling, draining through tiles or channels, or removing the wetland vegetation and planting upland vegetation or crops. For example, tilling the soil within a wetland will disturb its soil structure (Nowak 1980, Hayes 1995). Livestock grazing in riparian wetlands also has well documented effects on the structure of plants and soils in wetlands as described below. Another example of disturbing the physical structure of riparian wetlands is the building of dams for irrigation since water

flow is a major determinant of the physical habitat in aquatic systems (Bunn and Arthington 2002). The disturbances created by dams are discussed in Section 3.2.3.4.

In studying riparian wetlands, Chappell et al. (2001) concluded that wetland loss in western Washington has been caused primarily by conversion to land development and agriculture. Although Chappell et al. (2001) do not estimate the loss that can be attributed to the different types of land uses, Bell (2002) found that 40% of the losses to peat wetlands in King County between 1958 and 2000 could be attributed to agriculture.

A recent study in the Willamette Valley (an urbanizing area similar to the Puget Sound Area) found that wetlands continue to be lost due to agriculture. Approximately 2.1% of the wetland area (3,800 hectare) was lost, and of this 70% was associated with agriculture, 6% to urbanization, and 24% to other causes (Bernert et al. 1999).

Outside of Washington, tremendous loss of wetland acreage has been attributed to agricultural filling, draining, and ditching in the prairie pothole regions of North America (Tiner 1984, Turner et al. 1987, Bardecki 1988). Researchers in Canada estimated 73% to 95% of the original wetlands in the area studied had been lost to agricultural conversion by the late 1960s (Snell as quoted in Bardecki 1988). Their work in Canada parallels the findings of Tiner (1984) that up to 87% of wetland loss in the United States was related to agricultural practices.

The literature on the effects of grazing on the physical structure of wetlands is focused primarily on riparian habitats, including riparian wetlands. Only a few of the studies found on this topic are located in the Pacific Northwest. However, much of the literature from the Midwest and even some from Australia may also be relevant because the types of disturbances caused by grazing are not geographically isolated. Many of the studies focused on riparian areas without differentiating between riparian upland and riparian wetland areas.

In summary, the effects of grazing in riparian areas include (Armour et al.1991, Busby 1979):

- Loss of the structure provided by vegetation
- Trampling and related sloughing and erosion of streambanks
- Shallower and wider streams

The effects of grazing on riparian vegetation vary significantly depending on the frequency and intensity of grazing (Clary 1995, Clary et al. 1996, Jansen and Robertson 2001). Soil compaction and a reduction in ground-cover vegetation lead to erosion and greater volumes of runoff from the compacted areas. Also, as native plant species are trampled and grazed and shading is reduced, there is more opportunity for establishment of species that can tolerate disturbance (see Chapter 4).

3.3.2 Increased Amounts of Water in Wetlands Resulting from Agricultural Practices

Water availability was a limiting factor for agricultural practices in the areas of low rainfall until the U.S. Bureau of Reclamation began intensive damming and irrigation projects in the early 1900s (Lemly 1994). Since then, irrigation practices have been influencing the presence of wetlands and their functions in areas in the rain shadow of the Olympic Mountains and the arid parts of eastern Washington. Most of the scientific literature concerns western states such as Colorado and Wyoming as well as Washington east of the Cascade Mountains. No information was found regarding the disturbances caused by irrigation practices on the Olympic Peninsula.

Irrigation can increase the amount of water at or near the surface (Adamus 1993). This may result in the creation and maintenance of wetlands in locations where they did not previously exist. New wetland areas have formed because of the sustained higher water table from seepage out of irrigation reservoirs, irrigation channels, and irrigation runoff. Leakage from irrigation channels and ditches often allows the formation of wetlands along channel margins or immediately downslope of ditches. Excess irrigation water applied to fields that exceeds the capacity of the soils to absorb water ("tailwater") may also form wetlands in low-lying areas that collect excess runoff. Tailwater also includes the spillage that occurs during operation of the irrigation system (Adamus 1993). For example, the Potholes Reservoir area within the Columbia Basin Irrigation Project contains wetland complexes that exist because of high groundwater caused by the high water levels in the reservoir (Tabor, Washington State Department of Fish and Wildlife, personal communication 1998).

Studies in Wyoming by Peck and Lovvorn (2001) support the idea that irrigation can be significant in creating and supporting wetlands and the biotic communities that depend upon them. The authors noted that 65% of inflows into wetlands in the Laramie Basin were derived from irrigation waters. They reached this conclusion by studying the loss of wetlands when irrigation practices were made more efficient (this is discussed further in Section 3.3.3).

In some instances, pre-existing wetlands experience deeper water for longer durations in the summer due to runoff from irrigation. Wetlands in the Potholes Reservoir that may have been seasonally inundated have become permanently inundated because of irrigation (Creighton et al. 1997).

In Colorado, Adamus (1993) differentiated between types of irrigation-related wetlands during a study of bird use of wetlands associated with irrigation waters. His work is cited here for relevant insights into the complexities of wetlands associated with irrigation.

However, due to physiographic and climatic differences between the Colorado Plateau and Washington, not all of his findings may be directly relevant to irrigated agricultural lands of the state. He identified the following types of irrigation-related wetlands:

- ***Irrigated wetlands*** are those that are created on farmed lands as the result of the duration and frequency of inundation from irrigation waters. The wetlands are most often created on the farmed lands within the actual zone of irrigation.
- ***Enhanced wetlands*** are those that are enlarged or their hydrologic regime extended (i.e., longer inundation or saturation) as the result of runoff from irrigation waters.
- ***Induced wetlands*** are those that develop as a result of irrigation runoff (from the farmed lands) where wetlands did not exist previously. These wetlands may or may not be located on the lands that are irrigated, but the source of the runoff water that creates these wetlands is excess runoff from irrigated fields.

Adamus (1993) also noted:

> *However, even after visiting a site it is difficult to determine conclusively the primary source of water that sustains a wetland. Irrigated wetlands, as considered by this project, can range from wetlands that are completely supported by irrigation runoff at all seasons, to wetlands that exist naturally but for which any measurable amount of their water originates from irrigation, however indirectly (e.g., through seepage or raised water tables). …determining whether the primary water source of a wetlands is irrigation-related in many cases requires considerable judgment, and no highly replicable approach exists that is applicable to all situations.*

Adamus (1993) determined that the following are *not* adequate criteria to distinguish the water source and, therefore, whether the major source of water to a wetland is irrigation:

- **Seed species richness.** Wetlands that are the result of irrigation water and are more than a few decades old are difficult to distinguish from pre-existing wetlands based on the species richness of the seed bank.
- **Organic content of soils.** Organic material is not an appropriate indicator of water origin. Organic detritus likely accumulates at different rates based on a variety of influencing factors. Much of the organic detritus appears to mineralize by the end of the growing season.
- **Presence of large willows and black cottonwoods.** A lack of large mature stands of black cottonwood and willows is also not an indicator of pre-existing vs. irrigated systems. Cottonwood stands may have been harvested or may never have become established. Anecdotal information concludes that cottonwood regeneration may not occur as frequently in irrigated wetlands due to overgrazing and the effects of flood management.

In the Wyoming setting studied by Peck and Lovvorn (2001), salinity of groundwater was also a factor in wetlands receiving shallow groundwater inputs from irrigated fields. Vegetation and biotic communities in the wetlands were correlated to both the water availability and the relative salinity of waters reaching wetlands. In summary, "…different irrigation practices have contrasting effects on a range of wetland types. These effects will change seasonally to impact different organisms with varying life histories, flooding requirements, and salinity tolerances" (Peck and Lovvorn 2001). The effects of changes in salinity are discussed in Section 3.3.8.

3.3.3 Decreased Amounts of Water in Wetlands Resulting from Agricultural Practices

Creighton et al. (1997) note that extensive areas of the landscape in the Columbia River Basin of eastern Washington have been altered by irrigation and the building of dams. One result of irrigation projects, they note, was "a sharp reduction in the amount of water available to native wetlands." In some instances sources of fresh water for wetlands, not resulting from irrigation, were diverted for agricultural uses and less water reached the wetlands.

In Wyoming, Peck and Lovvorn (2001) investigated the potential consequences of increasing efficiency in irrigation practices by lining ditches and using sprinkler systems (rather than flooding the fields). The authors noted that 65% of inflows into wetlands in the Laramie Basin were derived from irrigation waters. Therefore, with increased efficiency of water used for irrigation, the presence of wetlands in irrigated arid lands could decline. (The Wyoming data may be relevant to eastern Washington although the underlying geology and irrigation practices may not be identical.)

In California, the drought of 1985 through 1992 resulted in implementation of greater water conservation measures and therefore a decrease in the production of irrigation tailwater. There was a subsequent decrease in the volume of water reaching wetlands (Creighton et al. 1997).

Lower water levels in a wetland can also result from the direct ditching and draining for agricultural purposes. In this case the water entering the wetland is not reduced, rather it is shunted through the wetland and the storage capacity of the wetland is diminished. The ditching may be so effective that the area becomes upland. If, however, the draining is only partial the wetland may remain, but with lower water levels and probably a reduced area. The literature review did not disclose any information on how many wetlands in Washington may be impacted in this way.

3.3.4 Increased Fluctuations of Water Levels in Wetlands Resulting from Agriculture

The findings of Euliss and Mushet (1999) in North Dakota on the effects of agriculture on water level fluctuations in wetlands are probably significant for wetlands in the arid

grasslands of the Columbia Basin. These areas have similarities in precipitation and geologic patterns. These authors found that the hydroperiods for temporary, seasonal, and semi-permanent wetlands were all significantly affected by agricultural practices within the wetland's contributing basin. There was a three-fold increase in water level fluctuations of wetlands within tilled agricultural landscapes (average 5.5 inches [14 cm] fluctuation) compared to those surrounded by natural grasslands (average 1.6 inches [4 cm] fluctuation). The authors concluded, "Tillage reduces the natural capacity of catchments to mitigate surface flow into wetland basins during precipitation events, resulting in greater water level fluctuations in wetlands with tilled catchments."

3.3.5 Increased Input of Sediment Resulting from Agriculture

Tillage and grazing adjacent to a wetland or in a watershed can disrupt the soil, creating a source of sediment for surface runoff to transport downstream into wetlands and other aquatic systems. In addition, ditching wetlands in agricultural areas increases the rate of water movement by removing or reducing vegetation that acts to decrease the velocity of water. Unvegetated channels and ditches may be the source of sediment through increased erosion within the ditch (Brown 1988).

Baker (1992) compared sediments in agricultural runoff to those of wastewater plant effluent. He found that agricultural runoff can have suspended solids in the range of 100 to 1,000 milligrams per liter (mg/l), compared to less than 30 mg/l for wastewater that had received secondary treatment. Baker (1992) also found that non-point-source pollution from agricultural lands is driven by storms. It is therefore highly variable in extent and timing. He noted that in agricultural settings large storms can increase the sediment load by two to three orders of magnitude in a year, while the loads in wastewater discharge remain relatively consistent.

Wind-borne sediments that are eroded from tilled fields also generate high sediment loads to wetlands and streams in eastern Washington. The U.S. Department of Agriculture estimates that about half of the total farmland in Washington lost more than 2 tons of soil per acre per year through the action of wind in 1997. About 10% of the total farmland lost more than 10 tons per acre per year (Natural Resources Conservation Service 1997). By adding up the estimates of erosion rates and area that is farmland, it can be estimated that in 1997 about 15 million tons of topsoil were lost through wind erosion from fields in the state.

Sediment will eventually be transported into rivers and streams or deposited in wetlands. Wetlands found in depressions are often the low points in a landscape and will receive sediments that fall in the surrounding areas. The field teams that are calibrating both the methods for assessing wetland functions and the Washington State Wetland Rating System have observed wind-blown sediments in many wetlands of eastern Washington that were several inches deep.

3.3.6 Increased Input of Nutrients Resulting from Agriculture

In the United States the export of phosphorus and nitrogen from agricultural land can be three times higher for phosphorus and 12 times higher for nitrogen than from forested lands (Omernik 1977). Many of these nutrients are transported to wetlands, streams, rivers, and lakes because they are washed out of fields or infiltrate into groundwater. In Washington State, Williamson et al. (1998) found elevated levels of nutrients in the groundwater below irrigated fields on the Columbia Plateau. Their assumption is that the source of these nutrients is their application to fields above the groundwater.

The changes in the input of nutrients as a result of agriculture are illustrated by a study in Estonia in eastern Europe that documented what happened when agricultural fertilizers were no longer placed on agricultural lands. There was a four-fold to 20-fold decrease in pollutants associated with agricultural runoff after the collapse of agricultural collectives and the subsequent decline in the application of commercial fertilizers and manure (Mander et al. 2000). Based on 10 years of data (1987 through 1997), the researchers determined that total nitrogen, total phosphorus, biochemical oxygen demand (BOD), and sulfate all declined significantly with the demise of agricultural practices in the contributing watersheds. Forested portions of the watersheds upstream of the agricultural lands did not experience measurable changes in water quality parameters, eliminating the possibility that climatic change was the cause.

3.3.7 Increased Input of Toxic Contaminants Resulting from Agriculture

Several authors have identified agriculture across the country as one of the primary causes of non-point-source pollution in aquatic systems (Brenner 1995, Reinelt and Horner 1995, Thurston 1999). Agricultural chemicals are used to control noxious weeds, insect pests, and damaging fungi and bacteria.

Agricultural chemicals applied to fields enter downstream aquatic resources such as wetlands through three primary pathways (Neely and Baker 1985):

- Adsorbed to sediment particles
- Dissolved or suspended within surface flows
- Dissolved within subsurface drainage

Farming practices and the type of chemicals used determine how the pollutant is transported into wetlands. For example, some herbicides applied to corn are water soluble. Neely and Baker (1985) reported that water flowing across crop residue left after harvesting may wash off remnant herbicides. The concentration of such an herbicide in wetlands downgradient of a corn field may increase as a result. Similarly, Donald et al. (1999) documented that wetlands in the Canadian, prairie-pothole region receive high levels of pesticides when pesticides are applied to fields prior to significant

rains (precipitation totaling more than 2 inches [50 mm] after application). Another study, in California's Central Valley, found that surface water runoff from irrigated fields could have elevated levels of pesticides and herbicides if there had been aerial application of the chemicals or a recent land-based application (Lemly 1994).

Subsurface drainage may also contain pollutants at low levels. Lemly (1994) reported that subsurface waters from irrigated fields had low levels of herbicides or pesticides. These substances were removed from the water column through adsorption as the water filtered through the soils before draining into the subsurface collection system. Williamson et al. (1998) found elevated levels of pesticides in the groundwater below irrigated fields on the Columbia Plateau.

3.3.8 Increased Levels of Salt Resulting from Agriculture

Agricultural practices in irrigated areas can increase the salt content of water in a watershed or in areas immediately adjacent to a field. This means that wetlands receiving water from irrigated areas may also be subject to higher salt concentrations.

The soils in dry areas have developed in an environment of limited rainfall and significant periods of drying. In these areas the rate of evapotranspiration is higher than rainfall, and this draws water from below the ground's surface and causes many soluble minerals to accumulate in the upper soil horizons (Caltech 2003).

Soluble salts in irrigation water will be deposited in soils near the root zones of plants because much of the water in arid regions is lost by evaporation rather than downward transport. This salinization occurs with nearly any type of irrigation. Even if the irrigation water is only slightly saline, repeated cycles of evaporation lead to build-up of toxic salt levels in the soil (Caltech 2003). Thus, irrigation return waters are often high in salt content (Adamus et al. 2001) and this may impact wetlands that receive runoff from irrigation.

3.3.9 Fragmentation of Habitat Resulting from Agriculture

No information specific to fragmentation, the disruption of the connections between wetlands and between wetlands or other habitats, resulting from agricultural activities was found in the literature. It can be hypothesized, however, that such fragmentation has occurred because agricultural practices have fragmented habitats in general (Dale et al. 2000, Fahrig 2003). The direct loss of wetlands through conversion to uses such as agriculture increases fragmentation by removing "patches" of wetlands in the landscape. The conversion of wetlands to agricultural uses is discussed in the beginning of this section.

3.3.10 Other Disturbances Resulting from Agriculture

Several other types of disturbances that have been attributed to agricultural activities:

- Alteration of soils
- Construction of roads
- Noise
- Invasion by exotic plant and animal species

These disturbances are not discussed in detail in this chapter because little information was found describing how agricultural practices create these disturbances. The impacts of these disturbances, however, have been documented and are summarized in Chapter 4.

3.3.11 Summary of Key Points

- Agriculture may affect wetlands directly through conversion of the wetland to fields or pasture. This is often done by direct filling or tilling, by draining through tiles or channels, or by removing the wetland vegetation and planting upland vegetation.
- Livestock grazing in streams and riparian wetlands also has documented effects on the physical structure of wetlands.
- Irrigation can result in the creation and maintenance of wetlands in locations where they did not previously exist. This is a controversial regulatory issue in areas of the state that are irrigated.
- Conversely, agriculture can reduce the amount of water available to wetlands by either diverting water that would otherwise reach pre-existing wetlands, or imposing more efficient irrigation practices that reduce the amount of leakage reaching irrigation-related wetlands.
- Wetlands in tilled areas may experience greater water level fluctuations.
- Disruption of the soil through tilling and grazing can create a source of sediment than can be transported further downgradient. Sediments may also be carried by winds from tilled fields.
- Agricultural areas can have an increased load of nutrients and pesticides in surface runoff and groundwater.
- Agricultural practices in irrigated areas can lead to accumulation of salts in the upper soil horizons. Irrigation may leach out the accumulated salts.
- Fragmentation of wildlife habitat is a secondary consequence of loss of wetlands through agricultural practices. Clearing land for farming removes natural cover and connections between habitats.

3.4 Disturbances Caused by Urbanization

Urbanization creates disturbances that affect wetland functions, both at the scale of the watershed and within individual wetlands. These disturbances impose a variety of changes that profoundly affect watershed processes and, therefore, the downgradient drainage system and the wetlands found there. Changes include filling wetlands, clearing of vegetation, compaction of soil, modifications to water conveyance, alterations to riparian corridors, human intrusions, introduction of chemical contaminants, and increased areas of impervious surface.

A summary report by the U.S. Environmental Protection Agency (1993) concludes that urbanization strongly affects water movement within a watershed by increasing rates of surface flow, reducing subsurface volumes, and reducing baseflow. These pervasive, landscape-level changes commonly affect virtually all areas of an urban watershed (Dunne and Leopold 1978, Booth 1991, Booth and Reinelt 1993, Hollis and Thompson 1998).

Much of the scientific research on urbanization in the Pacific Northwest comes from the Puget Sound Wetlands and Stormwater Management Research Program initiated in 1986 in King County. Published results include theses by Azous (1991), Chin (1996), Ludwa (1994), and Taylor (1993). The book *Wetlands and Urbanization: Implications for the Future*, edited by Azous and Horner (2001), is a summary of the significant findings of the research. More information about the research done is available on the web site for the Center for Water and Watershed Studies at the University of Washington http://depts.washington.edu/cuwrm/ .

3.4.1 Loss of Wetlands Resulting from Urbanization

Approximately 13% of the wetland losses in the United States can be attributed to urbanization, road building, and other types of conversion (Tiner 1984). Kusler and Niering (1998) estimate that 85% of the wetlands in urban areas of the nation have been destroyed, and most of the remaining 15% are moderately to severely impaired in function. Data specific to Washington are very limited. One study (Bell 2002) found urban and residential development in King County accounted for 28% of the peat wetlands lost between 1958 and 2000.

The information available suggests that this trend will likely continue. It is estimated that more than 80% of the U.S. population will be living in urban areas by 2025, up from 74% in 1989 (Gerguson and Robinette 2001). Increases in urban population are generally accompanied by increased development density and sprawl. Wetlands in these areas are either converted to urban land uses or, if they are not directly disturbed, are degraded through a variety of causes as described in the following sections.

3.4.2 Increased Amount of Water in Wetlands Resulting from Urbanization

Urbanization is recognized as both increasing and decreasing the flows that reach downgradient aquatic systems such as wetlands. Greater volumes of water are generated more quickly while smaller, long-duration flows that would occur under less developed conditions are reduced or perhaps eliminated. Research has shown that collecting stormwater through modern storm drains, culverts, and catchments results in the rapid transport of large volumes of stormwater runoff into rivers, lakes, and wetlands at much faster rates and higher volumes than under predevelopment conditions (Dunne and Leopold 1978, Booth 1991, May 1996). Although some of the research has focused on the effects of urbanization on streams, the findings on changes in flow volumes, rates, and frequency apply equally to wetlands that receive storm drainage. Streams and wetlands are "intimately interconnected in the watersheds of western Washington" (Booth 1991).

Research conducted in the Puget Sound lowlands has shown statistically significant correlations between the effects of urbanization in a watershed and the hydrologic regime in that watershed (Konrad and Booth 2002). The amount of impervious surface within a contributing basin is a key influence on hydrologic patterns, and even small changes in watershed conditions have measurable influences on the flows and volumes of water in the system (Azous and Horner 2001).

3.4.2.1 Increased Frequency of Erosive Flows

One consequence of urbanization is an increase in the frequency of erosive flows within a watershed. As reported by Booth (1991), several studies concluded the most common effect of urbanization was an up to five-fold increase in peak flow rates from a given storm event. The largest relative increases in erosive flows were found for the smallest storm events. This is very significant because small storm events are the most frequently occurring storms. A small storm event is the *two-year-event*, a storm with a given volume of rain falling within a 24-hour period that has the statistical likelihood of occurring every two years (the statistics are based on over 40 years of measured rainfall). That means that small storm events have the greatest percent increase in flows over natural conditions, and frequent small storms have the greatest relative increase in erosive flows. Contrary to what might be expected, it is these recurring small storms that have the greatest cumulative effect on erosion and sedimentation, not the large, less frequent storm events (Booth 1991).

Thus, larger volumes of water enter channels and wetlands more rapidly after a given storm event in a basin where the removal of forests and the increase in impervious surfaces have altered hydrologic processes (Booth 1991). After an area has been developed and the forest canopy removed, high rates of flow continue for a longer duration. These flows may carry sediment and other pollutants into downgradient wetlands.

3.4.2.2 Increased Volume of Runoff and Longer Duration of Flows

Booth and Reinelt (1993) notes that a basin with increased imperviousness will experience an increase in the magnitude of runoff volume from a given storm event. The "typical" event occurs far more frequently. For example, the peak flows created from a two-year storm event, after urbanization, will occur far more frequently than every two years. Small storm events that did not create measurable peak discharges in forested conditions create measurable peak runoff flows in urbanized conditions, because the removal of the forest canopy makes the same size storm event result in far greater volumes of water reaching aquatic resources such as wetlands and streams. Modeling based on detailed data from basin monitoring identified that larger flows with more erosive force may occur in urbanized basins with much greater frequency, for example increasing from once or twice per decade to several times per year.

In urbanizing watersheds, stormwater ponds are designed to hold the excess volume of stormwater generated from the impervious surfaces. The ponds are designed to release stormwater at the same rate as that modeled for the natural vegetated basin for a given storm in pre-existing conditions (Booth 1991). However, in order for the ponds to discharge the increased volume of water at the same low rates, they must take more time, or cause an increased duration of flows.

3.4.2.3 Consequences of Changes in Water Regime

The consequences of the interplay between rates, volumes, and durations are complex. Research on the impacts of urbanization on stormwater and watershed processes indicates that urbanization results in several disturbances that can impact wetlands (Booth 1991, Azous and Horner 2001, Reinelt and Taylor 2001, Thom et al. 2001):

- Increased erosion
- Sediment movement and deposition
- Burying of vegetation
- Increased depths of inundation
- Water level fluctuations
- Downcutting of natural channels (which can remove riparian vegetation from the floodplain)
- Changes in the seasonal extent and duration of saturation and inundation
- Unstable substrates

Urbanization can also cause a decrease in interflow (shallow, subsurface flow) and base flow from the urbanized watershed (U.S. Environmental Protection Agency 1993). Changes in the volume of interflow may influence the hydroperiod of downgradient wetlands if they are fed by that shallow subsurface flow.

Roads and parking lots are an important component of the impervious surface area in a watershed. The City of Olympia in 1994 determined that transportation features (roads and parking lots) typically composed between 63% and 70% of total impervious area within suburban areas (Schueler and Holland 2000).

3.4.3 Increased Fluctuations of Water Levels Resulting from Urbanization

Reinelt and Taylor (2001) used water level fluctuation as the primary measure of wetland hydroperiod, stating: "Water level fluctuation is perhaps the best single indicator of wetland hydrology, because it integrates nearly all hydrologic factors." They documented four factors in a depressional wetland and its watershed that have the strongest influence on water level fluctuations:

- Forest cover in the watershed
- Impervious cover in the watershed
- Constriction of the wetland outlet
- Ratio of wetland to watershed area

Wetlands in basins with the highest degree of impervious area had the highest water level fluctuations. Wetlands in basins with 90% or more forested land cover and less than 3% impervious area generally exhibited smaller ranges in water level fluctuations (Reinelt and Taylor 2001). Further information on thresholds at which impervious surface influences aquatic resources is provided in Section 3.2.3.3.

Wetland size is also important in determining the effects of urbanization on water level fluctuations. Reinelt and Taylor (2001) observed that wetlands that were small in relation to their contributing watersheds had greater water level fluctuations and were dominated by surface inflow. Wetlands that were larger in comparison to their contributing watersheds had smaller water level fluctuations and more groundwater influence. Wetlands with a constricted outlet (undersized culvert, beaver dam, or embankment) had a greater water level fluctuation than wetlands with less constricted outlets.

Stormwater runoff from urbanization, as well as other land-use alterations, frequently causes several changes in how water levels fluctuate in wetlands. All aspects of fluctuations in water levels are changed by urbanization:

- The **magnitude** of the effect of storms is changed by causing a two-year event to act like a larger storm. A larger volume of water reaches the wetland more often. Urbanization can also prevent infiltration through native soils into the shallow groundwater zone (Booth 1991, Azous and Horner 2001).

- The **timing** of water's presence and duration is changed by the use of engineered stormwater systems. Water is collected from impervious surfaces into stormwater ponds. Infiltration into shallow groundwater is prevented. The stormwater is discharged at given rates for longer durations into downstream receiving waters (Booth 1991, Azous and Horner 2001).

- The **frequency** of runoff volumes from storm events increases. The volume of runoff normally generated from small storm events is generated by smaller volumes of precipitation (Booth 1991, Azous and Horner 2001, Reinelt and Taylor 2001, Thom et al. 2001).

- The **duration** of particular flows becomes extended as large volumes of stormwater are discharged at metered rates over longer periods of time (Booth 1991, Thom et al. 2001).

- The **rate of change** is increased through increasing the frequency and magnitude of water level fluctuations in urbanizing watersheds (Azous and Horner 2001, Reinelt and Taylor 2001, Thom et al. 2001).

3.4.4 Increased Input of Sediment Resulting from Urbanization

Researchers in the Puget Sound area have documented that urbanization increases erosion and this, in turn, increases the movement and deposition of sediment in depressional and riverine wetlands (Booth 1991, Azous and Horner 2001, Reinelt and Taylor 2001, Thom et al. 2001).

Studies at the national level undertaken by the U.S. Environmental Protection Agency confirm that sediment in urban runoff is a problem nationwide (Tasker and Driver 1988). Sediments and solids constitute the largest volume of pollutant loads to receiving waters in urban areas (U.S. Environmental Protection Agency 2003).

A major source of sediment in urban areas comes from construction when the surface of the soils is disturbed and exposed to erosive forces. Runoff from construction sites is by far the largest source of sediment in urban areas under development (U.S. Environmental Protection Agency 1993).

3.4.5 Increased Input of Nutrients Resulting from Urbanization

Research on the impacts of urbanization in the Puget Sound area (Booth 1991, Azous and Horner 2001, Reinelt and Taylor 2001, Thom et al. 2001) has also documented that urbanization increases the amount of nitrogen entering aquatic systems including wetlands. Studies at the national level undertaken by the U.S. Environmental Protection

Agency confirm that nitrogen in urban runoff is also a problem nationwide (Tasker and Driver 1988).

Nutrients are introduced into runoff from a number of different sources that include nutrients bound to sediment from construction sites, fertilizers applied to lawns, and decomposing grass clippings and leaves left on impervious surfaces (Johnson and Juengst 1997). Nutrients are also increased in groundwater in areas where wastewater is treated by septic systems (Valiela et al. 1993). More specifically, nutrients from septic systems have been correlated with an increase in nutrients in the groundwater that flows into lakes and their associated wetlands in urbanizing areas (Moore et al. 2003).

In addition to the application of fertilizers in residential areas, nitrogen is introduced into aquatic systems and wetlands from the release of nitrogen compounds in car and truck engines and through the burning of wood and coal (Paerl and Whitall 1999). The amount of nitrogen coming from the deposition of these air pollutants in the United States is about 20% of the total excess nitrogen derived from human activities (Prospero et al. 1996). In heavily urbanized areas such as the Eastern Seaboard, the total amount of nitrogen coming from combustion can be as high as 40% or more of the total input by all human activities (Valigura et al. 1996).

3.4.6 Increased Input of Toxic Contaminants Resulting from Urbanization

In addition to sediment and nutrients, urban land uses generate a wide range of pollutants that include the following (U.S. Environmental Protection Agency 1993):

- Heavy metals (copper, lead, zinc)
- Hydrocarbons
- Organic matter that reduces oxygen
- Pesticides

Schueller and Holland (2000) cite a number of studies indicating that urban pollutant loads are directly related to the amount of impervious surface in the watershed. Impervious surfaces such as roads, parking lots, and storage yards are places where toxics from numerous sources collect. Precipitation falling on the impervious surfaces washes the collected chemicals and particles into the storm drain system (Schueller and Holland 2000).

The runoff from many different types of land use in urban areas can be toxic to aquatic life. Pitt et al. (1995) studied the relative toxicity of the runoff from different types of land uses in urban and suburban areas. Parking areas, storage areas, and landscaped areas (lawns, gardens) had the highest toxicity with approximately 20% of the samples being highly toxic. Over half of the samples of runoff from these urban land uses were moderately toxic.

Sriyaraj and Shutes (2001), working in London, documented that hard rains after extended dry periods result in the greatest concentrations of pollutants. This is also known to occur in Washington, where the greatest concentration of pollutants in surface runoff is typically observed in the fall with the first rains following summer drought (Booth 1991).

3.4.6.1 Heavy Metals and Hydrocarbons

Most heavy metals in urban runoff are adsorbed to sediment particles, although copper and zinc can occur in dissolved forms (Canning as referenced in Newton 1989). The sources of heavy metals are various including motor vehicle brake linings, tire particles on roadways, emissions from vehicles, and industrial sources.

Sriyaraj and Shutes (2001) found that sediment from road runoff had high to moderate levels of heavy metals associated with it, and the metals were deposited within the sediments of the receiving wetland. Heavy metals, such as lead, zinc, copper, and cadmium, are some of the pollutants that accumulate on roads during dry summers. These pollutants are particularly concentrated when they are washed off during intense storms following long dry periods (Sriyaraj and Shutes 2001). Thurston (1999) found that lead and petroleum hydrocarbons were the most common pollutants attached to particles in an urban wetland receiving direct runoff from a municipal garage parking lot.

Most of the adsorbed metals are buried in sediment deposits within wetland substrates, thereby becoming substantially "locked up" from further biological activity (Canning as referenced in Newton 1989) when covered by un-contaminated sediment. Where contaminated sediments are constantly being discharged to wetlands (e.g., urban stormwater discharges), however, new contaminated sediments are constantly coming in. Thus, there is always contamination in the biologically active zone. Also, if the pH of the incoming water changes some toxic metals may be released (see Section 2.6.1.4).

3.4.6.2 Organic Matter

Another contaminant present in runoff from urban areas is organic matter (examples listed below). As this organic matter decomposes in the water, it uses up oxygen that is dissolved in the water (called dissolved oxygen or DO). DO plays the same role as atmospheric oxygen in that it is critical for biological activity in aquatic communities. Oxygen is used by aquatic organisms. It is also used by bacteria for the decay of organic matter. This is called the biological oxygen demand (BOD) of the system. In natural systems, BOD fluctuates as oxygen use and organic inputs vary both daily and seasonally. The natural BOD of a system is thrown out of balance when there is excessive organic matter in the system. An increased BOD results in a decreased availability of dissolved oxygen.

Contaminants in urban runoff that cause increases in BOD include:

- Septic system effluent
- Oil and grease
- Organic matter such as dog and cat feces
- Incidental sources from atmospheric fallout

Direct urban runoff can create a demand for oxygen that is equal to or greater than that from sewage effluent. BOD from urban runoff can have substantial cumulative effects (Canning as referenced in Newton 1989).

3.4.6.3 Pesticides

Pesticides in urban areas are used for residential and commercial landscaping. According to studies conducted in the Puget Sound Basin, more types of pesticides were detected in urban streams than in agricultural streams (Bortleson and Davis 1997). Furthermore, more pounds of pesticides were applied in urban areas than in agricultural areas (Tetra Tech 1988 as reported in Voss et al. 1999). Voss et al. (1999) found 23 pesticides in urban streams in King County of which five exceeded the recommended maximum concentrations set by the National Academy of Science. Although all these data were collected from streams it can be assumed that riverine wetlands that intersect these urban streams can be subject to these pesticides as well.

3.4.7 Fragmentation of Habitat Resulting from Urbanization

Urbanization causes fragmentation of habitat as new developments divide undisturbed areas (COST-Transport 2003). Conversion of the land for urbanization has turned large, continuous patches of habitat into numerous small patches, which are isolated from each other and surrounded by land uses that are not hospitable to many native wildlife species (Aurambout 2003). The fragmentation of habitat continues to increase as the human population grows (Dale et al. 2000). Developed lands in the U.S. increased by 18% between 1990 and 2000 to total 4.4% of the area of the country (Dale et al. 2000).

Wetlands, as part of an undisturbed landscape, are also subject to the fragmentation that results from urbanization. Gibbs (2000) analyzed the distribution of wetlands along urban to rural gradients in New York State and in Maine and found statistically significant correlations between the density of human population and two measures of fragmentation – the average distance between wetlands and the percent of the landscape that was in wetlands.

3.4.8 Other Disturbances Resulting from Urbanization

Several other types of disturbances have been attributed to human activities in urbanizing areas:

- Alteration of soils
- Construction of roads
- Noise
- Recreational access
- Invasion by exotic plant and animal species, including household pets

These disturbances are not discussed in detail in this chapter because little information in the literature was found quantifying how urbanization creates these disturbances. The impacts of these disturbances on wetlands have been documented and are summarized in Chapter 4.

3.4.9 Summary of Key Points

- Increases in urban population are generally accompanied by increased development density and sprawl. Wetlands in these areas may be converted to urban land uses or may be degraded through a variety of causes.
- Urbanization results in modifications to water movement, alterations to riparian corridors, human intrusions, introduction of chemical contaminants, and increased areas of impervious surface. These changes profoundly affect environmental processes in contributing basins and, therefore, the downgradient drainage systems.
- Urbanization alters the movement of water into aquatic systems. Consequences of increased amounts of water include an increased frequency of erosive flows, greater volume of runoff, and longer duration of high flows.
- With urbanization comes increased transport of sediment, nutrients, metals, oil, pesticides, and other contaminants in surface runoff.
- Fragmentation of habitat results as the total area of wetlands is reduced and the connections between wetlands and other habitats are eliminated.

3.5 Disturbances Caused by Forest Practices

In general, forest practices cause several types of disturbance that can impact the factors that control wetland functions and therefore affect the performance of those functions. These disturbances include (as reviewed in Cooke in press):

- Increased peak flows
- Increased water level fluctuations
- Increased nutrients
- Increased sedimentation
- Changes in soils
- Invasion by exotic species

The effects of forest practices have recently received much attention. As a result, the scientific literature is being reviewed and synthesized by the Washington State Department of Natural Resources and is now in a draft form (Cooke in press). Therefore, this review of the literature does not cover the disturbances that result from forest practices and their impact on wetland functions.

3.6 Disturbances Caused by Mining

Surface mining generates large quantities of unusable rock that is often left on the surface after it is extracted. This exposes the rock (called spoils) to an oxidizing environment, resulting in a complex series of chemical reactions. The minerals contained in the spoils are not in equilibrium with the oxidizing environment and almost immediately begin weathering and mineral transformations.

The reactions are analogous to "geologic weathering" which takes place over extended periods of time (hundreds to thousands of years) but the rates of reaction are orders of magnitude greater than in "natural" weathering systems. The accelerated reaction rates can release damaging quantities of acidity, metals, and other soluble components into the environment (U.S. Department of the Interior, Office of Surface Mining 2003).

Thus, the two major disturbances created by surface mining are (Adamus et al. 2001):

- An increase in the levels of heavy metals that are toxic to many organisms
- An increase in the acidity of surface waters

Another type of mining activity that occurs in the state is gravel mining in streams and floodplains. We were unable to find any published information on the impacts of gravel mining on wetlands, and research into this question is only beginning at the national level by the U.S. Geological Survey (Spooner 2004). As a result, we were unable to synthesize the information on the impacts of this activity.

3.7 Chapter Summary and Conclusions

The focus of Chapter 3 has been to describe how different land uses may change the environmental factors that control wetland functions. A general conclusion that can be

made from the scientific literature is that disturbances of environmental factors can occur at several geographic scales. Much of the early research focused on disturbances that occur at a single site or wetland. More recent research has documented the significance of disturbances that occur at the much larger scale of a watershed (called the landscape scale). The disturbances created by different land uses are summarized in Table 3-3 (at the end of this section) by the type of land use, the severity of the disturbance, and the scale at which the disturbance occurs. This table represents a synthesis of the severity of impacts by the authors of this document based on the information in the literature.

The effects of different land uses on the flow and fluctuations of water are well documented. Changes in land uses and vegetation communities on the land, whether for agriculture or as a result of urbanization, alter the patterns of surface and shallow groundwater movement across a landscape. Flows of water can be reduced or increased by different land uses as can the frequency and amplitude of water levels.

Removal of vegetation and/or compaction of native soils through agricultural practices, creation of lawns or grazed pastures, or creation of impervious surfaces all have the same relative consequence: increased volumes of water and rates of flows after a given storm event. The threshold of roughly 10% imperviousness within a basin appears to be the point above which significant impacts begin to occur to aquatic resources based on research in the Puget Sound Basin.

While the effects of urbanization on water movement have been extensively studied, agriculture can also influence the water regime of wetlands, leading to loss of wetlands in some areas and creation or maintenance of wetlands in other areas where wetlands did not originally exist, such as areas influenced by irrigation.

Human activities also increase sediment and other pollutants in runoff. In agricultural areas, pesticides and fertilizers can contribute to contamination of surface waters. In urban areas, stormwater runoff frequently contains sediment, organic matter, phosphorus, metals, and other pollutants. Pollutants often adhere to sediment particles that enter wetlands. Mining increases the acidity of surface waters as well as adding toxic heavy metals. Logging increases sediments in a watershed and can also change the amount of water and its fluctuations.

Fragmentation of habitats is of increasing concern. As connections between wetlands and other habitats are broken and more wetlands across the landscape are converted to other uses, the remaining habitat becomes more isolated.

A key finding of this chapter is that different land uses may cause the same change in the controls of wetland functions. For example, urban land uses, agricultural practices, and logging have all been shown to increase sediments in a watershed. From the wetland's "point of view," the source of the sediment is irrelevant—the impact of excess sediments on wetland functions is similar, regardless of the source of sediments.

Chapter 4 shifts from a focus on the disturbances caused by human land uses (agriculture, urbanization, logging, and mining) to describe how these disturbances impact wetlands and their functions.

Table 3-3. Disturbances resulting from different land-use practices that can change the factors that control wetland functions.

Disturbance	Scale of Disturbance	Agriculture	Urbanization	Mining
Changing the physical structure within wetlands (filling, vegetation removal, tilling of soils, compaction of soils)	Site scale	xx	xx	h
Changing the amounts of water	Landscape scale	xx	xx	?
	Site scale	xx	xx	h
Changing fluctuations of water levels (frequency, amplitude, direction of flows)	Landscape scale	xx	xx	?
	Site scale	xx	xx	h
Changing the amounts of sediment	Landscape scale	xx	xx	h
	Site scale	xx	xx	h
Increasing the amount of nutrients	Landscape scale	xx	xx	nm
	Site scale	xx	xx	nm
Increasing the amount of toxic contaminants	Landscape scale	xx	xx	x
	Site scale	xx	xx	xx
Changing the acidity	Landscape scale	nm	nm	x
	Site scale	nm	nm	xx
Increasing the concentrations of salt	Landscape scale	x	nm	nm
	Site scale	x	nm	nm
Fragmentation	Landscape scale	xx	xx	h
Other disturbances	Site scale	xx	xx	h

Key to symbols used in table:
(xx) land use creates a major disturbance of environmental factors that affects large areas in the state
(x) land use creates a disturbance
(nm) studies on impacts of this land use do not mention this disturbance
(h) literature is lacking but disturbances can be hypothesized based on authors' experience
(?) information lacking

Chapter 4

Negative Impacts of Human Disturbances on the Functions of Wetlands

4.1 Reader's Guide to This Chapter

Chapter 4 integrates the concepts discussed in Chapter 2 and Chapter 3. Chapter 2 described the functions performed by wetlands and the environmental factors that control functions of wetlands. Chapter 3 discussed the major disturbances to the environment caused by different human activities and uses of the land. This chapter continues by summarizing how each of the disturbances ultimately leads to impacts to wetland functions.

As mentioned in Chapter 3, disturbances to wetlands can alter how they function. Changes that are caused by human disturbances are often called *impacts* to separate them from changes that are caused by "natural" or non-human disturbances. From a legal perspective (National Environmental Protection Act), human impacts are divided into *direct impacts*, those which are caused by the action and occur at the same time and place, and *indirect impacts*. Indirect impacts are caused by an action but occur later in time or are farther removed in distance, but are still reasonably foreseeable. (http://ceq.eh.doe.gov/nepa/regs/ceq/1508.htm#1508.1)

Impacts can be either beneficial or detrimental to the ecosystem, environmental process, or species. Defining an impact as either beneficial or detrimental depends on the values of the society or group making the decision (Beanlands and Duinker 1983). The natural system does not judge a change as either good or bad; it is we, as a society, that make that judgment. Social values, as represented by its laws, provide the means of determining the importance of human impacts (Beanlands and Duinker 1983).

The Growth Management Act and the state and federal clean water acts all have the protection of wetland functions and values as a goal. Thus, human impacts to wetlands, from this perspective, need to be considered in terms of those that reduce the level of functions they perform or the values they represent.

Therefore, the objective of the synthesis in this chapter is to summarize the information on the changes caused by human disturbances that reduce the level of different functions performed by wetlands. For this reason the chapter is titled *negative impacts*. When the word *impact* is used it assumes there is a reduction in the levels of functions and the societal values they represent.

4.1.1 Chapter Contents

Major sections of this chapter and the topics they cover include:

Section 4.2, The Geographic Scale of Impacts to Wetland Functions describes how disturbances that impact functions of wetlands can occur either within the wetland itself or in the surrounding landscape. While the literature generally does not distinguish the scale of the disturbance when assessing impacts on wetland functions, there are some disturbances at the site scale that can remove all or most functions of the wetland (such as changing the physical structure of the wetland through filling).

Following this introduction, the chapter continues by describing how the major types of disturbances resulting from human activities affect wetland functions. As discussed in Chapter 3, different land uses may create the same type of disturbance (for example, both agriculture and urbanization may cause sedimentation). Therefore, each of the remaining sections of this chapter focuses on the different types of disturbances, without division by land-use type, and their impact on each wetland function. The following is a list of the disturbances discussed in this chapter:

Section 4.3, Impacts from Changing the Physical Structure within a Wetland

Section 4.4, Impacts from Changing the Amount of Water in a Wetland

Section 4.5, Impacts from Changing the Fluctuation of Water Levels within a Wetland

Section 4.6, Impacts from Changing the Amounts of Sediment Coming into a Wetland

Section 4.7, Impacts from Increasing the Amounts of Nutrients Coming into a Wetland

Section 4.8, Impacts from Introducing Toxic Contaminants to a Wetland

Section 4.9, Impacts from Changing the Acidity (pH) of Soils or Water in a Wetland

Section 4.10, Impacts from Increasing the Concentrations of Salt in a Wetland

Section 4.11, Impacts from Fragmenting Wetland Habitats

Section 4.12, Impacts from Other Human Disturbances on Wetlands

Within each section, the impact of each disturbance is summarized in terms of the following wetland functions:

- Impacts on hydrologic functions
- Impacts on functions that improve water quality
- Impacts on plants
- Impacts on invertebrates
- Impacts on amphibians and reptiles

- Impacts on fish
- Impacts on birds (species closely associated with wetlands)
- Impacts on mammals (species closely associated with wetlands)

Section 4.13, Chapter Summary and Conclusions ties together the major concepts presented in the chapter.

4.1.2 Where to Find Summary Information and Conclusions

Each major section of this chapter concludes with a brief summary of the key points resulting from the literature on that topic in a bullet list format. The reader is encouraged to remember that a review of the entire section preceding the summary is necessary for an in-depth understanding of the topic.

For summaries of the information presented in this chapter, see the following sections:

- Section 4.3.9
- Section 4.4.9
- Section 4.5.9
- Section 4.6.9
- Section 4.7.9
- Section 4.8.9
- Section 4.9.9
- Section 4.10.9
- Section 4.11.9
- Section 4.12.6

In addition, Section 4.13 provides a summary and conclusions about the overarching themes gleaned from the literature and presented in this chapter.

4.1.3 Sources and Gaps in Information

Data on some of the subjects related to the negative impacts of human disturbances on wetland functions are abundant for select areas in the state. For example, the Puget Sound Wetlands and Stormwater Management Research Program (summarized in Azous and Horner 2001) has provided several studies on how changes in land uses in a watershed affect the physical, chemical, and biological processes in wetlands of the Puget Sound lowlands. The impacts on wetlands in other areas of the state are less well studied.

Similarly, studies on the effects of changes in wildlife habitat resulting from physical changes within wetlands and fragmentation between habitats have been performed in Washington for some species and some types of habitat changes. The impacts to other species are less well studied or have only been examined in other states or other countries. Information from other locales is included for these topics when relevant.

This chapter contains text that was adapted (re-organized and paraphrased) from a review of current scientific literature on the impacts of human activities on wetlands and their functions undertaken by the U.S. Environmental Protection Agency (Adamus et al. 2001). This review represents a very detailed summary of the literature published between 1990 and 2000 regarding wetlands across the United States. Portions of the review that were considered relevant to wetlands in Washington State were adapted for inclusion in this chapter, with permission from Dr. Adamus. The sections of this chapter that incorporate text adapted from the Adamus et al. (2001) review include:

- **Sections 4.3.3 – 4.3.8**, the impacts on plants, and habitat for invertebrates, reptiles and amphibians, fish, and mammals from changing the physical structure in the wetland
- **Sections 4.4.3 – 4.4.7**, the impacts on plants, invertebrates, amphibians and reptiles, fish, and birds from changing the amount of water in the wetland habitat
- **Section 4.5.4**, the impacts on invertebrates from changing the fluctuations of water levels in the wetland habitat
- **Sections 4.6.3 – 4.6.4**, the impacts on plants and invertebrates from changing the amounts of sediment in the wetland habitat
- **Sections 4.7.3, 4.7.4, 4.7.7**, the impacts on plants, invertebrates, and birds from increasing the amount of nutrients in the wetland habitat;
- **Sections 4.8.3 – 4.8.7**, the impacts on plants, invertebrates, amphibians and reptiles, fish, and birds from increasing the amount of toxic contaminants in the wetland habitat;
- **Section 4.9.3 – 4.9.7**, the impacts on plants, invertebrates, amphibians and reptiles, and birds from changing the acidity in the wetland habitat;
- **Sections 4.10.4, 4.10.7**, the impacts on invertebrates and birds from increasing the concentration of salts in the wetland habitat;
- **Section 4.12.1, 4.12.5.4**, the impacts on plant communities from altering soils and the impacts of exotic invertebrates on native invertebrates in wetlands.

The literature sources cited in the portions of the text that were adapted from the report by Adamus et al. (2001) are included in the list of references at the end of Volume 1. These sources, however, were not obtained and reviewed independently.

4.2 The Geographic Scale of Impacts to Wetland Functions

The disturbances that impact functions in wetlands can occur either within the wetland itself or in the surrounding landscape. Chapter 2 introduced the idea that the controls of wetland functions occur at both the "site scale" and the broader "landscape scale." As with the controls of wetland functions, disturbances caused by human activities can also occur at the same two scales (site and landscape).

For example, increased nutrients can flow into a wetland directly from an adjacent lawn or from animals grazing within the wetland (disturbance at the site scale). The nutrients could also originate from development or fertilized fields somewhere higher in the contributing basin (disturbance at the landscape scale). As another example, the water levels in a wetland can be increased through the direct discharge of stormwater into a wetland (the site scale) or by adding impervious surface higher in the contributing basin (the landscape scale).

Much of the discussion in this chapter does not differentiate the scales at which the disturbance occurs. For example, the impacts on wetland functions resulting from excess nutrients or higher water levels can be expected to be the same whether they are delivered directly to the wetland or come from a distant source in the contributing basin. The literature does not usually differentiate between scales when discussing the impacts on wetland functions.

However, an alteration to the physical structure of the wetland itself is a type of disturbance that occurs only at the site scale. Filling, removing vegetation, tilling, or grazing within a wetland has a direct impact on the functions at that site. The most extreme impact to a wetland is the complete removal of all the factors that contribute to the existence of the wetland. Thus, filling a wetland or draining all the water eliminates all of the wetland functions because the wetland no longer exists.

4.3 Impacts from Changing the Physical Structure within a Wetland

Disturbances that directly change the structure of wetlands can be so severe that the wetland is destroyed. Filling or draining a wetland can so alter the water regime that the land can no longer support the wetland vegetation and maintain hydric soils. If a wetland is lost, most if not all of its wetland functions are also lost. Dahl (1990) estimated that 31% of the wetlands in Washington State had been lost prior to the 1980s as a result of filling or draining to the extent there is no longer enough water to maintain areas as wetland.

There are, however, some human alterations of the structure in wetlands that do not result in the complete loss of functions, including:

- Human removal of vegetation (e.g., logging, mowing, or application of herbicides)
- Animal grazing
- Alteration of the soil through tilling or compaction
- Partial draining

This section describes what the literature reports about how these alterations impact wetland functions. The impacts of grazing and removal of vegetation are better understood than those of alterations to the soils. Information was not available on how some of these alterations affect wetland functions described in the following sections, and some impacts are hypothesized based on synthesizing other information.

4.3.1 Impacts on Hydrologic Functions from Changing the Physical Structure

No information was found on how changing the physical structure of wetlands impacts their hydrologic functions (reducing peak flows, reducing erosion, and recharging groundwater). One could hypothesize that removing erect and persistent vegetation (emergent, shrub, or forest species) may impact the reductions in water velocity that occur in wetlands. The density of vegetation is a factor in reducing water velocity during flooding or storm flows (Adamus et al. 2001). If this vegetation is removed, the wetland will probably not be as effective at slowing these flows (in other words, there will be a change in how this wetland function is performed). As a result, downstream erosion and flooding may increase.

4.3.2 Impacts on Functions that Improve Water Quality from Changing the Physical Structure

No information was found on how changing the physical structure of wetlands affects how well wetlands remove pollutants. Removal of vegetation has impacts on both bacteria and plants, and this may affect the uptake and transformation of nutrients and toxic compounds in a wetland. The same can be hypothesized for direct alteration of soils, which may affect the chemical properties in a wetland. It is not possible, however, to predict or hypothesize how such changes might alter the wetland functions (that is, whether functions to improve water quality will increase or decrease).

4.3.3 Impacts on Plants from Changing the Physical Structure in a Wetland

Plants are one of the major factors that determine the physical structure within a wetland. Thus, changing the physical structure in a wetland means that the plants, and the structure they provide, have been removed or modified. Examples of structure that is based on plants include different layers within a forest (e.g., canopy, sub-canopy, ground cover) or the sub-surface root mass of perennial plants. In addition, removal of any vegetation causes at least a short-term change in plant biomass and possibly a change in the composition of plant species.

Vegetation can be removed by fire, tilling, mowing, or grazing (Newman 1991, Naiman and Rodgers 1997). Mortality from logging, dredging or construction activities, flooding, as well as contaminants such as herbicides can also cause loss of plants (Adamus et al. 2001). The process by which vegetation is removed or damaged appears to influence the type, duration, and magnitude of the impact on plants. Vegetation patterns in some wetlands result in part from the differing causes of plant removal and whether those causes are lethal or not (Heitschmidt and Stuth 1991, Baldwin and Mendelssohn 1998).

Impacts to the population of plants in a wetland also depend partly on the process through which the plants re-establish. When all or nearly all of the plants are removed through methods lethal to vegetation (such as with herbicides), recovery occurs mainly via recruitment of seeds. When removal is by non-lethal methods (such as grazing), recovery often is by re-growth of the plants.

The effects of grazing on plants and other aspects of ecosystems has received much attention in the last three decades because of the potential impacts in semi-arid areas (see review in National Research Council 1984). Impacts on wetlands have been studied less intensively, but some information is available. The impacts of grazing on wetland plants depend partly on the density of grazers, how long, and when they are present in the grazed area, the availability of food and water in nearby alternative habitats, and the season (Clary 1995, Fitch and Adams 1998). Specifically:

- In a laboratory experiment Crossle and Brock (2002) found that simulations of grazing changes the reproductive output of plants in wetlands in different ways and that this can change the populations by changing the proportions of seed produced.
- A study of riparian vegetation in eastern Oregon used different simulated grazing treatments to determine the effects of light and heavy grazing (Clary et al. 1996). While not clearly identified, it is evident that some of the plots were in riparian wetlands and others in non-wetland riparian habitats. The authors observed that herbaceous plants increased in growth and vigor in the ungrazed and moderately grazed plots, particularly if the grazing occurred only in the spring. Heavier grazing that lasted all season had detrimental effects on the vegetation.
- In another study in Oregon of riparian meadows, Clary (1995) found that the biomass of the grass redtop (*Agrostis* sp.) remained stable or increased at a low-elevation site

the year following simulated grazing treatments. At higher elevations, sedge species (almost all of which are found mostly in wetlands) either maintained or declined in biomass production the following year. The author concludes that grazing only annually (for several months once a year as opposed to year-round) would significantly reduce sedge production, while not decreasing redtop production.

4.3.4 Impacts on Invertebrates from Changing the Physical Structure of the Habitat

The presence of invertebrate species in a wetland is influenced by the type of plants that grow there. For example, in a Washington pond, some leeches (*Helobdella*), aquatic sowbugs (*Asellus*), mayflies, and some dragonflies (especially the large-bodied *Anax*) were more commonly associated with emergent vegetation than with submerged vegetation or open water areas. Midges, freshwater shrimp (*Hyalella azteca*), and mollusks (especially *Lymnaea* sp., *Gyraulus* sp., and *Anodonta* sp.) were more common on the submerged plants (Parsons and Matthews 1995).

The removal of vegetation either mechanically or through grazing, therefore, has a significant impact on the presence and abundance of invertebrate species in a wetland. Wetland managers often manipulate the structure of vegetation by mowing, burning, plowing, or planting to encourage or discourage populations of desirable or undesirable invertebrates (Batzer and Resh 1992, Kirkman and Sharitz 1994, de Szalay et al. 1996, de Szalay and Resh 1997).

Adamus et al. (2001) conclude from their literature review that the removal of vegetation:

- Removes substrates that would otherwise provide additional vertical space in the water column for invertebrates to colonize
- Removes shade, thus increasing water temperature and causing stress for invertebrates
- Increases the circulation and perhaps the velocity of water, with accompanying increases in dissolved oxygen and possible resuspension of sediments; this may result in changes to the habitats that favor different species of invertebrates
- Reduces inputs of leaf litter that provide food to some invertebrate taxa
- Reduces structures that otherwise shelter invertebrates from predators (Jordan et al. 1994)

Complete removal of vegetation generally reduces the richness of the wetland invertebrate community, but patchy removal or moderate grazing sometimes increases richness (McLaughlin and Harris 1990, Gray et al. 1999).

4.3.5 Impacts on Amphibians and Reptiles of Changing the Physical Structure of the Habitat

The information on the impacts of direct disturbances to the physical structure of a wetland on amphibians is ambiguous for Washington and the impacts cannot be predicted. In the Puget Sound Basin of Washington, surveys of 19 wetlands found no correlations that were statistically significant between amphibian richness and vegetation form (i.e., structure of plants) (Richter and Azous 1995). Plant stem diameter is apparently more important than plant species (Richter 1997).

Removing dense emergent vegetation, however, may impact populations of amphibians. A survey of 40 wetlands in the Puget Sound area found more native species of amphibians among wetlands containing dense emergent vegetation (Adams et al. 1998). Dense vegetation may help protect the larvae of native aquatic amphibians from larger predators. It can be hypothesized, therefore, that removing dense emergent vegetation would probably impact the populations of amphibians.

Other studies have focused on the impacts of grazing. Based on personal observations, Maxell (2000) asserts that livestock grazing can impact amphibians through:

- Trampling of vegetation that results in loss of habitat and reduces insect populations that are food sources for amphibians
- Changes in substrate composition and bank structure
- Increased sedimentation

These observations have been confirmed by Knutson et al. (2004) who reported a statistically significant negative effect of grazing and direct access of livestock to ponds on the reproduction of amphibians.

However, a study of the Columbia spotted frog in 127 ponds in northeastern Oregon does not support these findings. Bull and Hayes (2000) found no significant differences between grazed and ungrazed ponds in terms of the numbers of frog egg masses and the abundance of recently metamorphosed frogs. The volume of egg masses was larger at grazed sites, possibly due to a greater presence of adults or an older population (older, larger females lay bigger egg masses). Six of the eight most productive ponds (those with 20 or more egg masses) were grazed, indicating that grazing had no detrimental effect on this frog in these wetlands.

The differences in the conclusions between these studies may be a result of different intensities of grazing in the wetland. Jansen and Healy (2003) found a clear relationship (statistically significant) between the condition of a grazed wetland (as measured by vegetation and water quality) and the species richness of frogs. They also found a direct correlation between the intensity of grazing and the condition of a wetland.

4.3.6 Impacts on Fish from Changing the Physical Structure of the Habitat

Information in the literature did not differentiate between the responses of resident and anadromous fish to changes in the physical structure in wetlands. The information available addresses impacts to fish in general. For example, the removal of vegetation can have a significant impact on the fish present in a wetland as a result of (Adamus et al. 2001):

- Increased water temperature that may go above the tolerance limits of certain species
- Decreased cover and thereby increased susceptibility to predation
- Changes in foods and their availability

Woody material is especially important as a source of cover for fish in off-channel wetlands such as oxbows and sloughs and in lakes (Leitman et al. 1991, Dewey and Jennings 1992, Fausch and Northcote 1992, McIntosh et al. 1994).

In wetlands along the fringes of lakes, submerged plants are particularly important and their removal can change the habitat for fish. For example, declines in plants resulting from introductions of grass carp (Bain 1993) have been linked to an increase in the proportion of fish species found in limnetic areas (open water) (Bettoli et al. 1991, Maceina et al. 1991, Martin et al. 1992). However, intentional thinning of plant beds can sometimes result in higher growth rates of some age classes of lake fish, presumably by giving them better access to invertebrates that are their food source (Olson et al. 1998).

One impact that has been hypothesized in situations where the physical structure of wetlands is changed is the "stranding of fish (R. Friesz, K. March, B. Zeigler, Washington State Department of Fish and Wildlife, personal communications 2000-2004). Changing the shape or drainage of wetlands can create situations where shallow surface water is connected to streams such as during flood events or high precipitation and then isolated as water levels drop. This may result in the stranding of fish in these shallow pools, and their subsequent demise as the temperatures rise and oxygen levels decrease.

4.3.7 Impacts on Birds of Changing the Physical Structure of the Habitat

Many guilds of birds are sensitive to the presence and type of vegetation and its location in relationship to open water (Kauffman et al. 2001). The removal of vegetation can, therefore, be expected to change the distribution and abundance of birds in wetlands. For example, the rearing success of waterfowl in wetlands is reduced by removing herbaceous cover because it exposes the young to predation (Skovlin 1984).

Grazing has also been found to change the distribution of birds. In a study in southeastern Oregon on the effects of grazing on birds, researchers used exclosures to remove livestock from portions of riparian meadows (Dobkin et al. 1998). They found that the richness and abundance of bird species increased within the exclosures in comparison to the plots that

remained available for livestock grazing. Moreover, the exclosures were dominated by wetland-associated birds while the open plots were dominated by upland bird species.

The changes in physical structure of wetlands that result from grazing can have both positive and negative impacts on shorebirds that use freshwater wetlands (Buchanan, 2004). The negative impacts he reported include the direct trampling that destroyed eggs and nests, the compacting of soil that reduce populations of invertebrate prey, and an increased erosion that reduced populations of invertebrate prey in semi-arid regions.

The changes in the structure of vegetation that result from the conversion of forested wetlands to emergent and open water wetlands can alter species composition and richness of breeding birds. For example, 53% of the bird species that formerly used forested wetlands no longer occur regularly where such forests have been logged and converted to emergent wetlands (Doherty 2000 as reported in Adamus et al. 2001). In the Columbia Basin, where forests are not present, changes in the vegetation of the buffer also had impacts. Heavy grazing next to wetlands removed buffer vegetation and reduced waterfowl production by 50% (Foster et al. 1984).

4.3.8 Impacts on Mammals from Changing the Physical Structure of the Habitat

Many mammals are sensitive to the presence and type of vegetation and its location in relationship to open water. The removal of vegetation is therefore expected to change the distribution and abundance of mammals in wetlands (Adamus and Brandt 1990).

Adamus and Brandt (1990) created a synthesis of the literature on mammal habitat which serves as the basis for the following discussion.

The species richness of small mammals in wetlands has been correlated with the complexity of vegetation structure (Arner et al. 1976, Searls 1974, Landin 1985, Nordquist and Birney 1980, Stockwell 1985, Simons 1985). Removal of vegetation and associated long-term destruction of den sites in both wooded and emergent wetlands have caused changes in furbearer populations and small-mammal communities (Krapu et al. 1970, Malecki and Sullivan 1987). In contrast, restoration of riparian vegetation has led to increases in use by mink (Burgess and Bider 1980).

Grazing at levels recommended by the Natural Resources Conservation Service had no significant effect on the abundance or distribution patterns of small mammals in a cottonwood floodplain in Colorado (Samson et al. 1988). Based on this study, controlled grazing that does not contribute to structural changes in vegetation, appears to have no significant effect on the abundance and distribution of small mammals.

4.3.9 Summary of Key Points

- Filling or draining a wetland can so alter the water regime that the land can no longer support wetland vegetation and maintain hydric soils. If a wetland is lost, most if not all of its functions are also lost.
- Some direct disturbances of wetlands, such as removal of vegetation, grazing, and alteration of the soil, change the wetland functions but do not result in the complete loss of functions.
- Impacts of removing vegetation on the habitat functions in wetlands have been documented for invertebrates, fish, birds, and mammals. Impacts on amphibians, however, are ambiguous. Impacts to the hydrologic and water quality functions resulting from vegetation removal can only be hypothesized since no information was found in the literature.
- Impacts of grazing on habitat functions have been documented for invertebrates and birds and are somewhat conflicting for amphibians. The one study of mammals suggests that low levels of grazing in a floodplain may have minimal impacts on the habitat of this group. No information was found on impacts of grazing on the hydrologic and water quality functions.
- No information was found on the impacts of soil alterations (through tilling and compaction) on any of the functions performed by wetlands.

4.4 Impacts from Changing the Amount of Water in a Wetland

The quantity of water in the landscape is a critical factor in controlling how wetlands function. Many human land uses change the amount of water flowing into and out of wetlands, thereby creating a disturbance that affects the performance of functions in wetlands. The literature is quite clear that the frequency, timing, and duration of water in the landscape determine the presence of a wetland and the functions that it provides (see Chapter 2). How water enters a wetland, how long it is present, and the depths to which it is impounded all influence the functions that a wetland can provide or perform (Brinson 1993b, Mitsch and Gosselink 2000).

The movement and routing of water above and below the surface is the primary force in transporting nutrients, sediment, salts, and contaminants, and this in turn affects the functions provided by wetlands (Naiman et al. 1992). Water moves (or carries) sediment, nutrients, and energy throughout a watershed (Naiman et al. 1992). Changes in the amount of water and thereby the depth of inundation in a wetland, can alter how sediments, nutrients, and toxic contaminants come into a wetland and how they are “processed” within the wetland.

4.4.1 Impacts on Hydrologic Functions from Changing the Amount of Water

Specific documentation was lacking on how increasing or decreasing amounts of water may affect wetland functions in reducing flooding or erosion or recharging groundwater. It can be hypothesized, however, that the storage capacity of a wetland in a depression that drains to areas prone to flooding will be reduced if water levels increase. The volume that would have been available to store floodwaters is used instead to store the increased volumes coming into the wetland. This suggests that the functions related to reducing flooding would also decline because storage is a large component of flood reduction. On the other hand, wetlands in which water is deeper or covers more of the wetland may provide better recharge of groundwater because infiltration depends on the depth of water in the wetland (hydraulic head) and the area that is submerged (Hruby et al. 1999).

The converse can be hypothesized if water levels in wetlands decrease. The potential amount of water that can be stored in a wetland will increase as it becomes drier, thereby increasing the "flood reduction" functions. The function of recharging groundwater would decrease because less water would be present and it would be shallower.

4.4.2 Impacts on Functions that Improve Water Quality from Changing the Amount of Water

Increasing the amount of water in a wetland brings a greater volume of surface water in contact with wetland plants, soils, and the chemical processes that lead to water quality improvement. Increased flooding in wetlands can change residence time, the distribution of aerobic and anaerobic environments, and a variety of microbial and non-microbial chemical processes (Kadlec and Knight 1996). These factors can all change how wetlands remove contaminants.

Because there are so many factors involved in removing individual contaminants it is not possible to generalize the response of a wetland to changes in water levels. Kadlec and Knight (1996) provide further discussion on the many different ways water levels affect the capacity of wetlands to remove toxic compounds. The discussion below provides only a few examples.

For example, the activity of microbes potentially increases conversion of inorganic mercury to the much more toxic form, methyl mercury (Kelly et al. 1997). In this case flooding would reduce the effectiveness of a wetland at improving water quality because the wetland may become a source of this more toxic compound. We do not have specific data about mercury in Washington's wetlands, although mercury is a water quality issue in some waters of the State (e.g., the high levels of mercury found in freshwater fish) (Ecology 2003). We can hypothesize, therefore, that mercury is present in some of the state's wetlands and can be released under anaerobic conditions.

In addition, a change in the rate of nitrogen removal can be hypothesized to result from a shift in the amount of water present in a wetland. In Washington, the area that is seasonally

inundated was judged to be a critical factor in determining nitrogen removal by wetlands (Hruby et al. 1999). If the increase in water levels expands the area that is seasonally flooded, the rates of nitrogen removal will probably increase. If, however, increases in the amount of water in a wetland expand the amount of permanent water at the expense of the areas that were seasonally flooded, the rates of removal can be hypothesized to decrease. Thus, wetlands in which the water regime has been changed will probably have a different rate of nitrogen removal than they had previously.

4.4.3 Impacts on Plants from Changing the Amount of Water

Much of the literature on how changing amounts of water affect plant populations in wetlands of the Pacific Northwest is in terms of changes in the dynamics of water movement (hydroperiod). This concept combines both changes in water levels and changes in how water levels fluctuate (the latter is addressed as a separate disturbance in Section 4.5).

The composition and richness (number of species) of the plant community are influenced by the water in the root zones of wetland plants. This is influenced by:

- The **duration** of saturation (Dicke and Toliver 1990, Merendino and Smith 1991, David 1996, Vivian-Smith 1997, Silverton et al. 1999, Casanova and Brock 2000)
- The **timing** of saturation (Merendino et al. 1990, Squires and van der Valk 1992, Scott et al. 1996, 1997, Gladwin and Roelle 1998)
- The **frequency** of saturation (van der Valk 1994, Pezeshki et al. 1996, 1998, Smith 1996, Pollock et al. 1998, Casanova and Brock 2000)
- The **depth** of water (Casanova and Brock 2000).

Disturbances to any of these factors in a wetland can cause major changes in the distribution and richness of plant species. The response of an individual wetland to such changes, however, is difficult to predict. The existing information indicates that each plant species responds in a different way to changes in water levels. This means that overall the response of the plant community in a wetland will depend on the sum of the responses of the individual species. The following discussion summarizes some of the studies documenting how plant communities change with changes in water levels. It is beyond the scope of this document to provide detailed information on the response of individual plant species.

> Responses of hundreds of plant species to specific hydrologic variables that have been studied are presented in a database at EPA's web site (Adamus and Gonyaw 2000). The database is available at http://www.epa.gov/owow/wetlands/bawwg/publicat.html

The changes in plant communities are linked to differences among plant species in their ability to resist drought and flooding. The life history and physical characteristics of plants play a role (Earnst 1990, Koncalova 1990, Voesenek et al. 1993, Kirkman and Sharitz 1993, Teutsch and Sulc 1997). The characteristics of seed dispersal and germination of plants

relative to water dynamics may have the greatest effect on the relative abundance of species, according to a simulation conducted by Ellison and Bedford (1995) using six years of data from a southern Wisconsin sedge meadow. Some species, such as cattail (*Typha* spp.), are able to keep pace with rising water levels because their stem tissue elongates rapidly and to a greater degree than other species (Waters and Shay 1992, Galatowitsch et al. 1999) or they sprout adventitious roots (Voesenek et al. 1993).

Increases in inundation may change the exposure of plants to competitors and herbivores (Wilson and Keddy 1991) and cause a shift in the location of plant communities within a wetland (van der Valk et al. 1992). The opposite extreme—dehydration—kills plants partly by removing the pathway for taking up nutrients and maintaining tissues. Dehydration may also increase or decrease competition and plant exposure to herbivores (Adamus et al. 2001).

Woody plants are particularly sensitive to prolonged inundation, especially for longer than 80 days (Niswander and Mitsch 1995, Toner and Keddy 1997, Sharitz and Gresham 1997). Their seedlings consequently are most affected during years when flooding occurs at or shortly after the beginning of the growing season, or when flooding persists for more than 40% of the growing season (Toner and Keddy 1997). Annual (as opposed to perennial) species tend to increase proportionately in response to drought and some other severe disturbances (Poiani and Johnson 1989).

Species with small, light seeds seem particularly adept at colonizing mudflats exposed during drawdowns and after disturbances (Poiani and Johnson 1989, Ellison and Bedford 1995). These species tend to emerge early in the season and may be more successful by taking advantage of greater light availability (Toner and Keddy 1997).

Successive years of annual drawdowns can favor the spread of many non-native plant species within wetlands (van der Valk 1994). Dominance of a wetland by just a few species is sometimes a sign that the wetland has experienced prolonged drought or drawdown (Wilcox 1995).

Many species have only a narrow "window" in which they can germinate. For example, there may be only a few weeks when favorable water levels or a temporary lack of competitors must coincide with favorable temperatures and acceptable water quality (Rood et al. 1998).

4.4.4 Impacts on Invertebrates from Changing the Amount of Water in the Habitat

Disturbances to the amount of water in a wetland can cause major changes in the distribution and richness of invertebrate species. Because each species responds in a different way to increases or decreases in water regime, the overall response of the invertebrate community in a wetland will depend on the sum of the responses of the individual species.

Responses of hundreds of invertebrate species to specific hydrologic variables that have been studied (Adamus and Gonyaw 2001) are presented in a database at EPA's web site. The database is available at http://www.epa.gov/owow/wetlands/bawwg/publicat.html

In general, the amounts of water in a wetland influence the distribution and richness of invertebrates by:

- Altering the amount and pattern of horizontal and vertical habitat space available for colonization (Adamus et al. 2001)
- Changing the types of algae and vascular plants that occur, the proportions of these two major food sources for invertebrates, and the seasons in which they occur (Murkin et al. 1992)
- Changing the extent of contact between plants and water, thus influencing attachment space, availability of detrital foods, shade, and shelter (Ross and Murkin et al. 1991, de Szalay et al. 1996)
- Influencing the access of predators (Reice 1991, Martin et al. 1991, Mallory et al. 1994, Johnson et al. 1995, Wellborn et al. 1996)
- Affecting the intensity of competition (Wissinger et al. 1999)
- Causing mortality if complete desiccation or freezing occurs (Layzer et al. 1993)

4.4.4.1 Impacts on Invertebrates from Reducing the Amount of Water in the Habitat

Some of the most dramatic changes to wetland invertebrate communities occur when wetlands that seldom or never dry out completely are subjected to drought or complete drawdown (Adamus et al. 2001). Less dramatic changes to invertebrate communities occur with slight alterations in the timing, duration, predictability, and depth of surface water (Eyre 1992, Giberson et al. 1992).

Drought and drawdown render the less mobile species of invertebrates more vulnerable to predation, as well as causing their direct loss due to desiccation and related factors (e.g., Stanley et al. 1994). Drought also seems to favor non-insect invertebrates, which can increase at the expense of the insect component of the invertebrate community (Hershey et al. 1999). References to drought and drawdown section are for a desert stream (Stanley et al. 1994) and Minnesota (Hershey et al. 1999), respectively. It is reasonable to extrapolate the findings of these studies to eastern Washington, which may have climates and conditions that are somewhat similar to those in the cited literature, but they may not apply to western Washington.

Coupled with the studies that show invertebrate richness increasing with longer periods of inundation, these observations indicate that removing water from a wetland may reduce the species richness of invertebrates.

4.4.4.2 Impacts on Invertebrates from Increasing the Amount of Water in the Habitat

An increase in the amount of water in a wetland seems to change the composition of the invertebrate community. Densities of swimming (nektonic) and bottom-dwelling (benthic) predatory invertebrates do not increase with flooding as much as the numbers of nektonic and benthic herbivores and detritivores. Predatory species can even decrease after flooding (Murkin et al. 1991), and they often increase as drought or drawdown progresses.

Although flooding generally increases the density and richness of invertebrates in wetlands, the increase may be short-lived. For example, flooding of Manitoba marshes (Murkin et al. 1991) to a level 3 feet (1 m) above normal caused a major increase in numbers of nektonic invertebrates in both vegetated and open water areas for only one year. Furthermore, densities of benthic invertebrates increased in flooded vegetation but not in open areas. The biomass of nektonic invertebrates increased only in the vegetated areas (Murkin et al. 1991).

Some researchers have observed that food webs become more complex and taxa numbers increase as wetlands become wetter, such as those that are ponded for longer periods. This has been observed in seasonal wetlands of eastern Washington (Lang 2000). Also, the use of emergence traps in 19 wetlands in King County yielded more taxa from permanently flooded than seasonally flooded wetlands (Ludwa and Richter 2001b), suggesting that wetlands in which the water levels fluctuate more often will have fewer invertebrate species.

These results suggest that disturbances that cause water to remain longer in a wetland will probably increase species richness at first. The long-term effects of such increases, however, are not well understood.

4.4.5 Impacts on Amphibians and Reptiles from Changing the Amount of Water in the Habitat

Most amphibians cannot tolerate prolonged dry periods. Drying of seasonal pools, especially when it occurs ahead of normal seasonal schedules, can greatly diminish the breeding success of amphibians (Rowe and Dunson 1993). This is partly because many amphibian species disperse only short distances (Berven and Grudzien 1990).

Amphibian populations scattered across wetlands of varying depth and water permanence can enable species to survive long-term droughts or floods. The availability of numerous, scattered wetlands can protect amphibians against effects of localized drought. Some frog and toad species living in relatively intact landscapes seem mostly unaffected, at the level of populations, by significant periods of drought (Dodd 1995).

In addition, both prolonged desiccation and extreme floods can increase opportunities for invasion of wetlands by exotic plant species. This change in water regime can impact the suitability of a wetland as habitat for amphibians by changing the structure of the wetland. Patterns of vegetation typically become more homogeneous, prey abundance may decline, and the habitat may become less suitable for amphibians (Ludwa 1994).

Changing the amount of water in wetlands can also impact the populations of reptiles. During a two-year drought in Washington, a local population of painted turtle (*Chrysemys picta belli*) suffered a 70% decline (Lindenman and Rabe 1990). This appeared to be due to both mortality and movement of turtles out of the wetland. Growth of the turtles was suppressed but it recovered as conditions improved. Drawing down the water level in the autumn to allow wetland management, flood control, or for other reasons can cause high mortality among juvenile turtles that are overwintering due to freezing. This occurs if the drawdowns follow abnormally high water levels in late summer that attracted turtles (Galat et al. 1998).

These results indicate that changing the amounts of water in a wetland affects both amphibians and reptiles. Impacts may occur both from lowering the water levels (for example, through ditching, draining, or pumping) or raising the levels through increased flooding as a watershed is developed.

4.4.6 Impacts on Fish from Changing the Amount of Water in the Habitat

Declines in the amounts of water alter the community structure of wetland fish. Fish experience a greater need to use overlapping resources and face an increased risk of predation when wetlands become drier (Adamus et al. 2001). Low water also increases the chance of fish freezing in winter or dying from thermal stress in summer (Adamus et al. 2001).

Sustained drawdowns can also reduce competition among fish that return to wetlands when water levels rise again by temporarily eliminating larval dragonflies and other large invertebrates that normally compete for food with the fish or prey on larval fish (Travnichek and Maceina 1994).

Impacts of increasing water levels on fish in wetlands were not documented in the literature.

4.4.7 Impacts on Birds from Changing the Amount of Water in the Habitat

Disturbances to the amounts of water in a wetland can cause major changes in the distribution and species of birds. As with plants and invertebrates, the overall response of the bird community in a wetland will depend on the sum of the responses of the individual species.

4.4.7.1 Impacts on Birds from Reducing the Amount of Water in the Habitat

Drainage and some other disturbances in the amounts of water in wetlands have been well documented as contributing to the decline of many wetland bird species (David 1994, DeAngelis et al. 1997). In Manitoba, for example, wetland drainage has made breeding and brood-rearing areas for waterfowl less available (Rotella and Ratti 1992). As wetlands are

drained or converted to other land cover types, local densities of wetlands decline and the average distances between individual wetlands increase.

Drought conditions also expose duck nests to greater predation. With drought, plants are less dense and vigorous, and islands that formerly were inaccessible gain new access points (Hallock and Hallock 1993, Jobin and Picman 1997).

Widespread drawdown of water tables reduces the number and perhaps the variety of wetlands and their vegetation communities. This in turn diminishes the richness, density, and breeding success of birds in many individual wetlands and wetland complexes (Higgins et al. 1992, Bethke and Nudds 1993, Bancroft et al. 1994, Greenwood et al. 1995, Dobkin et al. 1998).

4.4.7.2 Impacts on Birds from Increasing the Amount of Water in the Habitat

Increasing the duration of saturation or inundation can change the use of wetlands by a variety of birds. This change can occur when shallow ephemeral ponds are dredged to make areas with longer periods of standing water (such as stock ponds). In the Columbia Basin, Creighton et al. (1997) found an increase in use by several species of diving and dabbling ducks, coots, and terns when shallow, densely emergent wetlands were dredged to create deeper pools of open water. They also documented an increase in the biomass of zooplankton, a food source for several guilds of birds. However, there was a decrease in use by sora (*Porzana carolina*) and Virginia rails (*Rallus limicola*) as well as red-winged blackbirds (*Agelaius phoeniceus*). The use of the excavated habitats by rails was expected to increase over time as emergent vegetation became reestablished in the excavated pools because rails prefer vegetation that is a mix of robust and thin-stemmed species. An increase in use by shorebirds was one short-term benefit. The shorebirds fed on the moist, fresh dredge spoils and exposed unvegetated soils of the newly excavated basins. Once the soils became vegetated, use by shorebirds declined.

On the other hand, while construction of reservoirs raises water levels, this affects birds by eliminating many wetlands through flooding and destabilizing water levels in the remaining wetlands (Nilsson and Dynesius 1994). Associated changes in river morphology influence the species composition of wintering waterfowl (Johnson et al. 1996).

4.4.8 Impacts on Mammals from Changing the Amount of Water in the Habitat

Information on how disturbances to the amount of water in a wetland may affect their ability to provide habitat for mammals was not found. It is not possible at this stage to hypothesize either positive or negative impacts on habitat for mammals because no logical deductions could be made from the available information.

4.4.9 Summary of Key Points

- Impacts of reducing water levels on the habitat functions of wetlands have been documented for invertebrates, fish, birds, and amphibians. All these groups have reduced species richness and abundance when wetlands dry up.
- Impacts of increasing water levels in wetlands on its functions as habitat have been documented for invertebrates and birds. The species richness of invertebrates may increase for a short time if a wetland becomes wetter. The impacts on the populations of birds are mixed. In some cases the richness of birds increases and in some cases it decreases.
- Impacts to the suitability of wetlands as mammal habitat resulting from either increasing or reducing water levels have not been studied.
- Reducing the amount of water changes the distribution of plants in a wetland, but the studies did not address if species richness will increase or decrease. Data suggest that woody species will tend to be replaced by more grass-like species when water levels in a wetland increase.
- Impacts to the hydrologic and water quality functions from either increasing or reducing water levels can only be hypothesized since no information on these topics was found in the literature.

4.5 Impacts from Changing the Fluctuation of Water Levels within a Wetland

A major finding of the Puget Sound Wetlands and Stormwater Management Research Program was that fluctuations in water level are key in determining biological responses. There are different types of fluctuations in water levels in a wetland and these are described in the shaded box below. The researchers found a decline in the biotic diversity of wetlands associated with an increase in water level fluctuations caused by expanding impervious area within the contributing basin (Reinelt et al. 1998, Azous and Horner 2001).

Prolonged inundation (that is, less frequent water level fluctuations) resulting in a lack of oxygen in the soils has been indicated as a factor in changing the biota of wetlands. Although many hydric soils may be anaerobic, changing the length of time the soils are inundated results in prolonged anaerobic conditions and chemical changes in the soils. These changes in soil chemistry influence the survival of vegetation and microbes in the soil that were adapted to shorter periods of inundation (Thom et al. 2001).

Mechanisms for how fluctuations of water levels affect aquatic systems

Richter et al. (1996) developed a method to model "indicators of hydrologic alteration" based on assessing changes in 32 hydrologic parameters. They identified these parameters as being relevant to the biotic integrity of aquatic ecosystems. They divided the parameters into the following five fundamental factors that characterized how fluctuations in water levels influence biotic communities in aquatic systems:

Magnitude. A measure of the availability or suitability of aquatic habitat. It defines such habitat attributes as wetted area or habitat volume, or the position of a water table relative to the rooting zones of wetland or riparian areas.

Timing. The timing of occurrence of a particular water condition. It can determine whether certain life-cycle requirements are met. It can also influence the degree of stress or mortality associated with extreme water conditions such as floods or droughts.

Frequency. Refers to the frequency of occurrence of specific hydrologic conditions, such as droughts or floods. It may be tied to events such as the reproduction or mortality of various species, thereby influencing population dynamics.

Duration. The length of time over which a specific hydrologic condition exists. It may determine the success of the life cycle of a particular species or the accumulation of stressful effects.

Rate of change. In hydrologic conditions may be linked to stranding of individuals (in isolated pools or along a wetted edge). It may also be related to the ability of sensitive species to maintain root contact within the phreatic zone (the portion of the soil that is influenced by proximity to the groundwater table).

4.5.1 Impacts on Hydrologic Functions from Changing the Fluctuations in Water Levels

The literature did not provide explicit information on possible impacts of changes in water level fluctuations on factors within a wetland that affect its hydrologic functions. It is not possible at this stage to hypothesize either positive or negative impacts on hydrologic functions because no logical deductions could be made from the available information. The major questions that need to be addressed include:

- Will changes in the frequency or amplitude of water level fluctuations change the flood storage capacity of a wetland?
- Will changes in the frequency or amplitude of water level fluctuations change the way in which a wetland reduces water velocity?
- Will changes in the frequency or amplitude of water level fluctuations change the way in which a wetland recharges groundwater?

4.5.2 Impacts on Functions that Improve Water Quality from Changing the Fluctuations in Water Levels

How changing fluctuations in water levels impact the ability of wetlands to improve water quality was not detailed in the literature. It is not possible to hypothesize either positive or negative impacts on water quality functions because no logical deductions could be made from the available information. The major questions that need to be addressed include:

- Will changes in the frequency or amplitude of water level fluctuations change how a wetland traps sediment?
- Will changes in the frequency or amplitude of water level fluctuations change the way in which a wetland removes nitrogen?
- Will changes in the frequency or amplitude of water level fluctuations change the way in which a wetland captures or transforms toxic compounds?

4.5.3 Impacts on Plants from Changing the Fluctuations in Water Levels

In general, the amplitude and rate of water level fluctuations have been found to influence the species composition, biomass, and germination of plants (Hudon 1997, Shay et al. 1999). Furthermore, the timing of inundation and duration throughout the seasons also influences plant species richness and survival (Ewing 1996, Reinelt et al. 1998, Owen 1999, Azous et al. 2001). If these hydrologic factors change as a result of human activities as described in Chapter 3, one can then hypothesize changes in plant communities.

Researchers in the Puget Sound regions correlated a decline in plant species richness in urbanized watersheds where water level fluctuations had increased (Azous and Cooke 2001). Among 26 wetlands in the Seattle area, the degree of seasonal fluctuation in water level was negatively associated with richness found in emergent and shrub wetlands. However, it had no statistically significant effect on species richness in forested wetlands (Cooke and Azous 2001). These authors found that fluctuation during the early spring seemed to have an especially detrimental effect on plant richness in the emergent and shrub wetlands.

Reinelt et al. (1998) found that the development of plant communities in lowland wetlands of Puget Sound was related to water level fluctuations and depth of inundation during the early growing season. They noted that shifts in the "hydrologic profile" of the wetland caused a subsequent shift in the species composition of the wetland's plants. The emergent and scrub-shrub communities of the wetland tended to have lower plant richness when average, annual water-level fluctuations increased to over 8 inches (20 cm).

Azous and Horner (2001) determined that the duration of flooding, as well as depth, also strongly influenced plant diversity. They noted greatest plant diversity when:

- Flooding events were less than 0.5 feet (0.2 m) above predevelopment levels
- Floods were limited to an annual average of three or fewer events per month
- The cumulative duration of flooding was less than six days per month above predevelopment averages

On the other hand, a lack of fluctuation in water level can be just as damaging as excessive fluctuation to some wetland plant species (Rood and Mahoney 1990). This is because many species need a period of desiccation in order to germinate. Furthermore, the loss of wet-dry cycles in floodplain wetlands that result from the construction of dams favor exotic species that replace the native plant community (Bunn and Arthington 2002).

On the other hand, evidence from some studies suggests that the relative tolerance to increases in water level fluctuations is greatest among several non-native or invasive species (Figiel et al. 1995, Haworth-Brockman and Murkin 1993, King and Grace 2000). Increases in water level fluctuations and duration of inundation favor generalist plants (plants that are found under a wide range of environmental conditions) in the Pacific Northwest (Azous et al. 2001).

These results indicate that changes to water level fluctuations in wetlands are likely to result in shifts in the composition, distribution, and abundance of plants, especially in situations where there is a relatively stable hydroperiod with low level fluctuations. Furthermore, either decreases or increases in water level fluctuations will probably facilitate the invasion of non-native or "aggressive" native species by increasing the level of disturbances to which plants are subject.

4.5.4 Impacts on Invertebrates from Changing the Water Level Fluctuations in the Habitat

In the Northwest, researchers have observed a decline in the number of invertebrate species in wetlands as the impervious area in the basin increases (Ludwa 1994, Hicks 1996, Ludwa and Richter 2001a, Thom et al. 2001). Since changes in the fluctuations of water levels are a major disturbance that results from an increase in impervious surface, it can be hypothesized that the decline in the Northwest is a result of this disturbance. Information from other parts of the United States seems to confirm this hypothesis.

The densities of some invertebrate species can be decimated by rapid water level fluctuations, especially when the fluctuations are more frequent and severe than historically encountered in the wetland. For example, Missouri floodplain pools that experience large fluctuations in water level during major floods tend to have lower invertebrate density (Magee et al. 1993). Repeated exposure to desiccation in a short period of time can lead to a marked reduction in the density of invertebrates. In an Arizona stream that experienced 12 flash floods between August and December of a single year, densities of all invertebrates

were reduced by 75% to 100% (Boulton et al. 1992). In particular, the numbers of water spiders, midges, and some caddisflies, mayflies, and snails declined.

A number of studies have found that reducing fluctuations in streams by maintaining minimum water levels (such as in reservoirs) can increase invertebrate densities in the part of an adjacent wetland that is not permanently inundated (Weisberg et al. 1990, Troelstrup and Hergenrader 1990).

4.5.5 Impacts on Amphibians and Reptiles from Changing the Water Level Fluctuations in the Habitat

In Puget Sound wetlands, amphibian species richness was negatively correlated with the percent of impervious cover in a contributing basin. The primary cause is increased water level fluctuation (Richter and Azous 2001a). The richness of amphibians declined to less than three species when water level fluctuations increased to over 8 inches (20 cm) (Richter and Azous 2001a, Thom et al. 2001). Chin (1996) concluded that the reduced richness of amphibians was correlated with a reduction in the diversity of wetland plants that resulted from increases in water level fluctuations.

Increases in fluctuation of water levels also affect amphibians by (1) stranding egg masses when water levels drop, and (2) reducing the thin-stemmed emergent plant species on which amphibians lay their eggs. Unpublished work by Richter (K. Richter, King County, personal communication 2002) in western Washington found that amphibians preferred thin-stemmed vegetation on which to lay their egg masses. Greater water level fluctuation directly affects amphibian egg survival and causes changes in plant species, reducing the thin-stemmed emergent species used by amphibians for egg laying (Chin 1996).

No correlations were found between the richness of amphibian species and a variety of other factors including wetland size, distance to breeding habitats, presence of predators, and number of vegetation classes (Richter and Azous 2001a). The most significant factor affecting species richness was mean water level fluctuation, with 8 inches (20 cm) mean annual fluctuation being a threshold for lentic breeding species (those that breed in stagnant or slow-moving waters such as ponds and wetlands). Lentic breeding amphibians appear to be affected by increases in the duration and frequency of flooding and increased discharge rates resulting from the greater frequency and magnitude of storm peaks in urban watersheds (Richter and Azous 2001a).

Amphibian populations in western Washington generally experience impacts in contributing basins with increasing amount of impervious surface (Booth and Reinelt 1993). A more recent study documented that watersheds with less than 15% total impervious area had three or more amphibian species, whereas most watersheds with more than 25% impervious area had less than three species (Chin 1996). Chin (1996) concludes that changes in water level fluctuations and maximum water levels during spring breeding and embryo development are the primary adverse effects of increased impervious surface.

4.5.6 Impacts on Fish from Changing the Water Level Fluctuations in the Habitat

No specific information was found on how changing fluctuations in water levels impact the ability of wetlands to provide habitat for fish. It is not possible to hypothesize either positive or negative impacts on habitat for fish because no logical deductions could be made from the available information.

4.5.7 Impacts on Birds from Changing the Water Level Fluctuations in the Habitat

General observations have indicated a decline in bird richness for wetlands located in a contributing basin that is developed or developing. Richness was not reduced in contributing basins that remained rural or relatively undeveloped over the course of the Puget Sound Wetlands and Stormwater Management Research Program (Richter and Azous 2001b, Thom et al. 2001). These observations have not specifically been correlated with changes in the fluctuation of water levels, although it can be hypothesized that some of the changes observed are a result of changes in water level fluctuations because this is one of the major disturbances caused by impervious surface (see Chapter 3).

4.5.8 Impacts on Mammals of Changing the Water Level Fluctuations in the Habitat

No explicit information on how changing fluctuations in water levels will impact mammal populations in wetlands was presented in the literature. It is not possible to hypothesize either positive or negative impacts on mammal populations because no logical deductions could be made from the available information.

4.5.9 Summary of Key Points

- No information was found on the impacts to the hydrologic and water quality functions of wetlands resulting from altered fluctuations in water levels.
- Impacts on habitat for invertebrates and amphibians resulting from changes in how water levels fluctuate in wetlands have been documented. Both groups of wildlife exhibit reduced species richness and abundance when wetlands are subject to increased fluctuations in water levels. Impacts to the suitability of wetlands as habitat for mammals, fish, and birds have not been documented.
- Increasing and decreasing fluctuations in water levels also reduce plant richness in wetlands.

4.6 Impacts from Changing the Amount of Sediment Coming into a Wetland

The sporadic movement of sediment in and out of wetlands is a disturbance that also occurs in the absence of human activities. For example, the persistence of some wetlands (i.e., certain riverine and lakeshore wetlands) depends on a sporadic deposition of sediment (Mistch and Gosslink 2000). On the other hand, depressional wetlands are natural sinks for sediments because they are the low points in the topography (Brinson 1993b), and this is a function they perform with or without the presence of human activities. Negative impacts to wetlands occur when the amount of sediment coming into a wetland either increases or decreases from the levels that are present in the absence of human activities (see Mistch and Gosslink 2000 for general references to this process).

4.6.1 Impacts on Hydrologic Functions from Changing the Amount of Sediment

Despite a lack of explicit information on impacts that sedimentation may have on hydrologic functions, it is possible to hypothesize that increases in sediment load to a wetland will reduce the amount of water it can store. For every cubic yard of sediment deposited in a wetland and not transported further, the storage capacity of water is reduced by a similar amount. This means that depressional wetlands along stream corridors with high inputs of sediment may lose much of their ability to store surface waters during floods. A similar hypothesis can be made for depressional wetlands with no surface outflow. Increases in sediment load to such wetlands can reduce the storage capacity.

4.6.2 Impacts on Functions that Improve Water Quality from Changing the Amount of Sediment

No information was found on how changing the sediment load to a wetland might change the water quality functions in wetlands. It is not possible to hypothesize either positive or negative impacts on the water quality functions because no logical deductions could be made from the available information.

4.6.3 Impacts on Plants from Changing the Amount of Sediment

Accelerated sediment deposition or erosion can tax the ability of plant communities to adapt (Kantrud et al. 1989, Jurik et al. 1994, Wang et al. 1994). Sediments have been found to impact plant communities in wetlands in several general ways:

- **Burying seeds, leaves, or plants.** Sedimentation can bury established vegetation and seed banks (Adamus et al. 2001). The burial of leaves prevents photosynthesis and restricts gas exchange through foliage (Ewing 1996). Buried plants expend energy

elongating their shoots in an attempt to outpace sedimentation, seeking oxygen and light, and consequently may be less robust.

- **Changing the depth of habitats.** Over the long term, sedimentation can shrink shallow wetlands or reduce the depth of ponds that previously were too deep to support many wetland plants. Such long-term changes in water depth or relative elevation also result in shifts in species composition, as has been documented in the Mississippi River floodplain (Adamus et al. 2001).

- **Inhibiting germination.** Seeds of the most sensitive species often fail to germinate when buried (Dittmar and Neely 1999). The addition of sediment has been found to reduce germination rates of herb species in wetlands by 34% (Neely and Wiler 1993), 80% (Jurik et al. 1994), and 90% (Wang et al. 1994) depending on the species involved. In general, the species with larger seeds appear to be better able to survive burial (Dittmar and Neely 1999, Jurik et al. 1994, Wang et al. 1994).

  Less than 0.5 inch (1 cm) of sediment can inhibit germination of cattails (*Typha* sp.), barnyard grass (*Echinocola crusgalli*), rice cutgrass (*Leersia oryzoides*), and sedges (*Carex* sp.) (Jurik et al. 1994). Sedimentation inhibits the germination of cattail (*Typha latifolia*) seeds more than seeds of bur-reed (*Sparganium eurycarpum*) (Neely and Wiler 1993). Germination of cattail (*Typha* x *glauca*) seeds decreased by 60% to 90% when sediment loads of less than 0.5 inch (0.2 to 0.4 cm) were applied to the surface of the soil (Wang et al. 1994).

  In contrast, burial by 1 inch (2 cm) of sediment does not interfere with germination of several non-native plant species (Blackshaw 1992, Reddy and Singh 1992).

- **Reducing survival of seedlings.** Excessive sedimentation can reduce the survival of seedlings (Jurik et al. 1994). For example, the density of cattail seedlings and their biomass decreased as sediment loads increased from 0.08 to 0.5 inch (0.2 to 1.0 cm). One study found a fourfold greater density of annuals (vs. perennials) in some heavily sedimented sites (Neely and Wiler 1993). Older and larger seedlings were more tolerant of burial (Wang et al. 1994).

- **Favoring species more tolerant of sediment.** Sedimentation impacts individual wetland species in different ways. The composition of the plant community will therefore change as the most sensitive species are suppressed by the sediment while the more tolerant ones thrive. Effects of sedimentation on particular wetland plant species are not well documented (van der Valk and Jolly 1992) but findings relevant to wetland species found in Washington are discussed here.

  Many mature plants, and especially woody species, apparently are not harmed by a small amount of sedimentation (Wang et al. 1994). Adult plants of wild celery (*Vallisneria americana*) tolerated burial to depths of up to 4 inches (10 cm) but none survived burial under sediment depths of 10 inches (25 cm) (Rybicki and Carter 1986). Among woody plants, saplings of red alder (*Alnus rubra*) tolerated burial less well than those of Oregon ash (*Fraxinus latifolia*) (Ewing 1996).

Growth of the invasive reed *Phragmites australis*, however, typically keeps pace with moderate rates of sedimentation (Pyke and Havens 1999). However, seeds, seedlings, and plants that have evolved in wetland types in which sedimentation is rare (such as bogs) may be highly sensitive to burial. The size of particles that are being deposited, not just their amount, may also influence plant survival (Dittmar and Neely 1999).

A recent study by Mahaney et al. (2004) found that the response of plants to increases in sedimentation depends on the hydrogeomorphic class of the wetland. Increases in sedimentation reduced the emergence of four species found in riparian depressions but only affected one species in slope wetlands and none in headwater floodplains.

4.6.4 Impacts on Invertebrates from Changing the Amount of Sediment in the Habitat

In general, increased amounts of sediment can reduce the richness and density of invertebrates and alter their species composition. Excessive sedimentation affects invertebrates through several mechanisms (reviewed in Adamus et al. 2001):

- Burial of detritus and algae, which are important food sources
- Increase in the time required for invertebrates to move through deposited sediment and collect scarce food items
- Reduced flow of water through soil particles, which is necessary to supplying invertebrates with adequate dissolved oxygen
- Mortality of plants that otherwise provide attachment structures and shelter to invertebrates

Some studies have linked changes in invertebrate communities to the development of watersheds (e.g., Hogg and Norris 1991, Ludwa 1994, Carlisle et al. 1998, Ludwa and Richter 2001a). Development often is accompanied by increased export of sediment to water bodies.

Many invertebrate communities in wetlands are adapted to occasional deposition of small amounts of sediment, whereas constant or severe deposition causes major changes. The following bullets summarize some of the studies that have documented impacts of sediment on individual invertebrate species, as well as groups of species, many of which are found in Washington.

- Once deposited, sediments can further damage wetland invertebrate communities if they are re-suspended by wind mixing or fish, making the water turbid. For example, bottom-feeding carp (*Cyprinus carpio*) noticeably increase turbidity, both directly (as they move along the bottom) and by consuming aquatic plants that otherwise would stabilize and trap sediments (Lougheed et al. 1998). The biomass of planktonic invertebrates declined in Utah ponds after introduction of carp (Huener and Kadlec 1992).

- In some instances, invertebrate density and perhaps richness can increase over the long term if sedimentation replaces coarser substrates with finer substrates that better support establishment of rooted plants. In temporarily flooded prairie pothole wetlands, only caddisflies seemed relatively unaffected by surrounding land use that generated sediments. Ostracods (seed shrimp), cladocerans (water fleas), and some snails (planorbiids, lymnaeids, physids) were diminished, presumably in part because of sedimentation (Euliss and Mushet 1999).

- Burrowing, tube-forming worms and midges commonly predominate where sediments accumulate (Magee et al. 1993). Filter-feeding species and those that graze on the bottom are most sensitive (Lougheed and Chow-Fraser 1998). However, invertebrate size and behavior also influence their tolerance to sediments (McClelland and Brusven 1980). On the other hand, substrates newly created by sedimentation may attract tolerant individuals and species that are poor competitors on older, more crowded substrates (Soster and McCall 1990).

- Severe and rapid sedimentation is inevitably lethal to nearly all aquatic invertebrates. In North Dakota, wetlands surrounded by cropland were virtually devoid of the resting eggs of zooplankton, whereas such eggs were abundant in wetlands surrounded by mostly natural grassland, which presumably minimized erosion and sedimentation (Euliss and Mushet 1999).

- Unionid mussels (mussels in the family Unionidae) are sensitive to increased sedimentation (Goudreau et al. 1993, Box and Mossa 1999). Numbers of the swamp fingernail clam (*Musculium partumeium*) and amphipods were reduced in willow wetlands in northeastern Missouri where 2 to 4 inches (5 to 10 cm) of sediment had been recently deposited (Magee et al. 1993).

- Sediments may clog the filter feeding mechanisms of some species and limit light penetration. This would adversely impact phytoplankton and other primary producers, with a subsequent adverse impact on food chains (Euliss and Mushet 1999).

- Sediments also potentially buries invertebrate eggs deposited in the substrates of wetlands (Euliss and Mushet 1999).

4.6.5 Impacts on Amphibians and Reptiles from Changing the Amount of Sediment in the Habitat

Few studies of the impacts of increases in the deposition of sediment on amphibians and reptiles have been conducted in wetlands. On one hand, some species require soft sediments as hibernation sites. For example, painted turtles (*Chrysemys picta*) used sediments 1.6 to 3 feet (0.50 to 0.95 m) thick in an Ontario pond (Taylor and Nol 1989). On the other hand, excessive sediments, when stirred, impair light penetration of the water column and thus can inhibit growth of algae and especially submersed aquatic plants, which provide cover and attachment sites for amphibian eggs.

4.6.6 Impacts on Fish from Changing the Amount of Sediment in the Habitat

No recent studies on the impacts of sediment on habitat for fish in North American wetlands or lakes were found. Most of the studies on the impacts of sediment on fish populations have been done in streams, especially as it concerns the growth and reproduction of salmonids in the Pacific Northwest. This information was reviewed and synthesized in Knutson and Naef (1997). The conclusion reached by Knutson and Naef quoted below can also apply to wetlands because streams are often considered a part of wetlands:

> *Sedimentation in fish-bearing waters affects habitat quality and fish survival in a number of ways. Stream bottoms covered with fine sediments are no longer suitable for spawning. Sediments cover and suffocate fish eggs and fry. High sediment deposits also block fish passage to upper spawning reaches. Suspended sediments clog the gills of fish, decrease dissolved oxygen levels, inhibit fish feeding and growth, and suppress macro-invertebrate food sources.*

4.6.7 Impacts on Birds from Changing the Amount of Sediment in the Habitat

Little information was found on how sedimentation impacts the habitat that a wetland provides for bird communities. One can hypothesize, however, that sedimentation can impact birds by altering structure of vegetation (see Section 4.6.3) that provide food for herbivorous birds or those that prey on invertebrates (see Section 4.6.4). In one case, the densities of breeding dabbling ducks were positively correlated with wetland turbidity in ponds in the interior of British Columbia (Savard et al. 1994).

4.6.8 Impacts on Mammals from Changing the Amount of Sediment in the Habitat

No information was found on how sedimentation might change the habitat that a wetland provides for mammals. As with birds, however, one can hypothesize that sedimentation can impact mammals by altering habitat structure or changing the abundance or availability of prey items.

4.6.9 Summary of Key Points

- No information was found on possible impacts of sedimentation on the functions of wetlands that improve water quality.
- Increasing sedimentation will decrease plant richness and tends to favor the more invasive types that tolerate disturbance.

- Impacts of increased amounts of sediment on the habitat functions of wetlands have been documented for invertebrates, amphibians, and fish. All of these groups generally have reduced species richness and abundance when wetlands are subject to increased sedimentation. In some cases, however, where the sediments coming into a wetland are finer than existing sediments, the number of invertebrate species may increase. Impacts from sedimentation on the suitability of wetlands as habitat for mammals and birds have not been documented.

4.7 Impacts from Increasing the Amounts of Nutrients Coming into a Wetland

The major nutrients for plant growth, phosphates, nitrates, and ammonium, can be transported into aquatic systems and impact the functions performed by wetlands. These nutrients are carried in water in dissolved forms or adsorbed onto sediment. The element phosphorus is usually the limiting nutrient for plant growth in freshwater aquatic systems (Newton 1989, Mitsch and Gosselink 2000). Because it is the limiting factor, phosphorus in the presence of the other critical element, nitrogen, allows expansive growth of phytoplankton, algae, and larger plants in aquatic systems when it is available in higher quantities.

Excessive algal growth is unsustainable, and when the algae blooms die, their decomposition causes the available dissolved oxygen to be consumed. The undesirable growth of vegetation caused by high concentrations of plant nutrients in bodies of water is called *eutrophication*. Eutrophication is defined as the process by which a body of water becomes enriched in dissolved nutrients (as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen (Merriam Webster online http://www.m-w.com/cgi-bin/dictionary?book=Dictionary&va=eutrophication accessed October 14, 2004).

Excess phosphorous and nitrogen, therefore, often leads to eutrophication with subsequent mortality of the aquatic organisms that require oxygen (Newton 1989, Mitsch and Gosselink 2000). Wetlands with areas of water on the surface can therefore become eutrophic if they receive excessive amounts of phosphorus and/or nitrogen.

4.7.1 Impacts on Hydrologic Functions from Increasing the Amounts of Nutrients

It is possible that the stimulation of plant growth by excess nutrients could increase the density of plants in the wetland. A thicker stand of vegetation can be expected to provide more resistance to flood flows than a thinner one (Adamus et al. 1991, Hruby et al. 1999). Therefore, excess nutrients might indirectly improve the reduction in velocity that a wetland provides during floods. The literature did not provide any other information on how nutrients might affect the hydrologic function of wetlands.

4.7.2 Impacts on Functions that Improve Water Quality from Increasing the Amounts of Nutrients

Some research indicates that excessive nutrients from agricultural operations may reduce the normal ability of wetland microbes to detoxify particular pesticides (Kazumi and Capone 1995, Chung et al. 1996, Entry and Emmingham 1996). Adding nitrogen to riparian wetlands may potentially compromise the long-term ability of the system to remove nitrogen via denitrification (Ettema et al. 1998). Other information on this topic was not documented in the literature.

However, several avenues of research could be combined to make some hypotheses about impacts. The addition of nutrients to acidic bogs results in changes in plant communities. The plant community that maintains the high acidity in the bog may change to one that maintains a more neutral pH. These changes might then alter several aspects of chemistry in the wetland that affect its ability to improve water quality. The rate of nitrification will probably increase because, as noted by Mitch and Gosselink (2000), low pH inhibits denitrifying bacteria. The change in pH will also probably change the ability of the wetland to bind different toxic metals and other compounds. (See the discussion in Chapter 2 on how pH is linked to the ability of a wetland to bind different pollutants.)

4.7.3 Impacts on Plants from Increasing the Amounts of Nutrients

Excessive nutrients can affect wetland plants in a variety of ways including:

- Shifting the species composition away from species that take up nutrients slowly, to those that are able to exploit nutrient pulses more rapidly or which have high nutrient requirements (Hough et al. 1989, Arts et al. 1990, Gopal and Chamanlal 1991, Wetzel and van der Valk 1998)

- Triggering algal blooms that can shade out many submersed herbaceous plants (Crowder and Painter 1991, Stevenson et al. 1993, Srivastava et al. 1995, Short and Burdick 1995)

- Causing dead plant material to accumulate faster than it can decompose completely, thus altering understory and soil structure (Neill 1990b, Craft and Richardson 1993)

Such changes usually result in long-term changes in the distribution and richness of plants within the wetland. Over the long term, nutrient additions to most wetlands tend to reduce species richness and increase the dominance of a few species. Often, non-native species are most capable of invading rapidly changing environments. Consequently they frequently come to dominate some nutrient-enriched wetlands (Adamus et al. 2001).

Increases in plant litter can smother other plants when the fast growing species die, thus helping maintain the dominance of species that exploit nutrients the most (Adamus et al. 2001). For example, the addition of nitrogen and phosphorus fertilizers to a marsh

dominated by cattail (*Typha glauca)* and the grass *Scolochloa festucacea* during two growing seasons resulted in increased biomass of both species. However, the biomass of *S. festucacea* declined in the second year due to accumulated litter of *T. glauca* (Neill 1990b).

The plants in bogs and other nutrient-poor wetlands are logically the most sensitive to nutrient additions (Moore et al. 1989). The increased availability of nutrients allows grasses and common opportunistic plants to out-compete rare plants (such as sundews, orchids, and pitcher plants) that are adapted to nutrient-poor conditions. For example, in Appalachian peat bogs, the spatial dominance of bristly dewberry (*Rubus hispidus*) was positively related to nutrient levels, but dominance of the Ericaceae shrubs was negatively related (Stewart and Nilsen 1993).

Many aquatic plant species respond to nutrient additions with increased growth, biomass, and productivity. Growth responses to enrichment have been documented for about 80 wetland-associated species in North America. Of these, most have tolerated enrichment or responded to enrichment with increased biomass or growth (Adamus and Gonyaw 2000).

> Information on the response of many individual plant species to nutrients can be found in the National Database of Wetland Plant Tolerances at: http://www.epa.gov/owow/wetlands/bawwg/publicat.html#database1

4.7.4 Impacts on Invertebrates from Increasing the Amounts of Nutrients in the Habitat

Excessive nutrients can cause long-term and short-term shifts in invertebrate communities. The information available suggests that excess nutrients can result in both decreases and increases in species richness as well as changes in the groups of invertebrates found. The direction of the change depends on how the nutrients impact the vegetation and soils that are the main habitat for invertebrates. Findings from the literature include:

- **Increased richness of invertebrates.** Up to some point, nutrient inputs to wetlands can lead to increased invertebrate richness, as more food sources become available to predatory invertebrates (Rader and Richardson 1992, Campeau et al. 1994, Cieminski and Flake 1995, Gernes and Helgen 1999).

- **Reduced richness of invertebrates.** Invertebrate richness in a series of highly enriched wastewater wetlands was found to be lower than in a less enriched reference wetland (Nelson et al. 2000).

- **Changes in the types of invertebrates.** In some cases excess nutrients result in the increased dominance of certain kinds of algae. Invertebrates that specialize in feeding on these algae, or that characteristically find shelter and attachment sites in the aquatic plants, then have an advantage and can become dominant (Murkin et al. 1991, Campeau et al. 1994). Exposure to organic enrichment and eutrophication frequently causes an increase in grazers (such as Tanypodinae midges), as well as

other herbivores, species that feed on detritus, predators, and "miners" that burrow into plants. These are groups that typically increase with increasing growth of algae growing on the bottom and emergent aquatic plants (Campeau et al. 1994). A study of four lacustrine wetlands bordering Lake Michigan also found that midge communities shifted across nutrient gradients (Murkin et al. 1992, Campeau et al. 1994).

- **Increased density of invertebrates.** Total invertebrate density increases with increased nutrients, as algal production becomes less of a limiting factor in the invertebrate community (Murkin et al. 1992, Campeau et al. 1994).

- **Changes in the bioaccumulation of metals by invertebrates.** Nutrients appear to influence the tendency of aquatic invertebrates to accumulate heavy metals and the type of metals that are accumulated. For instance, zinc, iron, and manganese concentrations were higher in midges from nutrient-rich wetlands, whereas high copper concentrations were found in midges from nutrient-poor wetlands (Bendell-Young et al. 2000). This may be due at least partly to the bioavailability of various metals being influenced by oxygen conditions in the sediment, which in turn are partly the result of decomposition of algal blooms triggered by high concentrations of nutrients (Adamus et al. 2001).

Information on the response of many individual invertebrate species to enrichment can be found in the National Database of Invertebrate Tolerances at: http://www.epa.gov/owow/wetlands/bawwg/publicat.html#database1

4.7.5 Impacts on Amphibians and Reptiles from Increasing the Amounts of Nutrients in the Habitat

The review of the literature indicates that amphibians can be impacted by the input of nutrients. No studies were found on impacts on reptiles.

Amphibians in the Northwest can be directly impacted by the input of nitrates. Five amphibian species in Oregon showed both sublethal responses and mortality following laboratory applications of nitrate. These studies indicated that the EPA nitrate criteria for drinking water of 10 milligrams per liter (mg/l) and/or for protection of warmwater fish are inadequate to protect these amphibians (Marco et al. 1999). In Texas, playa wetlands receiving nutrient-laden effluent from feedlots were devoid of amphibians found in natural playas (Chavez et al. 1999). Experiments indicated that effluent had to be diluted to less than 3% strength in order to minimize adverse effects on the leopard frog (*Rana pipiens*).

Indirect impacts of excessive nutrients can also be important to amphibians. Shifts in seasonal timing and amount of nutrients that enter a wetland can, over a period of years, increase the relative dominance of algae and/or emergent plants at the expense of submersed plants. This in turn can reduce the availability of submersed plants as attachment substrates for amphibian eggs and as cover for larvae (Beebee 1996).

Excess nutrients can also diminish dissolved oxygen levels (Tattersall and Boutilier 1999), alter the abundance of aquatic predators, and shift the algal and invertebrate foods available to amphibians (Horne and Dunson 1995). As a result, species composition and sometimes species richness of amphibian communities can decline as eutrophication becomes severe. However, well designed studies of such effects are few.

4.7.6 Impacts on Fish from Increasing the Amounts of Nutrients in the Habitat

No information was found documenting direct impacts of excess nutrients on fish in wetlands. However, the secondary impacts of eutrophication such as oxygen depletion do affect fish. Much of the literature deals with impacts of low oxygen in streams (for a review see Knutson and Naef 1997), and it can be assumed that the impacts of low oxygen in wetlands will be similar.

As mentioned previously, the increased plant production that results from added nutrients often results in low oxygen levels when the plant material dies and starts to decompose. Many fish species suffer from reduced levels of dissolved oxygen, and feeding habits also may shift. To some degree, fish families can be grouped according to their susceptibility to oxygen deficiencies. Salmonids and coregonids (whitefish) require high levels of dissolved oxygen, whereas cyprinids (a large family that includes carp and goldfish) often tolerate low dissolved oxygen levels (Harper 1992). Thus the species composition and richness may change depending on the initial state of the wetland and the duration and magnitude of the eutrophication.

4.7.7 Impacts on Birds from Increasing the Amounts of Nutrients in the Habitat

Eutrophication can indirectly impact the composition of the wetland bird community by altering the vegetation structure and availability of prey. In general, moderately elevated nutrient levels also spur the growth of submersed plants that provide food for ducks, as well as supporting more aquatic insects that are especially important as food for ducklings and aerial foragers like swallows. However, excessive nutrients cause algal blooms that can kill fish eaten by birds, reduce the growth of plants growing on the bottom by blocking light, and reduce visibility of other food items under the water surface.

Studies that have documented changes in the bird community related to excess nutrients are summarized below:

- Excessive nitrates have been implicated in deaths of some frogs (see Section 4.7.5). Frogs are a significant prey item for some wetland birds (Adamus et al. 2001).
- Northern shoveler (*Anas clypeata*) and eared grebe (*Podiceps nigricollis*) were positively associated with phosphorus in a survey of wetlands in interior British Columbia (Savard et al. 1994).

- The abundance and biomass of water-birds were positively correlated in 46 Florida lakes with levels of phosphorus, nitrogen, and chlorophyll. There also was a positive correlation of water-bird richness with phosphorus, after accounting for nutrients contributed to the lakes by the birds themselves (Hoyer and Canfield 1994).

- Total density of dabbling ducks was correlated positively with total dissolved nitrogen (Savard et al. 1994).

- The parasitic nematode *Eustrongylides ignotus*, which has only been found in disturbed and enriched wetlands (Spaulding and Forester 1993), negatively affects the health of adult wading birds and the survival of their nestlings (Spaulding et al. 1993).

4.7.8 Impacts on Mammals from Increasing the Amounts of Nutrients in the Habitat

No information was found on impacts from increases in nutrients on the habitat of mammals in wetlands. It can be hypothesized, however, that, if eutrophication results in anoxic conditions that are lethal to the prey of mammals (e.g., fish and some amphibians), the community composition may shift from predator species (such as otter or mink) to vegetarian or invertebrate-eating species and opportunists (such as muskrat).

4.7.9 Summary of Key Points

- Some impacts to the hydrologic functions from increased nutrients can be hypothesized because the increased growth of plants resulting from increased nutrients may provide better resistance to the movement of flood waters.

- Some impacts to the functions of improving water quality have been reported. These include a potential reduction in the ability of wetlands to detoxify pesticides and to remove nitrogen as a pollutant. Impacts from increased nutrients can also be hypothesized for bogs. The ability of bogs to bind toxic metals may be reduced but their ability to remove nitrogen may be increased.

- Increasing nutrients will stimulate plant growth and may change the composition of the species present.

- Impacts of increased amounts of nutrients on the habitat wetlands provide have been documented for invertebrates, amphibians, and birds. Excess nutrients can result in both an improvement in the habitat through the production of food and a reduction in habitat through eutrophication. The actual impacts depend on local conditions in the wetland. Impacts to the habitat for fish and mammals can be inferred because eutrophication causes reductions in the levels of oxygen in the water with resultant impacts to both water quality and the food sources for these two groups.

4.8 Impacts from Introducing Toxic Contaminants to a Wetland

4.8.1 Impacts on Hydrologic Functions from Toxic Contaminants

Contaminants are chemical compounds, solutions, or particles introduced into the environment that change how the environment or the organisms living there function. Toxic contaminants are poisons that specifically impact the growth and reproduction of living organisms.

No explicit information was found in the literature on the possible impacts of toxicity from contaminants on the hydrologic functions provided by wetlands (storing flood waters, reducing erosion, and recharging groundwater). It is not possible at this stage to hypothesize either positive or negative impacts on hydrologic functions because no logical deductions could be made from the available information.

4.8.2 Impacts on Functions that Improve Water Quality from Toxic Contaminants

Information on how toxic compounds affect the function of wetlands to remove pollutants is sparse. It can be hypothesized, however, that an input of low levels of toxic compounds may stimulate the ability of a wetland to detoxify pollutants. Some microbial species biodegrade particular contaminants and their abundance is increased in the presence of low levels of the contaminants. These species can flourish in some wetlands that are only mildly or moderately contaminated.

Contaminants that can be processed by microbes when concentrations are low to moderate include copper (Farago and Mehra 1993), mercury (Marvin-Dipasquale and Oremland 1998), selenium (Steinberg and Oremland 1990, Azaizah et al. 1997), cadmium (Sharma et al. 2000), manganese (Sikora et al. 2000), and petroleum (Nyman 1999, Megharaj et al. 2000).

4.8.3 Impacts on Plants from Toxic Contaminants

Most plant species are relatively tolerant to toxic contaminants. Impacts usually result from the effects of contaminants on plant metabolic pathways, enzymatic reactions, and growth (Fitter and Hay 1987). Symptoms of toxicity can include reduced growth; small, discolored, or dying leaves; early leaf fall; and stunted or suppressed growth of roots (Pahlsson 1989, Rhoads et al. 1989, Vasquez et al. 1989).

Shifts in the composition of the plant community in response to contaminants have not been widely documented. Relevant studies include:

- Arsenic, cadmium, copper, lead, and zinc inhibited growth in hybrid poplar (*Populus*) and several other tree species (Lejeune et al. 1996).
- Iron and manganese, although not usually toxic to wetland plants, do affect species in some wetland types. For example, laboratory experiments revealed differences among 44 fen species with regard to the influence of iron on growth (Snowden and Wheeler 1993).
- Oil spills can have long-lasting effects on wetland plant communities (Obot et al. 1992). In a greenhouse experiment, oil and a detergent used to clean up oil spills were applied to broadleaf arrowhead (*Sagittaria lancifolia),* salt marsh sedge (*Scirpus olneyi),* and common cattail (*Typha latifolia).* The leaves on all of the study plants died following oiling, but new leaves soon developed on those plants subjected to oil and subsequent cleaning with the detergent. *S. olneyi* was the least sensitive of the three species, whereas *T. latifolia* appeared to be the most sensitive (Pezeshki et al. 1998).
- The herbicides Rodeo® and Garlan 3A®, applied to control purple loosestrife (*Lythrum salicaria*), also reduced the growth rates of non-target species such as duckweed (*Lemna gibba)* (Gardner and Grue 1996).

4.8.4 Impacts on Invertebrates from Toxic Contaminants in the Habitat

General studies on the impacts to invertebrates in wetlands of Puget Sound found that increased levels of contaminants and changes in the water regime correlated with declines in species richness among the scraper and shredder functional feeding groups and the Chironomidae family (small, mosquito-like flies) (Ludwa 1994). These authors found declines in richness and abundance of invertebrate groups whose presence is seen as an indicator of the general health or quality of a water body. Another study in Massachusetts also showed a direct and negative correlation between urbanization and the abundance and richness of macro-invertebrates (Hicks 1995) primarily through impacts to water quality.

The following sections first review the effects of metals on invertebrates and then describe the effects of organic and synthetic compounds such as pesticides. Much of the information on the impacts on invertebrates is based on studies in streams. These studies are probably applicable to wetlands because some of the species and many of the invertebrate families reported in the studies are also found in wetlands.

4.8.4.1 Impacts of Heavy Metals on Invertebrates

Heavy metals such as mercury, lead, zinc, copper, and cadmium can be directly toxic to wetland invertebrates. Metals can also impact invertebrate communities by altering the species composition and abundance of algae and aquatic plants upon which invertebrates

depend for food and shelter. Growth, larval development, and reproduction of invertebrates can also be harmed by long-term exposure to sublethal concentrations of trace metals (Timmermans 1993). Relatively little, however, is known about the sublethal effects of metal pollutants in freshwater wetlands or how metals are metabolized or accumulated.

The extent to which heavy metals are toxic to wetland invertebrates depends largely on the acidity of the wetland and the particular form of the metal involved. Acidic conditions can mobilize and increase the toxicity of some metals, such as cadmium (Wright and Welbourn 1994), and decrease the toxicity of others, such as aluminum (Wren and Stephenson 1991). On the other hand, some metals, such as iron and aluminum, can to some degree protect invertebrates from otherwise toxic effects of heavy metals in acid mine drainage (Whipple and Dunson 1992).

Specific studies documenting the impact of heavy metals on invertebrates are summarized below:

- Moderate recovery of invertebrates from metal contamination was demonstrated in the Coeur D'Alene River in Idaho. Over 22 years after contamination by zinc and other metals ceased, the number of species grew from zero to 18, while the proportion of mayflies, stoneflies, and caddisflies relative to the proportion of midges rose (Hoiland and Rabe 1992, Hoiland et al. 1994).
- Some studies show herbivores and detritivores as the most sensitive to additions of metals (Kiffney and Clements 1994a, Leland et al. 1989), whereas others have reported scrapers being the most sensitive group (Clements 1994).
- Mayflies and some stoneflies of western streams are sensitive to metals, whereas caddisflies and midges are relatively tolerant (Clements 1994, Kiffney and Clements 1994b, Leland et al. 1989).
- Agricultural drainage water containing arsenic, boron, lithium, and molybdenum entering the Stillwater Wildlife Management Area in Nevada proved acutely toxic to many wetland invertebrates (Hallock and Hallock 1993).
- Copper and some other heavy metals appear to be more damaging to aquatic communities in the spring and summer rather than in the fall (Leland et al. 1989). Summer exposure to metals may coincide more closely with hatching of many macro-invertebrates, and early periods in the development of the invertebrates may be more susceptible.

4.8.4.2 Impacts of Pesticides, Oil, and Other Contaminants on Invertebrates

Pesticides, oil, and other toxic contaminants represent a wide range of pollutants. In general, however, most have been shown to change the community structure (abundance, distribution, and richness) of invertebrates. Contaminants cause these effects through several mechanisms, including:

- Causing acute or chronic toxicity to invertebrates
- Altering algal communities and aquatic plants upon which some invertebrates depend for food and shelter
- Altering predation on invertebrates by decimating numbers of other crustaceans, fish, and amphibians
- Reducing rates of oxygen diffusion
- Changing the effects of other potential disturbances, such as acidity

The range of pesticides and organic pollutants used today is very large and it is not possible to generalize the impacts of this group of pollutants on invertebrates. Table 4-1 summarizes numerous studies that demonstrate the wide range of responses of invertebrates to contaminants.

Table 4-1. Summary of studies on effects of contaminants on invertebrates.

Reference	Contaminant Studied	Results
Eisler (1992)	diflubenzuron (insecticide)	In laboratory tests diflubenzuron was most toxic to crustaceans, followed by mayflies, midges, caddisflies. Larvae of corixids, dragonfly adults and larvae, spiders, dytiscids, and ostracods had moderate sensitivity
Eisler (1992)	paraquat, cyanide, fenvalerate, acrolein	These substances were lethal to invertebrates
Dieter et al. (1996)	phorate (pesticide)	In Prairie Pothole Region, macro-invertebrates that were particularly sensitive to phorate included hemipterans, mosquitoes, flies, mayflies, water mites, and water beetles. Less sensitive were leeches, snails, aquatic worms, ostracods
Lieffers (1990)	3-trifluoromethyl-4-nitrophenol (TFM) (lampricide)	TFM had a significant effect on invertebrates in a small stream
Fairchild and Eidt (1993)	fenithrothion (insecticide for forest insects)	Fenithrothion reduced emergence of aquatic insects for 6 to 12 weeks. Densities of most invertebrates (especially predatory species, midges, some other dipterans) were reduced by as much as 50% for more than one month after treatment. Wetland sediments became dominated by aquatic worms and water mites. Although in many streams and large lakes fenithrothion has transitory effects, residual toxicity remained in bog wetlands during winter and into the next year
Hachmoller et al. (1991)	various organic pollutants	Mayflies, stoneflies, caddisflies decreased in abundance in stream contaminated by various organic pollutants

Reference	Contaminant Studied	Results
Keller (1993), Metcalfe and Charlton (1990)	various contaminants	Mussels are especially sensitive to combined effects of pesticides, organic compounds, excessive nutrients
Kemp and Spotila (1996)	industrial pollutants, PCBs	Isopods, oligochaetes, craneflies were main survivors in a Pennsylvania stream with industrial pollution (including PCBs) compared with non-urbanized control segments
Crunkilton and Duchrow (1990)	oil	After 25 days, an oil spill in a Missouri stream reduced macro-invertebrate population to less than 0.1% of normal densities. Recovery of some species of stoneflies, mayflies, and caddisflies did not occur for at least nine months
Henry et al. (1994)	surfactant	In laboratory tests, a surfactant was approximately 100 times more toxic than the herbicide glyphosate, with which it is commonly applied
Wipfli and Merritt (1994), Kreutzweiser et al. (1994), Jackson et al. (1994), Waalwijk et al. (1992)	*Bacillus thuringiensis* var. *israelensis* (Bti) (biological control agent)	Bti appears to have minimal adverse effects on non-target insects in streams although mortality has been observed in Lepidoptera, some midges, craneflies, caddisflies, mayflies
Euliss and Mushet (1999)	agricultural contaminants	Direct adverse correlation found between aquatic invertebrate species richness and agricultural practices for seasonally inundated wetlands in prairie pothole region of North Dakota. Adverse effects on invertebrates could result from agrichemicals (shown to cause increased mortality of aquatic invertebrates in other studies). Tilling around wetlands could increase erosion, leading to suspended sediments and adsorbed metals that are toxic to some zooplankton and thus affect the food chain

4.8.5 Impacts on Amphibians and Reptiles from Toxic Contaminants in the Habitat

Studies of the effects of heavy metals, pesticides, and other toxins on amphibians and reptiles have been conducted mainly on species, not communities. A review of relevant literature was published by Sparling et al. (2000). Schuytema and Nebeker (1996) have compiled a database of toxicity information from published literature for 58 amphibian species as related to 135 chemicals.

Many different pollutants have been documented as toxic to species of amphibians and reptiles found in Washington's wetlands. The following references document the impact of toxic compounds on some species found in the Pacific Northwest:

- Toxic effects of aluminum and other metals on the embryos and tadpoles of the northern leopard frog (*Rana pipiens*) were found by Freda (1991), Freda and McDonald (1990), and Freda et al. (1990).

- Many synthetic organic compounds affect amphibians and aquatic reptiles. Northwestern salamander (*Ambystoma gracile*) egg mortality corresponded with levels of total petroleum hydrocarbons in western Washington (Platin 1994, Platin and Richter 1995).

- The pesticide esfenvalerate caused damaging sublethal effects on tadpoles of the northern leopard frog (Materna et al. 1995).

- Tests of three forest insecticides (fenitrothion, triclopyr, and hexazinone) on the northern leopard frog in Ontario suggested that tadpoles were sensitive to triclopyr and fenitrothion (Berrill et al. 1991).

4.8.6 Impacts on Fish from Toxic Contaminants in the Habitat

The response of fish communities and individual species to toxic compounds is varied and complicated by many environmental factors. Smaller fish may be the first to respond to contaminants (Matuszek et al. 1990).

The toxicity of copper and zinc to some fish species depends on other chemical characteristics of the water (Munkittrick and Dixon 1992, Welsh et al. 1993), as well as fish behavior (Pourang 1995). For example, dissolved organic matter from a marsh at a level of 5 mg carbon per liter kept copper from binding to the gills of small steelhead (*Oncorhynchus mykiss*), thereby reducing its toxicity. This occurred because copper formed a complex with dissolved organic carbon, making the copper unavailable (Hollis et al. 1997). In addition, some fish species may acclimate to moderately elevated levels of some metals (Klerks and Lentz 1998).

Selenium is not directly toxic to fish at concentrations usually found in soils but can become toxic once concentrated in fish food chains. This is especially true in some wetlands that receive effluents from irrigated fields or power plant reservoirs in some regions (Zilberman 1991, Lemly 1996).

Synthetic organics, including pesticides, can accumulate in wetland fish (Cooper 1993), often with adverse effects. In a Canadian wetland receiving effluent containing oily sand, fish had altered blood chemistry and died within fourteen days (Bendell-Young et al. 2000).

4.8.7 Impacts on Birds from Toxic Contaminants in the Habitat

The response of individual bird species and bird communities to toxic compounds is varied. Individual species are directly affected by many pollutants. Many pesticides, however, are more likely to impact bird populations by altering their habitat and foods rather than by direct toxicity. Studies that document such impacts are summarized below:

- Several instances have been documented of wetland birds being directly poisoned by insecticides applied at recommended rates (e.g., parathion, as documented by Flickinger et al. 1991).

- Herbicides have been applied to wetlands to change the structure of vegetation and the composition of plant species, with consequent shifts in the composition of bird species (Solberg and Higgins 1993, Linz et al. 1996). Information on pesticides in prairie wetlands has been compiled by Facemire (1992).

- Detrimental reproductive effects from dioxins have been documented for great blue herons (*Ardea herodias*) (Hart et al. 1991); for dioxins and furans for wood ducks (*Aix sponsa*) (White and Seginack 1994); for PCBs (polychlorinated biphenyls) in American kestrels (*Falco sparverius*); and for petroleum in mallards (*Anas platyrhynchos*) (Holmes and Cavannaugh 1990).

- Research has continued to focus on the effects of selenium on waterfowl in western states. Biogeochemical conditions favoring the release of selenium into wetlands are found throughout the arid regions of the western states and threaten bird communities in many wetlands along the Pacific and Central Flyways (Paveglio et al. 1992). Agricultural drainage, irrigation, and natural waters can leach selenium from many western soils. Subsurface irrigation is the most widespread and biologically important source of selenium toxicity for waterfowl, including the waterfowl in six national refuges (Ohlendorf et al. 1990, Feltz et al. 1991). Selenium is often accompanied by boron, which is toxic to ducklings (Stanley et al. 1996).

Lead shot as a source of toxic metal

The use of lead shot for hunting is banned in Washington State but its use is still allowed for target shooting. If target ranges are adjacent to wetlands the potential exists of lead entering these wetlands. The pathways for uptake of lead shot by aquatic birds would be the same whether the source is from active hunting or from target shooting.

Lead is toxic to aquatic biota (Eisler 1988). Waterborne lead is the most toxic form. The introduction of lead into the aquatic food chain via aquatic plants has been found in the roots and foliage of the pond weed *Potamogeton foliosus* and in the exoskeleton of crayfish (Eisler 1988, Knowlton et al. 1983). Elemental lead (lead shot), however, has been shown to be significantly less bioavailable to rooted aquatics than powdered lead (Behan et al. 1979).

Waterfowl are at risk from ingesting lead shot as they forage in wetlands. Because of the proximity of wetlands to shooting ranges, other aquatic organisms, including amphibians, and some bird species may be at risk from the spent lead. For example, Eisler (1988) found that lead in tadpoles might contribute to the lead levels reported in wildlife that eats tadpoles. Predatory animals that feed on amphibians include reptiles (such as the garter snake), birds such as the great blue heron and the marsh hawk, and mammals such as raccoons (Martin et al. 1951).

4.8.8 Impacts on Mammals from Toxic Contaminants in the Habitat

No explicit information was found in the literature on the possible impacts of toxicity from contaminants in wetlands on mammals using wetlands. It is not possible at this stage to hypothesize either positive or negative impacts on mammals because no logical deductions could be made from the available information.

4.8.9 Summary of Key Points

- No information was found on the impacts of contaminants on the hydrologic functions of wetlands, but it can be hypothesized that increases in sediment can reduce the storage of water in depressional wetlands.
- The rates at which wetlands remove toxic compounds may actually be increased under low levels of contamination because the specific microbes that detoxify the pollutants are stimulated.
- The impact of contaminants on plants has not been studied as extensively, but the information suggests that toxicity from contaminants can change the composition of the plant community.
- Impacts of increased contaminants on the habitat provided by wetlands have been documented for invertebrates, amphibians, fish, and birds. Many contaminants are toxic to these species and their presence in wetlands reduces the suitability of a wetland as habitat. Wetland-associated mammals are the only group of vertebrates for which no information was found.

4.9 Impacts from Changing the Acidity (pH) of Soils or Water in a Wetland

4.9.1 Impacts on Hydrologic Functions from Changing the Acidity

No information was found on the impacts that increasing acidity might have on the hydrologic functions performed by wetlands. In the absence of any information to the contrary, however, it is possible to hypothesize that decreasing pH will probably not change how wetlands perform these functions. Changes in the acidity of water are not expected to change how well wetlands store water, how well they slow it down during peak flows, or how well they recharge groundwater.

4.9.2 Impacts on Functions that Improve Water Quality from Changing the Acidity

Increased acidity (reduced pH) could change aspects of wetland chemistry that affect the ability to improve water quality. It can be hypothesized that the rate of nitrification will probably decrease because, as noted by Mitch and Gosselink (2000), low pH inhibits denitrifying bacteria. Changes in pH will also change the ability of the wetland to bind different toxic metals and other contaminants in the soils (Kadlec and Knight 1996). Each contaminant, however, has different chemical properties. Some are released when pH decreases (acidity increases) and some are more tightly bound when pH decreases. The impacts of changing the pH, will, therefore, depend on the contaminants coming into the wetland.

4.9.3 Impacts on Plants from Changing the Acidity

The pH is critical in determining the distribution of plants in wetlands. Changes in pH that result from human activities can, therefore, have major impacts. Studies described below have documented changes in plant populations that resulted from both decreases in pH (more acidic conditions) and increases in pH (less acidic conditions). However, the effects of acidification (or its reversal by liming) on the species composition of plants are not consistent among wetland types or even within individual wetlands (Farmer 1990, Baker and Christensen 1990, Mackun et al. 1994, Weiher et al. 1994).

For example, many plant species that inhabit bogs are adapted to acidity levels that would kill most wetland plants. Species whose decline or disappearance from a lacustrine wetland coincided with acidification include water lobelia (*Lobelia dortmanna)*, shore quillwort (*Isoetes riparia*), water milfoil (*Myriophyllum tenellum)*, yellow pond lily (*Nuphar* sp.), common bladderwort (*Utricularia vulgaris)*, and ribbon leaf pondweed (*Potamogeton epihydris)* (Farmer 1990). Species whose relative abundance increased included *Leptodictium riparium*, needle spike rush (*Eleocharis acicularis)*, sphagnum moss *(Sphagnum* sp.), and pipe wort (*Eriocaulon septangulare)* (Farmer 1990).

In general, making wetlands more acidic can directly impact plants by limiting the availability of some inorganic nutrients and carbon (Farmer 1990). Acidic conditions also promote the conversion of nitrates into ammonium.

Acidic conditions can impact plants indirectly by reducing the densities of invertebrates that graze or process detritus. Acidic conditions in wetland soils increase the toxicity of aluminum and manganese (Rendig and Taylor 1989, Crowder and Painter 1991).

4.9.4 Impacts on Invertebrates from Changing Acidity in the Habitat

In general, changing the acidity in a wetland can alter the community structure of invertebrates by:

- Causing acute or chronic damage to tissues of invertebrates; the species that easily lose sodium ions when pH is reduced tend to be most sensitive (Steinberg and Wright 1992)

- Altering algal communities and aquatic plants upon which some invertebrates depend for food and shelter (see discussion in Section 4.9.3)

- Altering the populations that are predators of invertebrates such as other crustaceans, amphibian, and fish (see Sections 4.9.5, 4.9.6)

The impacts of acidification on aquatic invertebrate communities have been researched extensively. Table 4-2 categorizes invertebrate species as more or less tolerant of acidification based mainly on the North American literature. The list is included here because many of these species are probably found in Washington's wetlands. Few local studies, however, document the distribution of invertebrates in the state so it is not possible to identify the tolerance of species that are found here.

Some invertebrates are sensitive to pH increases (decreased acidity). For example, stormwater input to a Florida freshwater marsh increased phosphorus levels, lowered oxygen levels, and raised pH and hardness. This resulted in a shift of the macro-invertebrate population toward species that otherwise are intolerant of the acidic, nutrient-poor conditions typically found in the studied wetland (Graves et al. 1998).

Acidity often reduces the richness of macro-invertebrates in aquatic habitats (Schell and Kerekes 1989, Hall 1994). One study showed that with increased acidity, many aquatic invertebrates declined in numbers and biomass, especially in wetlands with pH below 5.0 (Parker and Wright 1992). Reductions in acid emissions from some Canadian smelters were followed by significant increases in richness of invertebrates in water bodies downwind of the smelters (Griffiths and Keller 1992).

Table 4-2. Summary of studies describing relative tolerance of invertebrates to acidification.

Taxonomic Group and Study Reference	More Tolerant to low pH (Less Sensitive)	Less Tolerant to low pH (More Sensitive)
Dragonflies and Damselflies (Odonata)		
Damselflies (Parker and Wright 1992, Baker and Christensen 1990)	X	
Beetles (Coleoptera)		
Some water beetles (Parker and Wright 1992), especially hydrophilid and dystiscid beetles (Baker and Christensen 1990)	X	
True Bugs (Hemiptera, Homoptera)		
Some water bugs, at least Notonectidae, Gerridae, Corixidae (Baker and Christensen 1990)	X	
Some water bugs (Parker and Wright 1992)		X

Taxonomic Group and Study Reference	More Tolerant to low pH (Less Sensitive)	Less Tolerant to low pH (More Sensitive)
Caddisflies (Trichoptera)		
Some caddisflies: *Cheumatopsyche pettiti* (Camargo and Ward 1992).	X	
Some caddisflies (Parker and Wright 1992) and some in the scraper and predator guilds (Williams 1991)		X
Flies, Midges, Mosquitoes (Diptera)		
Midges (Havens 1994a, Baker and Christensen 1990, Tuchman 1993)	X	
Some midges, such as *Tanytarsus, Microtendipes*, and *Nilothauma* (Griffiths and Keller 1992)		X
Stoneflies (Plecoptera)		
Some stoneflies (Tuchman 1993) such as *Amphinemura* and *Leuctra* (Griffith et al. 1995)	X	
Many stoneflies, e.g., *Peltoperla arcuata* (Griffith et al. 1995)		X
Mayflies (Ephemeroptera)		
The mayfly *Eurylophella funeralis* (Griffith et al. 1995)	X	
Some mayflies (Balding 1992)		X
Other Macro-invertebrates		
Planarian *Dugesia dorotocephala* (Camargo and Ward 1992)		X
Some water mites (Havens 1994a)	X	
Molluscs (Grapentine and Rosenberg 1992, Gibbons and Mackie 1991, Balding 1992), including clams (Schell and Kerekes 1989)		X
Mussels, snails, leeches (pH >5.0, Schell and Kerekes 1989)		X
The amphipod *Hyalella azteca* (Havens 1994a); pH must remain above 5.8 (Grapentine and Rosenberg 1992)		X
The amphipod *Gammarus minus* (Griffith et al. 1995)		X
Zooplankton		
Some zooplankters, such as *Daphnia galeata mendotae, D. retrocurva, Skistodiaptomus oregonensis* (Havens 1993)	X	
The rotifers *Gastropus stylifer, Keratella taurocephala, Polyarthra renata, Symchaeta* sp. (Fore et al. 1996)	X	
The water flea *Bosmina longirostris* (Havens 1993)		X

Taxonomic Group and Study Reference	More Tolerant to low pH (Less Sensitive)	Less Tolerant to low pH (More Sensitive)
The rotifers *Asplanchna priodonta, Collotheca mutabilis, Conochiloides* sp., *Conochilus unicornis, Gastropus hyptopus, Kellicota longispina, Keratella cochlearis, Keratella crassa, Polyarthra dolichoptera, Trichocera cylindrica* (Fore et al. 1996)		X
Functional Feeding Groups		
Scrapers and collectors (Smith et al. 1990)	X	
Shredders (Tuchman 1993)		X
Deposit feeders (Smith et al. 1990)		X

4.9.5 Impacts on Amphibians and Reptiles from Changing the Acidity in the Habitat

Increased acidity (lower pH) damages amphibians directly (Horne and Dunson 1994b). Acidity may also have direct impacts as a result of its capacity to mobilize toxic metals and perhaps by making sodium less available in some soil types (Wyman and Jancola 1991).

No studies were found describing the impact of increased acidity on amphibians and reptiles in Washington. Studies from other states, however, document these impacts. The information below summarizes some of the information for amphibian and reptile species that are found in the state, even if the studies were done elsewhere.

In Ontario, the acid-neutralizing capacity (alkalinity) of 38 wetlands positively influenced the probability of the northern leopard frog (*Rana pipiens*) being present (Glooschenko et al. 1992).

Embryos of the tiger salamander (*Ambystoma tigrinum*) had more than 70% survival at pH 4.5 and above but suffered much greater mortality at lower pH levels (Whiteman et al. 1995).

Concerns have been raised regarding the vulnerability to acidification of Montane wetlands in the West. Acidification makes aluminum and cadmium more mobile and increases their concentration in surface waters. Amphibians (e.g., Jefferson's and spotted salamanders) are known to be sensitive to acidity and elevated concentrations of aluminum found in some acidic ponds (Blancher 1991, Ireland 1991, Horne and Dunson 1995).

Aluminum released into Montane pools as a result of acidification sometimes has harmed embryos, reduced growth rates, and/or caused deformities and premature hatching of native amphibians (Bradford et al. 1991, Corn and Vertucci 1992).

4.9.6 Impacts on Fish from Changing the Acidity in the Habitat

No information was found on the impacts of acidity on fish in Washington's wetlands. In their review of the literature, Adamus et al. (2001) found that acidity can be directly toxic to fish, inhibit reproductive maturation, inhibit spawning behavior, induce emigration, and alter food availability. Furthermore, in areas where acid rain may be a problem, the increase in acidity induces aluminum toxicity in fish in many lakes and wetlands (Keller and Crisman 1990). Surveys of literature on effects of acidification on fish in lakes (and therefore potentially in wetlands along lake fringes) are provided by Baker and Christensen (1990) and Minns et al. (1990).

4.9.7 Impacts on Birds from Changing the Acidity in the Habitat

Acidification of wetlands affects birds primarily because it reduces the availability of calcium, which is important for egg development; potentially increases the availability of toxic metals; and alters the species composition and abundance of aquatic insects, submersed plants, amphibians, and fish that are important foods for waterfowl (see previous discussions in Sections 4.9.3, 4.9.4, 4.9.5, 4.9.6).

Changes in the types of available food, especially those rich in calcium, can diminish egg shell thickness and generally reduce the reproductive success of waterbirds in wetlands (Sparling 1990, 1991, Blancher and McNicol 1991, St. Louis et al. 1990, Albers and Camardese 1993). Overall, calcium deficiency appears to affect birds in acidified wetlands more than metal toxicity (Albers and Camardese 1993). Breeding pairs of 15 waterfowl species were more abundant in Ontario wetlands with over 40 parts per million (ppm) of total alkalinity than in less alkaline wetlands (Dennis et al. 1989, Merendino et al. 1992). In British Columbia as well, densities of several breeding duck species were greater in ponds with higher levels of conductivity and calcium (Savard et al. 1994).

4.9.8 Impacts on Mammals from Changing the Acidity in the Habitat

No information on the effects of acidification on the overall community structure of wetland mammals was located. It can be hypothesized, however, that where acidification becomes severe, community composition may shift from fish-eating species (e.g., otter) to vegetarian or invertebrate-eating species and opportunists (e.g., muskrat) (Adamus and Brandt 1990).

4.9.9 Summary of Key Points

- No information was found on the impacts of acidity on the hydrologic functions of wetlands, but it is possible to hypothesize that impacts, if any, are minor.
- The rates at which wetlands remove nitrogen are impacted by increasing acidity because denitrification is reduced.
- The rates at which toxic metals and other contaminants are removed by soils can change with acidity, but the actual changes depend on the chemical properties of the contaminant.
- Increasing the acidity in wetlands can also change the composition of the plant community.
- Impacts of increasing acidity on the habitat provided by wetlands have been documented for invertebrates, amphibians, fish, and birds. In general, increased acidity reduces the richness of invertebrates in wetlands and impacts amphibians either directly or by changing the chemistry of the water in the wetland, making it less suitable as a habitat. Acidic wetlands also become a less suitable habitat for birds because the amounts of calcium rich foods are reduced. Mammals are the only group of vertebrates for which no information exists.

4.10 Impacts from Increasing the Concentrations of Salt in a Wetland

Salt concentration in wetlands can increase as a result of (from Adamus et al. 2001):

- Isolating wetlands from some types of groundwater inflow
- Increasing water lost through evaporation
- Discharging effluents that contain salts (especially irrigation return water)
- Routing runoff that has relatively high conductivity into wetlands

Increased concentrations of salt (salinization) impact the functions of wetlands as described below.

4.10.1 Impacts on Hydrologic Functions from Increasing Concentrations of Salt

No information was found on how changes in salt content might affect the hydrologic functions of flood storage and flood desynchronization [the process by which peak flows are

delayed in their downstream movement (Adamus et al. 1991)]. However, it is possible to hypothesize that salinization will probably not change how wetlands in Washington perform these functions. Changes in the salt content of water coming into a wetland are not expected to change the physical structure of the wetland on which the hydrologic functions are based. Increasing salt concentrations are not expected to change how well wetlands store water, how well they slow it down during peak flows, or how well they recharge groundwater.

4.10.2 Impacts on Functions that Improve Water Quality from Increasing Concentrations of Salt

One relevant study found that salinities greater than about 300 grams per liter can inhibit the ability of microbes to detoxify toxic forms of selenium (Steinberg and Oremland 1990). This was the only literature found on how salinization might impact the ability of wetlands to remove pollutants.

As noted below, salinization has some impacts on plants, and thus it may affect nutrient uptake and transformation in a wetland. However, it is not possible to predict or hypothesize how such changes in these species might change other functions that improve water quality.

4.10.3 Impacts on Plants from Increasing Concentrations of Salt

In general, high concentrations of soluble salts are lethal to freshwater plants, and lower concentrations may impair growth (Rendig and Taylor 1989). Woody plants tend to be less tolerant than herbaceous plants because they do not have mechanisms for removing salt, other than accumulating salts in leaves and subsequently dropping them (Adamus et al. 2001).

Many plant species that inhabit inland saline wetlands are, of course, adapted to tolerating salt levels that would kill most other freshwater wetland plant species. A survey of inland lakes in western Canada which spanned a salinity gradient identified relative tolerance to salinity and specific salinity tolerance thresholds of many wetland species (Hammer and Heseltine 1988).

Individual plant species have different tolerances and reactions to increasing salinity. It can be expected that the plant community in a wetland will change to one dominated by salt-tolerant plants when additional salts are introduced. For example, wetlands in which salt has been present for some time, such as alkali wetlands, have a completely different plant community than that found in non-alkali wetlands. In eastern Washington a major change in plant communities was found when the conductivity (a measure of the amount of salts present in the water) increased to 2.0 milliSiemens and higher (Hruby et al. 2000).

A study by Hutchinson (1991) describes the tolerance of many wetland plants found in Washington. It can be used to predict how the plant species might change in Washington's wetlands as salt concentrations increase.

It can also be expected that wetlands subject to increases in salinity through agricultural practices or discharges of salt will also be subject to a change in plant populations. One wetland undergoing such a change was observed in the Richland area by the technical team calibrating the Washington State wetland rating systems in the summer of 2002. The conductivity of the wetland was measured at about 6.5 milliSiemens. About one-quarter of the area was still dominated by cattails (*Typha latifolia*), a wetland plant with a relatively low tolerance to salt (Hutchinson 1991), but this species was dying. Dead stalks of this species covered almost half the area of the wetland.

4.10.4 Impacts on Invertebrates from Increasing Concentrations of Salt in the Habitat

The review of the literature indicates that high levels of salinity can alter the structure of freshwater invertebrate communities in many ways. Adamus et al. (2001) have identified the following mechanisms by which the invertebrate community can be altered:

- Acute and chronic damage to tissues of invertebrates
- Changes in the species composition and structure of algal communities and aquatic plants upon which some invertebrates depend for food and shelter
- Changes in predation on invertebrates by decimating numbers of other crustaceans, fish, and amphibians
- Changes in the bioavailability of some other substances, such as heavy metals and nutrients

Even at low concentrations, increases in chloride (a correlate of salinity, and often associated with road salt applications) among twenty-seven Minnesota wetlands were significantly correlated with declines in species richness among the wetlands (Gernes and Helgen 1999). In Wyoming wetlands of fairly low salinity (0.8 to 30 milliSiemens per centimeter), the dominant macro-invertebrates were amphipods and epiphytic snails. Other recent species-specific data on the impacts of salinity in wetland invertebrates are presented in Parker and Wright (1992), and Lovvorn et al. (1999).

4.10.5 Impacts on Amphibians and Reptiles of Increasing Concentrations from Salt in the Habitat

In general, relatively little is known about amphibian tolerance to salinity in Washington. Three studies have reported a statistically significant negative correlation between conductivity of the water and amphibian species richness (Azous 1991, Platin 1994, Platin

and Richter 1995). However, the implications of these studies for understanding impacts on existing populations of amphibians in a wetland that is undergoing an increase in salt concentrations is not clear.

4.10.6 Impacts on Fish from Increasing Concentrations of Salt in the Habitat

No information was found on the tolerance of native fishes in Washington to salinity. Adamus et al. (2001) reported the following information relative to some of the introduced game fish that now are found in Washington's wetlands.

Laboratory trials consisting of 120-day exposure of freshwater largemouth bass (*Micropterus salmoides*) to four salinity levels (0, 4, 8, and 12 ppm) indicated a significant decrease in growth rate with increasing salinity up to 8 ppm.

In another experiment, juvenile bluegill (*Lepomis macrochirus*) from a freshwater pond in northeastern Mississippi and a brackish bayou in coastal Mississippi were held in a chamber with zero salinity but given access to chambers containing 0, 2, 4, 6, 8, and 10 ppm salinity (Peterson et al. 1993). Fish from neither habitat showed a clear preference for any of the salinity options. These data and data from previous studies suggest bluegills are better able to physiologically and behaviorally tolerate elevated salinity relative to other centrarchids (the family of fish containing bluegills, bass, crappies, etc.), particularly bass (Peterson et al. 1993).

4.10.7 Impacts on Birds from Increasing Concentrations of Salt in the Habitat

The impacts of increasing salinity on birds are highly dependent on the species in question. The following summarizes relevant studies:

- Highly saline or alkali conditions are detrimental to some invertebrate and plant foods used by many duck species. High salinity is directly toxic or impairs the growth of young ducklings (Clark and Nudds 1991, Moorman et al. 1991).

- Breeding densities of most duck and grebe species in interior British Columbia were greater in ponds with higher conductivity (higher salt content), but marsh nesting species were unaffected (Savard et al. 1994).

- Some species of water birds are very tolerant of high salt concentrations. They occur regularly at very high densities in alkali wetlands during the breeding season and/or migration. Examples include the American avocet (*Recurvirostra americana*), snowy plover (*Charadrius alexandrinus*), phalaropes, killdeer (*Charadrius vociferus*), horned grebe (*Podiceps auritus*), tundra swan (*Cygnus columbianus*), and white-rumped, semipalmated, and Baird's sandpipers (*Calidris* spp.) (Jehl 1994, Savard et al. 1994, Oring and Reed 1997, Rubega and Robinson 1997, Warnock 1997).

4.10.8 Impacts on Mammals from Increasing Concentrations of Salt in the Habitat

No information was found on the impacts of salinization on the overall structure of mammal communities in wetlands and changes in the suitability of wetlands as habitat for mammals.

4.10.9 Summary of Key Points

- No information was found on the impacts of salinization on the hydrologic functions of wetlands, but it is possible to hypothesize that impacts, if any, are minor.
- Only one study was found that documents any impacts of salinization on the ability of wetlands to improve water quality. Very high salt concentrations inhibit the microbes that detoxify selenium.
- Increasing the salt concentrations in wetlands can change the composition of the plant community because specific species are more tolerant of saline conditions than others.
- Impacts of increased salt concentrations on the habitat provided by wetlands have been documented for invertebrates, fish, and birds. In general, increased salinity changes the composition of the invertebrate community in wetlands. Largemouth bass seem to be especially sensitive to increased salinity relative to other species. The young of some waterbird species may also be sensitive, but other species seem to prefer high salinities. No information exists on the impact of salinization on mammals and amphibians.

4.11 Impacts from Fragmenting Wetland Habitats

Fragmentation results directly from human conversion of land to other uses. As described in Chapter 3 fragmentation is a result of both the direct loss of wetland area that isolate populations of wildlife and from changes to the spatial configuration of the wetlands in the landscape. Wetland loss and isolation is seen as a major factor contributing to the loss of biological diversity in vertebrate populations that use wetlands (Harris 1988, Gibbs 2000).

In general, fragmentation of habitats affects biological diversity through (Harris 1988):

- Loss of the species less tolerant to disturbance or those that inhabit the interior parts of wetlands
- Loss of large species with broad ranges
- Loss of genetic integrity within populations
- Increase in numbers of habitat generalists that thrive in disturbed environments, such as parasites

Occasional migration between wetlands is vital in sustaining local populations of wetland-dependent organisms. Limiting the movements of these species reduces the exchange of genetic material among local populations and can result in population extinctions (Gibbs 2000). Three factors that impede movement among wetlands and other habitats include (Gibbs 2000):

- Greater distances between wetlands
- Degradation of upland habitats
- Increased road density

The effects of fragmentation on wildlife that use wetlands are most extensively documented for amphibians and birds. Little information is available for effects on macro-invertebrates, reptiles, and mammals. Several studies done in the Pacific Northwest are cited in the following discussion of how fragmentation impacts wetland functions.

4.11.1 Impacts on Hydrologic Functions from Fragmentation

No information was found on how fragmentation may impact the flood storage, flood desynchronization, and groundwater recharge performed by individual wetlands. It is possible, however, to hypothesize that fragmentation will probably not change how individual wetlands still remaining in the landscape perform these functions. Fragmentation at a landscape level is not expected to change how well the remaining individual wetlands store water or how well they slow it down during peak flows. On the other hand, fragmentation probably does impact the delivery and routing of water to wetlands as described in Chapter 3. This may change how much water gets to a wetland for storage but not how well the wetland can store it.

4.11.2 Impacts on Functions that Improve Water Quality from Fragmentation

No information was found on how fragmentation may impact the ability of wetlands to improve water quality. It is not possible to hypothesize precisely how such changes might affect these functions because related information was also not found.

4.11.3 Impacts on Plants from Fragmentation

The only information found on the response of wetland plant communities to fragmentation are the series of studies carried out by J. Lienert in fens of Switzerland (Lienert, Diemer and Schmid 2002; Lienert, Fischer et al. 2002; Lienert, Fischer, and Diemer 2002; Lienert and Fischer 2003). These studies on the populations of individual obligate wetland plants show that fragmentation can have the following impacts:

- Fragmentation can reduce the genetic variability in a population (Lienert, Fisher, et al. 2002)
- Fragmentation reduces the densities and size of a plant population (Lienert and Fischer 2003)
- Fragmentation reduces the viability of a plant population (Lienert, Diemer and Schmid 2002)
- Fragmentation can lead to the local extinction of a wetland species (Lienert, Fischer, and Diemer 2002)

4.11.4 Impacts on Invertebrates from Fragmentation

Few studies were found that documented the impact of decreasing connections on the suitability of wetlands as habitat for invertebrates. One study found that wetland isolation combined with the harshness of the surrounding upland landscape in more arid environments (such as much of eastern Washington) limit dispersal and colonization by aquatic invertebrates (Myers and Resh 1999).

Another study in New York comparing macro-invertebrate populations at restored wetlands and reference wetlands showed that less mobile invertebrates colonized new wetland sites very slowly or not at all, whereas insects that disperse aerially colonized the new sites rapidly (Brown et al. 1997). Therefore, wetland isolation may have greater effects on less mobile invertebrate species.

4.11.5 Impacts on Amphibians and Reptiles from Fragmentation

4.11.5.1 Amphibians

As early as the mid-1960s, researchers in various parts of the country documented the effects of fragmentation on amphibians. One author notes the disappearance of a number of species of frogs, toads, turtles, and snakes in an urbanizing area in the Midwest that he studied from 1949 to 1964 (Minton 1968).

The effects of increased wetland isolation have been extensively studied for amphibians since then. This is probably because amphibians:

- Are restricted to movement on the ground
- Do not typically have large migration ranges
- Often move between terrestrial and aquatic habitats
- Have experienced significant population declines throughout the world

The causes of declines in the populations of amphibians have been extensively studied and most researchers conclude that the problem is very complex and multiple factors are likely at work (Hayes and Jennings 1986, Pechmann et al. 1991, Pechmann and Wilbur 1994, Delis et al. 1996, Adams 1999a). Among these factors, there is evidence that increasing isolation of wetlands due to wetland loss may play a significant role in declining amphibian populations (Ostergaard 2000, Adams 1999a, Lehtinen et al. 1999, Semlitsch and Bodie 1998). This has significant implications for amphibians in Washington State because about 97% of amphibian species that occur here commonly use wetlands for at least one life cycle stage (Leonard et al. 1993).

Amphibians are not randomly distributed within acceptable habitats—they occur in higher abundance and species richness in habitats that are better connected to other desirable habitats (Lehtinen et al. 1999, Lehtinen and Galtowitsch 2001). A Minnesota study of 21 marshes noted that the two most important predictors of decreases in amphibian species richness in agricultural areas are the degree of wetland isolation and the road density (Lehtinen et al. 1999). The marshes in this study were located in both prairie and hardwood forest ecoregions in two primary land-use settings: urban and agricultural. The study noted some differences between ecoregions and land-use effects. In the agricultural prairie ecoregion, the amphibian assemblages observed appeared to be most influenced by:

- Road density
- Wetland isolation
- Biological interactions (presence of predators)

In deciduous forest areas that are urbanizing, amphibian richness was most closely related to upland land use and associated habitat fragmentation.

Other landscape-based studies also conclude that the distances between wetlands, as well as the suitability of terrestrial habitats, are key factors in amphibian distribution. Amphibian recolonization patterns are species and spatially dependent because not all species have the capacity to move beyond fragmented, isolated habitats (Lehtinen and Galatowitsch 2001).

Declines in the richness of amphibian species have also been documented as urban land use increases (Lehtinen et al. 1999, Knutson et al. 1999, Richter and Azous 2001a). A landscape analysis of habitats for anurans (frogs and toads) in Wisconsin and Iowa showed that anurans were positively associated with uplands, wetland forests, and emergent wetlands and negatively associated with urban land (Knutson et al. 1999). A positive association, in this study, means higher abundance and species richness. The negative association with urban land is attributed by the authors to:

- Conversion of habitat
- Roads acting as barriers
- Presence of exotic predators
- Chemical contamination
- Other factors

A study of the distribution of frogs in the Netherlands found that the likelihood of a pond being used by frogs depended on the density of ponds and the amount of suitable terrestrial habitat in the surrounding area (Vos and Stumpel 1995). A similar study in the Netherlands showed that frog use of ponds was negatively correlated with the degree of wetland isolation and road density in the surrounding landscape (Vos and Chardon 1998). Distances between breeding ponds and other life stage habitats, as well as the condition of the terrestrial habitats, were primary factors in determining frog distribution. Open fields were avoided by adults and newly metamorphosed juveniles. Roads increased the mortality of frogs and acted as barriers between wetlands, thus effectively increasing wetland isolation (Vos and Chardon 1998).

Similarly, an Indiana study concluded that amphibian distribution was influenced by (Kolozsvary and Swihart 1999):

- Forest area and proximity
- Density of ponds
- Duration of ponding
- Density of vegetation

The importance of each factor varied for each species.

Using a simulation model, one author concluded that the amount of breeding habitat had a significantly greater effect on the likelihood of population extinction than the extent of habitat fragmentation (Fahrig 1997). Her model showed that if breeding habitat covers more than 20% of the landscape, population extinction is very unlikely no matter how fragmented the habitat. However, this work was based on a generalized model that made a number of assumptions that cannot be verified without targeting a selected species, as do the more empirical studies of amphibian distribution.

Other studies indicate that there is a threshold for wetland isolation or distance between wetlands for the movement of each amphibian species. Several studies of maximum distances of amphibian movement to breeding habitats indicate that amphibian reproductive success is affected by wetland isolation and terrestrial habitat condition:

- Richter and Azous (1995) suggest that upland forest habitat must lie within 3,280 feet (1,000 m) of breeding wetland habitat for it to be useful to lentic (pond) breeding amphibian species in the Pacific Northwest.
- Baker and Halliday (1999) found limits on the distance that species of newts, frogs, and toads would move to colonize new ponds in England (1,312 feet [400 m] for newts, 3,117 feet [950 m] for frogs and toads). The authors also found that, in contrast to other studies, the condition and nature of the adjacent upland habitats did not have a strong correlation to pond colonization. The study may not have been sensitive enough, or the mixed land uses within the agricultural settings may have actually supported amphibian populations.

- The ability of juveniles to move from one wetland to the next depends on the spacing between wetlands and the habitat conditions within the buffers. Distances between ponds directly affect the probability of recolonization and the chance to prevent extinction of amphibian populations. Most individual amphibians cannot migrate long distances and adults return to their home ponds, usually after migrating no more than 656 to 984 feet (200 to 300 m) (Semlitsch 2000).

- A similar study in the Netherlands showed that amphibians would colonize new ponds up to 3,280 feet (1,000 m) away (Laan and Verboom 1990). The authors concluded, however, that the probability of a species colonizing a wetland increases with proximity to the source wetland and increased connectivity by upland forest habitats between the wetlands.

4.11.5.2 Reptiles

No studies were found that specifically addressed the effects of fragmentation on reptiles. In one study in North Carolina, researchers evaluated the adequacy of federal and state wetland regulations in protecting the habitats that freshwater turtles need to complete their life cycles (Burke and Gibbons 1995). They determined that the area protected as wetland under federal guidelines did not include the area in which two critical life-cycle stages occurred: nesting and terrestrial hibernation. This means that some of the habitats needed for turtle success are vulnerable to loss due to conversion to other land uses. However, this study focused not on the effects of wetland loss but the effects of eliminating upland habitats adjacent to wetlands.

A study that modeled the effects of wetland loss in Maine showed that local populations of freshwater turtles faced a statistically significant risk of extinction following the loss of small wetlands (Gibbs 1993).

As with amphibians, the limited dispersal distances of reptiles, in comparison to birds and mammals, would logically make reptiles particularly vulnerable to habitat fragmentation. However, documentation of the effects of habitat fragmentation on reptiles that use wetlands is very sparse, and it appears to be completely lacking for Washington State. With the exception of the western pond turtle (*Clemmys marmorata*) and the painted turtle (*Chrysemys picta*), no reptile species in Washington are primarily dependent on aquatic habitats. The terrestrial western and common garter snakes (*Thamnophis* spp.), however, are both common near water bodies, including wetlands.

4.11.6 Impacts on Fish from Fragmentation

No information was found on the impacts of fragmentation on the suitability of wetlands as habitat for fish. Also, not enough related information was found to make any hypotheses.

4.11.7 Impacts on Birds from Fragmentation

The impacts of fragmentation have generally been studied in two types of fragmented landscapes: one fragmented by growing urbanization and one fragmented by agricultural practices. In general there are no studies or conclusions in the literature that would suggest the fragmentation from these two types of land use has significantly different impacts on populations of birds, and so both types of studies are reported below.

The extent of wetland isolation is known to be an important factor that influences bird use of wetland habitats:

- In a study of Puget Sound wetlands, researchers documented a positive association between bird species richness and the proximity of lakes and open water habitats, as well as the structural complexity of the vegetation in the wetlands (Richter and Azous 2001b). This implies that fragmentation results in a reduction in species richness.
- In northern prairie marshes, bird species richness declined with increased isolation of the wetland (Brown and Dinsmore 1986). Marshes that were part of wetland complexes showed higher species richness than isolated wetlands. Smaller marshes had occurrences of certain bird species only when the marshes were part of a wetland complex.
- These findings are supported by a more recent study of wetland complexes in prairie marshes in Iowa (Fairbairn and Dinsmore 2001). This study related bird species richness and densities of individual species to habitat variables within the wetland complexes and to area of wetland habitat in the surrounding landscape. For some bird species, presence and abundance in a wetland complex were clearly related to the amount of wetland habitat in a 1.9 mile (3 km) area surrounding the complex. A similar study also determined that unfragmented landscapes with prairie marsh supported more waterfowl species than isolated wetlands (Naugle et al. 2001).

The pattern of habitat use in, and around, wetlands varies between different bird species that depend on wetlands (Naugle et al. 1999):

- Some species are sedentary and rarely use resources beyond the nest vicinity
- Some use only larger wetlands regardless of the surrounding landscape
- Others require a mosaic of wetlands on the landscape

Therefore, the entire landscape must be assessed, rather than just individual wetlands in order to determine the habitat suitability of an area for many species.

A correlation has been found between the degree of urban development in an area (and the resultant fragmentation) and the extent of declines in native bird species richness. One study in Santa Clara County, California, looked at six sites representing a gradient of development ranging from biological preserve to business district (Blair 1996). Increasing proportions of invasive and exotic bird species were found in the more highly developed areas. The moderately developed sites were highest in species richness and bird biomass. They were, however, lower in native bird diversity than the lesser disturbed sites. The shift in species

was related to changes in total available habitat and in habitat structure across the gradient. This study concluded that even relatively minor habitat alterations resulted in loss of species.

Wetlands in the Puget Sound area showed a similar response to urbanization. Researchers found no correlation between total bird species richness and amount of impervious surface, but there was a correlation with native species richness (Richter and Azous 2001b). The rarer, more sensitive birds, all of which are native, tended to decrease with urbanization. The more adaptive species, including a higher percentage of non-natives (e.g., European starlings [*Sturnus vulgaris*]), tended to increase in urbanizing watersheds. Again, these changes are most likely due to loss of habitat, and therefore reduced connections between habitats, as well as habitat degradation.

One study conducted in eastern Canada examined the role that habitat heterogeneity plays in the use of wetlands by ducks (Patterson 1976). It concluded that breeding duck pairs spaced themselves based on the physical size of the wetland. The authors also observed that breeding can occur in relatively less productive wetlands. However, duck broods hatched in less productive wetlands often moved to more biologically productive wetlands where there was a greater food source and more refuge/escape habitat. These preferable wetlands were close to the breeding wetlands because young waterfowl cannot fly. This would suggest that heterogeneity in the types of wetlands in an area are important in maintaining populations of ducks.

As with amphibians, the presence of terrestrial habitats between wetlands can be an important factor in waterfowl distribution. A study conducted in an area of intensive wheat farming demonstrates the importance of maintaining connections among habitats for birds (Saunders and DeRebeira 1991). These researchers found that native bird species used corridors as narrow as 13 feet (4 m) to move between patches of preferred habitat. Corridor width was positively correlated with species richness.

A study of bird populations in forest interiors found that habitat fragmentation impairs reproduction and can result in population declines and extinctions (Temple and Cary 1988). Though not focused on wetlands, the study can reasonably be applied to forested wetlands. The authors modeled the effects of habitat fragmentation. They predicted that success rates for nests for forest-interior birds would drop from 70% when nests are greater than 656 feet (200 m) from the forest edge, to only 18% when nests are less than 328 feet (100 m) from the edge. This indicates that fragmentation of forested wetlands through such activities as logging could have significant effects on species that are not tolerant of edge habitats.

In Minnesota, Mensing et al. (1998) assessed the implications of fragmentation at various landscape scales for birds. They found that:

- Diversity and richness of bird species increased with an increase in the extent of forest and wetland within the surrounding landscape.
- Habitats that were in good condition in the areas surrounding wetlands strongly influenced the biotic diversity, with positive correlations shown for birds within 1,640 feet (500 m) of the wetland edge.

4.11.8 Impacts on Mammals from Fragmentation

Information on the effects of fragmentation on mammals that depend on wetlands is sparse, even though many of the mammal species in Washington State are known to commonly use wetlands (beaver, muskrat, mink, otter, water vole, deer mouse, and others). Most of the literature on mammals in wetlands addresses the effects of beaver dams on wetland systems.

One study from the Pacific Northwest documented that fragmentation of wetlands and the elimination of surrounding upland habitats can have significant effects on small mammals that use wetlands (many of which are not, however, closely associated with wetlands). Richter and Azous (2001c) found that the total area of undeveloped land adjacent to a wetland (including forest, shrub, agricultural fields, and meadows) was weakly associated with mammal richness. A stronger correlation, however, was found between the percent of adjacent forest land (within 1,640 feet [500 m] of a wetland) and mammal richness. The highest small-mammal richness was observed in wetlands with at least 60% of the first 1,640 feet (500 m) surrounding the wetland in forest. The authors noted that richness of mammal species in Puget Sound wetlands has no correlation with area of impervious surface in the watershed.

Roads are an important factor in habitat fragmentation for mammals. For example, a major highway in Massachusetts increased wetland isolation and blocked major travel corridors between suitable habitat patches for mammals (Forman 1998). See Section 4.12.2 for additional discussion of effects of roads on wildlife.

4.11.9 Summary of Key Points

- No information was found on the impacts of fragmentation on the hydrologic functions or the functions that improve water quality.
- Increased isolation of wetlands appears to be a major factor in reducing species richness and abundance for most taxonomic groups. One author states that "modifications to the environment that preclude movement between component subsystems may be as devastating to vertebrates in the long run as are forces that actually destroy the wetland" (Harris 1988).
- Impacts of fragmentation on the habitat provided by wetlands have been documented for plants, invertebrates, amphibians, reptiles, birds, and mammals. No information was found on impacts to fish in wetlands.
- The impacts of habitat fragmentation are not as well documented for birds and mammals as they are for other taxonomic groups. There are different patterns of habitat use between groups of birds and mammals that can influence how they respond to fragmentation (Johnson and O'Neil 2001).

4.12 Impacts from Other Human Disturbances

There are many different human activities on the land which create disturbances that can impact wetland functions and values. The previous discussion addressed only impacts from disturbances caused by activities that have been extensively studied. The following sections review some of the impacts of other types of activities and disturbances that have been documented to a lesser extent. The discussions in these sections are not separated by wetland function because all of the impacts address either plants or wildlife, and the information is not extensive enough to warrant subdividing by functions.

4.12.1 Impacts on Plant Communities from Altering Soils

Physically disturbing wetland soils during the dry season, through tillage, compaction, excavation, or other means, can allow invasion by non-native plant species (Morin et al. 1989, Sutton 1996, David 1999, Galatowitsch et al. 1999). It can also destroy much of the viable seed bank (Lee 1991). Tilling the soil often reduces diversity, including both richness and evenness, as documented in a Carolina bay wetland (Kirkman and Sharitz 1994). The tillage treatment disrupted the roots of perennials more than burning, and it encouraged germination of annuals in the seed bank and colonization by several invasive species.

Invasive plants, especially non-native plants, significantly alter the species composition of many wetlands, sometimes even forming nearly monotypic stands. Among the most widespread invaders in North America are cattail (*Typha*), reed canarygrass (*Phalaris* sp.), purple loosestrife (*Lythrum salicaria*), giant reed (*Phragmites* sp.), milfoil (*Myriophyllum spicatum*), and hydrilla (*Hydrilla verticillata*). Their increased dominance is frequently attributed in part to the physical disturbance of soils or water levels within a wetland and/or the surrounding landscape, including accelerated sedimentation, eutrophication, and the construction of mitigation wetlands (Confer and Niering 1992, Magee et al. 1999).

Continuously disturbing the soil, for example through compaction and road building, can alter species composition. These disturbed conditions can lead to a decline in both the biomass of native species and a change in the soil conditions that support them (Ehrenfeld and Schneider 1991). Use of all-terrain vehicles also impacted wetlands on the Atlantic coastal plain, reducing the density of seed in wetland seed banks and allowing common rushes to displace rare species (Wisheu and Keddy 1991). Excavation and clearing of gas pipeline rights-of-way through forested wetlands in Florida resulted in increased species richness within the wetland clearings but an increased percent cover of non-native species (Van Dyke et al. 1993).

4.12.2 Impacts on Wildlife from Roads

Roads have been found to contribute to lower species richness for a variety of wildlife groups through the factors listed below. While most of the studies cited in this section were conducted in other regions of the country, much of the information is likely to pertain to effects on Pacific Northwest wildlife because the types of impacts described are inherent to

roads regardless of region, and many of the species impacted are also found in the Northwest. Furthermore, Findlay and Bourdages (2000) note that there may be long time lags between road construction and the time when effects on wildlife are perceptible. Impacts may be undetectable in some species for decades.

It is theorized that roads cause the loss of biodiversity by (Findlay and Bourdages 2000):

- Restricting movement between populations of wildlife
- Increasing mortality from road kills
- Fragmenting habitat
- Increasing edge habitat that increase the habitat for "generalist" species
- Facilitating invasion by exotic species
- Increasing human access to wildlife habitats

The following studies have documented the impacts of roads on different species of wildlife.

- In wetlands of southeast Ontario, the species richness of mammals, amphibians, reptiles, and birds was seen to decline with increased road density and forest removal (Findlay and Houlahan 1997).
- The numbers of frog and toads decreased with increasing traffic in a study by Fahrig et al. (1995). This study concluded that increased road density can contribute to a decline in the abundance of amphibians in urbanizing areas.
- A study of amphibians using small isolated wetlands in Florida found high mortality during migration between upland terrestrial habitats and temporary pond breeding habitats (Means 1996). The author attributes much of this to direct road mortality.
- A study of the "road-effect zone" of a four-lane suburban highway in Massachusetts was undertaken to determine the distance from a road that impacts can be measured (Forman 1998). This study concluded that the road blocks migration routes for salamanders up to several hundred meters from wetlands. The study also showed that the effect of the road on blocking major travel corridors between suitable habitat patches for small mammals could be measured to several kilometers from the road. The effects of traffic noise on birds could be measured up to 2,132 feet (650 m) from the road in forested areas and 3,051 feet (930 m) in open areas.
- A related study of the same Massachusetts highway showed that impacts on populations extended out at least 328 feet (100 m) from the highway. Forman and Deblinger (2000) studied nine ecological factors relating to, among other things, wetlands, streams, and amphibians. Assessing all factors, this study concluded that the "road-effect zone" averaged approximately 1,969 feet (600 m) wide, though it was quite variable in width at specific locations.
- In a study within the Columbia Basin, roads were found to increase human access and disturbance to fish and wildlife habitats, and this may reduce the number of waterfowl

using easily-accessed wetlands by an order of magnitude during the late-fall and winter months (Foster et al. 1984).

4.12.3 Impacts on Wildlife from Noise

The impacts of noise on wildlife are a topic of growing concern. The frequency of the sound waves and the duration of the sounds influence how noise affects wildlife species. Although many of the studies discussed below do not address wetlands specifically, the impacts of noise are not expected to change whether the species in question is in a wetland or another type of habitat.

Frequency is the pitch of a sound, and different animals show different sensitivities to the same range of frequencies. Generally, smaller mammals such as rodents, shrews, and bats have a greater sensitivity to higher frequencies—often within ranges exceeding 20,000 Hertz (Hz), the upper limit of human sound perception. Larger mammals show sensitivity to low frequencies and may be able to detect sound at or below 10 Hz. While most birds show a sensitivity to sound that is similar to humans (20 to 20,000 Hz), certain birds (such as rock doves) can also perceive low-frequency sounds, often with much greater sensitivity than their larger mammalian counterparts (Kreithen and Quine 1979). Some frogs and toads also show low-frequency sensitivity and even some small mammals are capable of discerning sounds of only a few Hertz (Plassman and Kadel 1991).

Sound duration may be divided into two classifications: continuous sounds which last for a long time with little or no interruption, and impulse sounds lasting for only short durations (Larkin et al. 1996). Impulse sound and continuous sound appear to have different physiological and behavioral effects. Generally, impulse noise appears to be more stressful to wildlife, at least in part due to the unpredictability of such noise (Larkin et al. 1996).

Overall, the literature suggests that species differ widely in their physiological response to various types, durations, and sources of noise (Manci et al. 1988). However, noise effects on wildlife may be broadly classified as primary, secondary, and tertiary:

- **Primary effects.** Are direct, physiological changes, such as stress and hypertension, to the auditory system and may be considered to include the "masking" of auditory signals. Masking is the inability of an individual to hear important environmental signals such as calls from mates or noises of predators or prey.

- **Secondary effects**. May include behavioral modifications that include interference with mating or reproduction and impaired ability to obtain adequate food, cover, or water.

- **Tertiary effects.** Are the direct result of primary and secondary effects at a population level and include population decline and habitat degradation. Most of the effects of noise are mild enough that they may never be detectable as variables of change in population size or population growth against the background of normal variation (Bowles 1995).

The behavioral responses of wildlife to noise show a high degree of variation depending on the species, the type of noise, and the habituation of the individuals to the source of noise. For example, some bald eagles can be very tolerant of auditory stimuli when the sources are screened from view (Stalmaster 1987), but other raptor species such as prairie falcons flush from perches and nests at sudden loud noises (Harmata et al. 1978).

Animals may become tolerant of repeated noises. Krausman et al. (1986) studied desert ungulates exposed to aircraft noise and noted that short-term habituation to aircraft noise occurred with repeated exposure. Sandhill cranes nesting meters away from a Florida highway showed no response to passing traffic (Dwyer and Tanner 1992). The effects of noise vary not only with the type of noise in question, but with an individual animal's experience, time of day (Herbold et al. 1992, Gese et al. 1989), and reproductive cycle (Platt 1977).

Research on the effects of traffic noise on breeding birds was conducted by Reijnen et al. (1995, 1996) who studied woodland and grassland bird populations in the vicinity of roadways. Ambient noise up to a given level resulted in no reduction in the density of bird populations. However, once an ambient noise threshold level was exceeded, densities decreased exponentially with increased noise. Threshold levels were found to range from 36 to 58 decibels, depending upon species, and the zones of decreased breeding densities surrounding the roadways ranged up to 2,670 feet (810 m) for particularly sensitive species near busy roadways. They found habitat avoidance by individual birds in habitat that would otherwise have been suitable for breeding.

One study also found evidence that reproductive output may be diminished in frogs breeding near highways because of acoustic interference (Barass 1985 in Larkin et al. 1996).

4.12.4 Impacts on Wildlife and Plant Communities from Recreational Activities

Little information was found on the impacts of recreational activities in wetlands. Most of the available information is anecdotal and focused on the more evident impacts such as loss of vegetation from the use of off-road vehicles. There is less information on the effects on wildlife of such disturbances as noise, light, glare, and human presence caused by recreational activities, particularly with respect to wetlands. None of the studies described in this section were located in the Pacific Northwest.

A synthesis paper on management of amphibians in Montana notes that among the many factors that are likely to contribute to a decline in amphibian populations are trail development, on- and off-road vehicles use, and development and management of recreational facilities (Maxell 2000). Citing a number of studies from the 1980s, Klein (1993) notes that recreational uses in natural areas can disrupt:

- Wildlife foraging and social behavior
- Animals that are feeding

- Parent-offspring bonds
- Pair bonds

The author also cites several studies stating that increased predation of nests and decreased densities of wildlife result from greater human recreational use of natural areas.

A study of flooded gravel pits in Britain examined the abundance and distribution of one species of wintering waterfowl with regard to recreational disturbance (Fox et al. 1994). The authors found that water-based recreational activity, such as boating, reduced the number of birds on the ponds to the greatest extent of all the observed activities. Ponds where fishing, walking, or other bank-side activities were allowed also showed reduced numbers of birds in comparison to the ponds that were designated reserves with restricted access. They were, however, not as reduced in abundance as those ponds that also allowed water-based activities.

The effects of recreational use on waterfowl were also studied in areas near the shore on Lake Erie (Knapton et al. 2000). Excessive human disturbance reduced the foraging efficiency and body fat acquisition for waterfowl and can result in decreased bird densities. Diving ducks appeared to be the most sensitive to disturbance.

In another study on recreation impacts on birds, Klein (1993) studied the specific behaviors of humans that disturb wildlife on a subtropical barrier island that is a National Wildlife Refuge off the coast of Florida. Her study sites were primarily in mudflat and mangrove wetland habitats. She tested a variety of treatments such as driving by without stopping, stopping the vehicle with and without getting out, approaching the birds on foot, and playing noise tapes. The author found that most of the bird species present were disturbed by the noise tape. Some species such as great blue heron consistently flew away when approached by a person, whereas other species tolerated human presence until closely approached.

Klein (1993) concludes that car traffic is less disruptive to wildlife than out-of-vehicle activity. Frequent human approaches may cause some bird species to forage in areas with fewer intrusions. Wildlife photographers were the most likely visitors to approach birds. Visitors who spoke with refuge staff and volunteers were the least likely to disturb birds, possibly due to an increased awareness of the habitat needs of wildlife. While this study involved a very different ecosystem, it is useful because it generated data on the Great Blue Heron, a bird species that also occurs in Washington. It also is one of the few studies that examined the effects of specific human behaviors on wildlife.

Recreational activity is believed to be one of the main factors in lakeshore deterioration and decline in reed-dominated wetlands in a study of Central European lakes (Ostendorp et al. 1995). It is likely that trampling of bank-side vegetation by recreational users is causing bank erosion and excessive siltation in wetlands near the shore.

Although recreation often occurs in more rural habitats, urbanization also brings increased intensity of recreational uses within remaining greenbelts and open spaces. A study in Western Australia examined the trend in smaller lot size relative to the owners' use of nearby open spaces (Syme et al. 2001). Smaller lot size resulted in an increase in recreational visits

by the homeowners to nearby wetlands. Increased access to and recreational use of wetlands is clearly one of the impacts that accompany urban development.

4.12.5 Introduction of Invasive and Exotic Species in Wetlands

Human activities increase the likelihood of introducing exotic animal and plant species to wetlands because they cause disturbances that favor the establishment of exotic species (Mack et al. 2000). The following factors have been found to favor the establishment of exotic species (Houck 1996, Dale et al. 2000, Mack et al. 2000, Gelbard and Belnap 2003, Maurer et al. 2003):

- Increased movement of seed and animals through higher road densities
- Greater fragmentation of the landscape that limit re-colonization of native species
- Higher densities of human land use
- Alterations of water regimes
- Direct disturbance of soils

The studies cited in the following discussion implicate disease, predation, and competition as major factors in limiting the success of native species when exotic, invasive species come in. Many of the relationships between invasive species and native species are not well understood because many environmental and biological factors play a role (Mack et al. 2000).

In Washington and Oregon, about 42 exotic vertebrate species have established populations (Witmer and Lewis 2001). These include species of 18 birds, 19 mammals, three reptiles, and two amphibians. The birds were mainly introduced for hunting or aesthetic purposes, while the mammals mostly escaped from commercial or domestic settings. The amphibians and reptiles were released pets or were introduced for food or aesthetic purposes. About 30% of these exotic species are restricted to freshwater and riparian systems, although others among this group will commonly use these habitats (Witmer and Lewis 2001). No information, however, was found on the number of exotic plant species found in wetlands.

4.12.5.1 Impacts on Wetlands from Exotic and Invasive Plants

Invasive plants, especially non-native invaders, significantly alter the composition of plant communities in many wetlands, sometimes even forming nearly monotypic stands (Adamus et al. 2001). Changes in the plant community can be expected to result in changes to all the invertebrates and microscopic organisms that are associated with specific plant species.

Among the most geographically widespread invaders in Washington's wetlands are reed canarygrass (*Phalaris arundinaceae*), purple loosestrife (*Lythrum salicaria*), giant reed (*Phragmites* sp.), and European milfoil (*Myriophyllum spicatum*). Their increased

dominance is frequently considered to be a result of human disturbances such as the following:

- Changes in soils or water levels within a wetland and/or the surrounding landscape, including accelerated sedimentation, eutrophication, and the construction of mitigation wetlands (Confer and Niering 1992, Magee et al. 1999)
- Changes in hydroperiod following urbanization (Cooke and Azous 2001)
- Increased human access and mechanical disturbance of wetlands (e.g., a study in southern Australia showed that vegetation removal and site disturbance are major factors in plant invasions; Detenbeck et al. 1999)
- Increases in sediment and nutrients resulting from agriculture or urbanization (Maurer et al. 2003).

4.12.5.2 Impacts on Species Using Wetlands from Domestic Pets

No information on the impacts of domestic pets on specific wetland-associated species was found. However, general information on predation by pets, specifically cats, indicate they can impact populations of many different small species living adjacent to residential areas. Residential development typically brings increased access to wetlands by domestic pets, primarily cats and dogs because wetlands are not fenced off.

Several studies of predation by house cats indicate that small mammals and birds were the preferred prey of house cats, but cats also killed reptiles and amphibians (Barratt 1997, Lepczyk et al. 2003). Many of the mice and rats captured by the cats are exotic species themselves. The results, however, suggest that house cats may have significant impacts on native populations as well, particularly along the fringes of suburban expansion where native mammals and birds are more common.

A study of predation by house cats in Virginia determined that individual cats caught an average of 26 animals in urban areas and 83 animals in rural areas over an 11-month period (Mitchell and Beck 1992). In another study in Michigan, Lepczyk et al. (2003) found that cats preyed on about 1 bird per week. Extrapolating these numbers of prey to the total number of cats in a specific urban or suburban area would give an astonishingly high toll attributable to house cats.

4.12.5.3 Impacts on Species Using Wetlands from Exotic Mammals and Birds

Many introduced birds are known to usurp nests of native birds or to compete with them for nest sites. European starlings (*Sturnus vulgaris*) are known to displace wood ducks, woodpeckers, and other species from their nests, often destroying the eggs and young (Witmer and Lewis 2001). Starlings also out-compete many native species for nest cavities, overwhelming them with their large numbers and aggressive behavior. Transmission of

disease, particularly from exotic birds and rodents from Europe, is also a major problem that threatens native wildlife (Witmer and Lewis 2001).

Introduced mammals affect native wildlife and plants through predation and herbivory (Witmer and Lewis 2001). For example, nutria (*Myocaster coypus*), which were introduced from South America for fur production, have tremendous impacts on wetland vegetation, uprooting plants as they dig for rhizomes and denuding vast areas (Mitsch and Gosselink 2000, Witmer and Lewis 2001). Nutria may be implicated in population declines of muskrats (*Ondatra zibethicus*), probably due to competitive exclusion (Witmer and Lewis 2001).

4.12.5.4 Impacts on Native Invertebrates from Exotic Invertebrates in Wetlands

Humans have introduced a number of non-native invertebrates to wetlands. Native invertebrate communities seem ill-adapted to compete with or avoid these alien species, but data on long-term effects to wetland communities are mostly lacking.

The zebra mussel (*Dreissena polymorpha*) has invaded many aquatic systems throughout North America. Although the zebra mussel has not yet been found in Washington, some local populations of mussels that live in wetlands may be highly susceptible if an invasion occurs. Some mussels (of the family Unionidae which is found in Washington streams and rivers) are particularly susceptible to disruptions from introduced mussels because they are relatively immobile and have long life spans, often over 10 years (Mehlhop and Vaughn 1994). Furthermore, riverine wetlands with higher alkalinity tend to be more susceptible to invasions by zebra mussels (Whittier et al. 1995).

In areas in other parts of the country that have been invaded by Zebra mussels substrates can become totally carpeted, displacing native mussels (Tucker and Atwood 1995). Some midges, snails, and caddisflies can be outcompeted as well. The mussel has minimal or positive effects on amphipods and flatworms (Wisenden and Bailey 1995). They may also concentrate contaminants, making them more available to invertebrate food chains (Bruner et al. 1994).

The rapid spread of zebra mussels may have been made more possible by the preceding decline of native mussels as a result of pollution and changes in habitat (Roberts 1990, Nalepa and Schloesser 1993, Mackie 1991, Haag et al. 1993, Whittier et al. 1995).

4.12.5.5 Impacts on Native Amphibians from Exotic Species in Wetlands

The effects of exotic species of amphibians on native amphibians that use wetlands are particularly well studied, but not well understood. Predation and competition from introduced amphibians has been suggested as one cause of population declines for native amphibian species (Witmer and Lewis 2001), but as described below the effects are complex.

Bullfrogs (*Rana catesbeiana*) are often cited as a factor in declining amphibian populations (Hecnar and M'Closkey 1996, Kiesecker and Blaustein 1998, Adams 1999a). Native to

eastern North America, bullfrogs were introduced to the Pacific Northwest in the early 1900s for hunting and food. Bullfrogs are suspected of causing amphibian declines because they prey on frogs and salamanders and are often so numerous in wetlands that they are thought to out-compete native species for space (Witmer and Lewis 2001). Studies of the role that bullfrogs play in declines of amphibian populations are, however, somewhat contradictory in their findings (Hecnar and M'Closkey 1996, Kiesecker and Blaustein 1998, Adams 1999a, Witmer and Lewis 2001). It is possible that the effects of bullfrogs may differ for various species, or their influence may be quite subtle and complex.

Several studies conducted in the Pacific Northwest have found either weak or no correlation between bullfrog presence and amphibian richness and abundance (Adams 1999a, Richter and Ostergaard 1999, Richter and Azous 1995). Data from a monitoring program of amphibians in wetlands in King County showed that bullfrogs are not causing competitive exclusion of native species (Richter and Ostergaard 1999). Native amphibian richness was not negatively correlated with bullfrog presence or with the presence of permanent water in the wetlands (Richter and Ostergaard 1999). Richter and Azous (1995) noted relatively high species richness for native amphibians in permanently ponded wetlands, the preferred habitat for bullfrogs.

Focusing on red-legged frogs (*Rana aurora*) in Puget Lowland wetlands, Adams (1999a) concluded that this species is not excluded from wetlands that also support bullfrogs. The study showed little to no negative correlation between red-legged frogs and bullfrogs. It noted that exotic fishes such as sunfish, yellow perch (*Perca flavescens*), and smallmouth bass (*Micropterus dolomieui*) had greater effect on amphibian richness in the wetlands studied. In a companion study Adams (1999b) found that habitat gradients or indirect effects of exotic vertebrates on native amphibians play major roles.

A study of red-legged frogs in the Willamette Valley in Oregon, however, stated their development was affected by both bullfrogs and exotic fishes (Kiesecker and Blaustein 1998). In this study, tadpoles showed decreased mass at metamorphosis and increased time to metamorphosis in the presence of larval and adult bullfrogs. Smallmouth bass alone had little effect on tadpole development, but red-legged frog tadpoles altered their use of microhabitats when both bullfrogs and smallmouth bass were present. Survival of tadpoles was affected only when both bullfrog adults and larvae were present, or when both bullfrog larvae and smallmouth bass were present.

4.12.5.6 Impacts on Wetland-associated Species from Exotic Fish

Non-native fish have been widely introduced into waters of the United States and Washington, both intentionally and by accident. Adamus et al. (2001) cite research showing that the effects of invading species on native fish communities are usually adverse (Baltz and Moyle 1993), especially when coupled with simultaneous impacts from other factors (Larimore and Bayley 1996, Marschall and Crowder 1996).

The presence of exotic fish has been implicated in reduced abundances and species richness of amphibians. A study in the Okanogan Highlands in northeast Washington showed that richness of pond-breeding amphibian and abundance were diminished by the presence of

exotic fish (Aker 1998). The non-native fish species observed in this study included largemouth bass, tench (*Tinca tinca*), brook trout (*Salvelinus fontinalis*), and perch. While there was lower amphibian richness in ponds with native fish than those with no fish, the data indicate that non-native fish had a greater impact on amphibian numbers and richness. Adams (1999a, 1999b) found that exotic, non-native, fish reduced survival of native amphibians to almost zero in the Puget Lowlands. Further studies by Adams (Adams et al. 2003) found that non-native fish facilitated the invasion of wetlands in Oregon by bullfrogs because they fed on invertebrate predators of bullfrog larvae.

Leonard et al. (1993) surveyed populations of the northern leopard frog (*Rana pipiens*) in Washington State. They found that the species had been extirpated from most of its historic range, with only small populations remaining in parts of eastern Washington. These authors noted that areas once inhabited by the northern leopard frog support exotic species such as largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), and brown bullhead (*Ameiurus nebulosus*). They hypothesized that these species may be implicated in the decline of the northern leopard frog but have no definitive data to support this hypothesis.

The introduction of carp has resulted in significant impacts on wetlands in eastern Washington. Large, herbivorous fish such as carp compete directly with birds for submerged aquatic plants (Bouffard and Hanson 1997). The fish also resuspend the sediments on the bottom of lakes and ponds. This has a significant impact on invertebrates as well as the submerged aquatic plants. Parkos et al. (2003) found that the presence of the common carp was positively correlated with increases of phosphorus (a nutrient that causes eutrophication), turbidity, suspended solids, and zooplankton biomass. Their presence was negatively correlated with the abundance of aquatic plants and invertebrates.

4.12.6 Summary of Key Points

- Alteration of soils can change the plant community in a wetland and allow invasion by exotic species.
- Noise creates stress for wildlife, but the impacts are very specific to individual species and to the type of noise generated.
- Recreational use of wetlands impacts the normal behavior of wildlife and reduces densities.
- Invasions by exotic species can alter the distributions of both plant and animal species in wetlands. The impacts of bullfrogs on other amphibians, however, seem to be ambiguous even though this question has been studied extensively.

4.13 Chapter Summary and Conclusions

Humans create many different types of disturbances that can affect the performance of wetland functions. The disturbances were reviewed in Chapter 3. Chapter 4 has reviewed the information available on how each type of human disturbance impacts wetlands and their functions. The disturbances that impact wetlands the most include:

- Direct changes to the physical structure of wetlands via filling, vegetation removal, tilling of soils, and compaction of soils
- Changes in the amount of water in wetlands
- Changes in how water levels fluctuate (frequency, amplitude, direction of flows)
- Changes in the amount of sediment
- Increases in the amount of nutrients
- Increases in the amount of toxic contaminants
- Changes in the amount of acidity
- Increasing the concentration of salts
- Increasing the fragmentation of habitat
- Other disturbances that are not as well documented including alteration of soils, construction of roads, noise, recreational use, and invasion by exotic species.

Table 4-3 reviews how various land-use practices create disturbances that can change the environmental factors that control wetland functions. Table 4-4 summarizes the effects of each of these disturbances in terms of the wetland functions they may impact. The rating of the impacts in the table represents a synthesis by the authors of all the information presented in this chapter. By combining the information in these two tables, it is possible to associate changes in functions of wetlands with general types of human land use, as shown in Table 4-5. The human land uses create various disturbances in the environment, and those disturbances in turn affect the factors that control wetland functions, ultimately leading to changes in those functions.

For example, Table 4-3 shows that urbanization creates significant disturbances that change the amount of water, the fluctuations of water levels, and input of sediments, nutrients, and contaminants to wetlands. Table 4-4 shows that these disturbances have a major impact on the wetland functions of providing habitat for plants, invertebrates and reptiles/amphibians. Table 4-5 synthesizes this information to show that urbanization impacts the habitat for plants, invertebrates, reptiles, and amphibians in wetlands.

The scientific information available indicates that human activities and uses of the land can have significant impacts on the functions in wetlands at both the larger, landscape scale and at the scale of the individual wetland itself. As a result many different approaches have been

developed to try to minimize these impacts. These include regulations to control human activities near wetlands, methods to replace the functions lost or altered including restoration, ways to protect the wetland resource through non-regulatory measures and incentives. The effectiveness of some of these tools at actually protecting wetland functions are discussed in Chapters 5 and 6.

Table 4-3. Summary of types of environmental disturbances created by some types of land use.

Disturbance	Scale of Disturbance	Agriculture	Urbanization	Mining
Changing the physical structure within wetlands (filling, vegetation removal, tilling of soils, compaction of soils)	Site scale	xx	xx	h
Changing the amounts of water	Landscape scale	xx	xx	?
	Site scale	xx	xx	h
Changing fluctuations of water levels (frequency, amplitude, direction of flows)	Landscape scale	xx	xx	?
	Site scale	xx	xx	h
Changing the amounts of sediment	Landscape scale	xx	xx	h
	Site scale	xx	xx	h
Increasing the amount of nutrients	Landscape scale	xx	xx	nm
	Site scale	xx	xx	nm
Increasing the amount of toxic contaminants	Landscape scale	xx	xx	x
	Site scale	xx	xx	xx
Changing the acidity	Landscape scale	nm	nm	x
	Site scale	nm	nm	xx
Increasing the concentrations of salt	Landscape scale	x	nm	nm
	Site scale	x	nm	nm
Fragmentation	Landscape scale	xx	xx	h
Other disturbances	Site scale	xx	xx	h

Key to symbols used in table:

(xx) Land use creates a major disturbance of environmental factors

(x) Land use creates a disturbance

(nm) Studies on impacts of this land use do not mention this disturbance

(h) Literature is lacking but disturbances can be hypothesized based on authors' experience

(?) Information lacking

Table 4-4. Synthesis of the information reported in the literature on the negative impacts of different human disturbances on wetland functions.

Disturbance Type	Functions							
	Hydrologic	Water Quality	Plants	Habitat for Invertebrates	Habitat for Amphibians and Reptiles	Habitat for Fish	Habitat for Birds	Habitat for Mammals
Changing the physical structure of wetlands	+	+	++	++	+	+	++	+
Changing the amount of water	+	+	++	++	++	+	+	?
Changing fluctuations of water levels	?	?	++	+	++	+	?	?
Changing amounts of sediment	+	?	++	++	?	?	?	?
Increasing amounts of nutrients	+	+	++	++	++	+	+	+
Increasing amounts of toxic contaminants	?	+	++	++	++	++	++	?
Changing acidity	0	+	+	++	++	+	+	+
Increasing concentrations of salt	0	?	++	++	?	?	+	?
Fragmentation	0	?	?	?	++	?	++	+
Other disturbances	?	?	++	+	++	++	++	++

Key to symbols used in table:

++ Major negative impacts on specific functions have been documented
+ Some data suggest impacts or impacts could be hypothesized
0 Data indicate that impacts are minimal
? Information is lacking

Table 4-5. Synthesis of the negative impacts of some land uses on wetland functions.

Land Use	Functions							
	Hydrologic	Water Quality Improvement	Plants	Habitat for Invertebrates	Habitat for Reptiles and Amphibians	Habitat for Fish	Habitat for Birds	Habitat for Mammals
Agriculture	+	+	++	++	++	++	++	+?
Urbanization	+	+	++	++	++	++	++	+?
Mining	?	?	+	++	++	+	+	+?

Key to symbols used in table:

++ Major negative impacts on specific functions have been documented
+ Some data suggest impacts or impacts could be hypothesized
? Information is lacking
+? Some impacts have been documented but more information is needed

Chapter 5

The Science and Effectiveness of Wetland Management Tools

5.1 Reader's Guide to this Chapter

This chapter builds on the previous discussion of how wetlands function (Chapter 2), how human activities and changes in land use cause disturbances (across the landscape and at specific sites) that influence the factors that control wetland functions (Chapter 3), and how wetland functions are impacted by these disturbances (Chapter 4).

Chapter 5 presents a synthesis of what the current literature reports on four tools currently used to identify wetlands and to address impacts to wetlands and their functions: wetland definitions, wetland delineation methods, wetland ratings, and buffers. This chapter does not provide language or recommendations for regulatory or policy language—those will be provided in a separate volume on management options and recommendations (Volume 2).

5.1.1 Chapter Contents

Major sections of this chapter and the topics they cover include:

Section 5.2, Introduction and Background on Regulatory Tools introduces the key wetland management tools that are discussed in this chapter.

Section 5.3, How Wetlands Are Defined and Delineated describes similarities and differences in the way various agencies define *wetland*. It explains the critical difference between "biological wetlands" and "regulated wetlands." It also discusses certain types of wetlands that are frequently exempted from regulation, such as isolated wetlands, small wetlands, or those designated as Prior Converted Croplands. The various manuals that have been developed to guide the delineation of wetland boundaries are also briefly discussed.

Section 5.4, Wetland Rating Systems discusses how rating systems have been developed to rapidly assess wetland characteristics in the field. These characterizations allow wetlands to be rated for regulatory or management purposes. This section introduces the reader to the Washington State wetland rating systems, which were briefly mentioned previously in a number of places in the document. It also includes discussion of certain wetland types that require particular attention under the Washington State wetland rating systems.

Section 5.5, Buffers comprises the bulk of this chapter. This section provides a synthesis of the literature on how buffers protect and maintain wetland functions. The section concludes by summarizing recommendations from the literature for establishing effective buffer widths.

Section 5.6, Chapter Summary and Conclusions ties together the major concepts presented in the chapter.

5.1.2 Where to Find Summary Information and Conclusions

Each major section of this chapter concludes with a brief summary of the major points resulting from the literature review on that topic in a bulleted list. The reader is encouraged to remember that a review of the entire section preceding the summary is necessary for an in-depth understanding of the topic.

For summaries of the information presented in this chapter, see the following sections:

- Section 5.3.6
- Section 5.4.2
- Section 5.5.3.5
- Section 5.5.4.4
- Section 5.5.5.4
- Section 5.5.6.1

In addition, Section 5.6 provides a summary and conclusions about the overarching themes gleaned from the literature and presented in this chapter.

5.1.3 Data Sources and Data Gaps

No literature review was conducted for the section on wetland definitions or delineations. Both of these management tools are currently established by state and federal statutes. It was determined that review of the previous discourse on these topics was not relevant to the current state of the science for Washington State.

Considerable research was published prior to 2000 on the role of small wetlands relative to wildlife in a landscape context. Since then, several synthesis documents on small and isolated wetlands have been published.

Papers on the adequacy or effectiveness of wetland rating systems were not found; instead, the literature concentrates on function assessment methods. This chapter does not attempt to assess the science on wetland function assessment because the Washington State Department of Ecology (Ecology) has evaluated and described different function assessment methods previously (see Volume 2, Appendix 5-B for more information). Additionally, Ecology completed function assessment methods for several different

wetland hydrogeomorphic types on both sides of the state within the last five years (see Chapter 2 for further information).

The subject of buffers is well documented in the scientific literature. Numerous studies from across the U.S. have been conducted for wetland and stream buffers. The results of buffer studies, completed here in the Pacific Northwest as well as other areas of the country, provide remarkably consistent findings related to the factors that are important in determining appropriate buffer widths. This consistency is particularly striking in the numerous buffer synthesis documents. Additionally, the results of many studies conducted in other parts of the U.S. have been replicated in studies in the Pacific Northwest.

Determining relevance to Washington, however, can be challenging, since the physical settings of the studies vary widely. Some, however, obviously do relate to Washington; for example, literature related to agricultural practices and vegetated filter strips from the north-central United States and south-central Canada is relevant to some agricultural practices in Washington, especially in areas east of the Cascades.

The majority of research on buffers tends to focus on how buffers influence water quality. Far fewer studies examine the influence of a buffer's physical characteristics on attenuating rates of surface water flow.

Most studies on buffers related to wildlife document the needs of a particular species or guild related to how far they travel from aquatic habitats to fulfill their life-needs. While there is substantial literature on the implications of habitat fragmentation, this literature does not specifically address the role of buffers in reducing fragmentation between wetlands and other parts of the landscape.

Numerous compilations and syntheses of the literature concerning buffers have been completed since 1990. These synthesis documents are used in this document as direct sources when no more recent research was found. This chapter also cites literature related to stream buffers and riparian areas when the findings are relevant to the functions or processes these areas provide to the adjacent aquatic resource.

A more detailed description of the types of literature used and any recognized gaps in the scientific literature are provided within each section on buffers as appropriate.

5.2 Introduction and Background on Regulatory Tools

The regulatory tools discussed in this chapter are components of "typical" wetland protection programs. The intent is not to analyze all elements of protection programs and their regulations but to focus on the key science-based elements relating directly to wetland protection and management. Therefore, this chapter focuses on the following four elements:

- Wetland definitions
- Wetland delineation methods
- Wetland ratings
- Buffers

The topic of compensatory mitigation, another key regulatory tool, is discussed separately in Chapter 6 because of the volume of information and literature available on this subject.

5.3 How Wetlands are Defined and Delineated

5.3.1 How Agencies Define Wetlands

Several definitions of wetlands have been developed and used by various federal, state, and local agencies and jurisdictions. The effectiveness of current federal or state wetland definitions was not evaluated as part of this synthesis. However, definitions are included here because how a wetland is defined is critical to determining what areas are subject to the provisions of a law or regulation.

For the purposes of most laws and regulations, wetlands are usually defined using one of the following two definitions:

> *Those areas that are saturated or inundated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.* (U.S. Army Corps of Engineers 1987);
>
> or
>
> *"Wetlands" or "wetland areas" means areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands.* (Washington Administrative Code 173-22-030.)

The Washington State definition is derived from the U.S. Army Corps of Engineers (Corps) definition, but it also includes clarifying language that identifies which common human-made or -induced features are not meant to be defined as wetland. The state definition is required by the Growth Management Act (RCW 36.70A.030 (20)) to be used in all local critical area regulations.

In addition, for the National Wetland Inventory, the U.S. Fish and Wildlife Service (USFWS) defined wetlands as follows:

> *Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purpose of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.* (Cowardin et al. 1979)

Note that the definition used by the USFWS allows the use of a single parameter to determine if an area is a wetland. The definition also includes areas that may not be vegetated, such as gravel bars and mudflats. In most cases, the Corps and Ecology definitions require the presence of all three parameters (vegetation, soil, and hydrology) for an area to be considered a wetland, and they both assume that wetlands generally are vegetated.

5.3.2 Biological vs. Regulated Wetlands

In some jurisdictions, all lands that meet the definition of *wetland* are regulated. However, it is not unusual for a jurisdiction to differentiate within its regulations between "wetlands" (i.e., biological wetlands) and "regulated wetlands" (i.e., wetlands that they intend to regulate). The definition of what constitutes a regulated wetland may vary from jurisdiction to jurisdiction.

In reviewing regulatory language from local wetland regulations, the three primary criteria used to differentiate between "wetland" and "regulated wetland" were:

- The category or rating of the wetland
- The size of the wetland
- The type of wetland (such as isolated wetlands and those designated as Prior Converted Croplands)

In general, a category or rating system has been used historically in regulatory language to differentiate between wetlands that need different degrees of protection. Rating systems are used by local jurisdictions to group wetlands based on physical characteristics and/or functions that the wetlands may provide and how those characteristics or functions are valued. Section 5.4 of this document describes the current

state of the science on wetland ratings and the wetland rating systems developed for eastern and western Washington.

The criterion of wetland size is usually a minimum below which the jurisdiction will not regulate a wetland. For example, the jurisdiction may allow no fill in wetlands larger than 10,000 square feet, or they may include language such as "Category 2 wetlands larger than 0.25 acre cannot be altered." The historical rationale for the use of size as a regulatory criterion was the perception that "bigger is better," and the belief that small wetlands were less important and did not provide significant functions. The scientific literature of the last 10 years has made it clear that size does matter but not in the way previously believed. In multiple studies, small wetlands have been shown to contain a significant diversity of plant and animal species (See Section 5.3.3 for more information).

Additionally, two other wetland types may be exempted from regulation: isolated wetlands and wetlands designated as Prior Converted Croplands.

In 2001, the U.S. Supreme Court determined that isolated wetlands are not subject to regulation under Section 404 of the federal Clean Water Act if the only basis for their regulation is their use by migratory birds. However, the Court did not define "isolated," and the federal government has not issued any new guidance or regulations to clarify the situation. In general practice, the U.S. Army Corps of Engineers (Corps), the federal agency that administers the Clean Water Act, considers isolated wetlands to be those of any size that are not adjacent to or have no direct surface water connection to any navigable waters. However, recent lower court decisions have interpreted Corps jurisdiction over isolated waters differently, and the situation is in flux.

Washington State has determined that isolated wetlands are regulated by the Department of Ecology under the state Water Pollution Control Act (RCW 90.48). Since some local jurisdictions in Washington fashion their wetland regulations on the federal or state standards, it is important to consider the implications of not regulating isolated wetlands. Thus, scientific information on isolated wetlands is discussed in Section 5.3.4.

Wetlands that are designated as Prior Converted Croplands (PCC) are another type of wetland that are exempt from regulation by the federal government. PCC are those wetlands that were drained or otherwise manipulated prior to December 23, 1985, for the production of commodity crops. They are wetlands in which inundation (ponding) does not occur for more than 14 consecutive days during the growing season. These sites must produce an agricultural commodity that requires planting a crop that needs annual tilling. These areas are considered waters of the U.S. if they are abandoned (i.e., tilling and planting has not occurred for five consecutive years), and hydrophytic vegetation and wetland hydrology returns. However, even if they are not abandoned, many of the PCCs in Washington still meet the three criteria required for biological wetlands. As with isolated wetlands, the Department of Ecology regulates PCCs that are wetlands under state law.

No information on wetland areas meeting the definition of PCC was found in the scientific literature. However, many wetlands meeting the criteria for PCC would still be expected to provide important functions, given that the criteria for being designated "Prior Converted" require only that the wetland has been manipulated for production of commodity crops since 1985 and does not pond for more than 14 consecutive days during the growing season. The authors of Volume I have observed widespread flooding in PCC areas during the winter and have observed use of these areas by several species of overwintering waterfowl. One published study of waterfowl in Puget Sound documented significant use of farmlands by several duck species for feeding during the winter (Lovvorn and Baldwin 1996). This study found greater use by waterfowl of farm fields that were flooded in winter, but made no distinction between upland farm fields, farmed wetlands, and Prior Converted Croplands. In addition, the authors of Volume I have documented significant water quality and quantity functions provided by PCCs in projects reviewed and permitted by the Department of Ecology (This data has not been published).

If the agricultural activities were abandoned, PCCs could revert to a plant community characteristic of wetland; and, without maintenance of the hydrologic modifications, the wetland's water regime may revert to a condition more like that which existed prior to the alteration. Further analysis of the functions of wetland areas designated as PCC is needed.

No literature was found that discussed the ecological consequences of the legal bifurcation between biological wetlands and regulated wetlands. However, literature was found that discusses the functions and values provided by small wetlands and isolated wetlands, as discussed below.

5.3.3 Small Wetlands

The elimination of small wetlands is an issue that has gained attention over the past 10 years. Many regulations have preferentially allowed filling of small wetlands. Many regulations completely exempt wetlands under a certain threshold. Also, size is one of the most common characteristics used in determining wetland ratings at the local level, and smaller wetlands typically receive lower levels of protection. Yet, the loss of small wetlands is one of the most common cumulative impacts on wetlands and wildlife (Weller 1988, Tiner et al. 2002).

No definition of *small* is provided here because what constitutes "small" varies between jurisdictions and scientific studies (see also Section 5.3.2). In some contexts, small is determined exclusively by size. Small may mean less than 0.10 acre; in others, it may mean less than 10 acres.

Some jurisdictions, however, also differentiate small wetlands using criteria that reflect function and values. Small wetlands can have outlets, be in a floodplain, or be otherwise associated with a larger aquatic system. These characteristics are often used in rating systems and, combined with size, determine what is considered a small wetland. For

example, a jurisdiction may include language in their regulations such as "Category 2 wetlands larger than 0.25 acre cannot be altered." For each of the studies below, we have included the authors' definition of small.

In addition to the obvious loss of habitat for wildlife, fragmentation of habitat increases as small wetlands are eliminated, resulting in greater distances between wetland patches in the landscape. Semlitsch and Bodie (1998) found that creating greater distances between wetlands of 0.5 to 10 acres in size can have a significant effect on the ability of a landscape to support viable populations of amphibians, as juveniles dispersing from a source wetland may not be able to travel far enough to recolonize other surrounding (now distant) wetlands. Management priorities have focused on larger, semi-permanent wetlands, with the least emphasis on protecting the smaller, seasonal wetlands (< 1.2 acres) that are critical components of wetland complexes (Naugle et al. 2001).

The following sections describe studies of the use of small wetlands by wildlife, and the role that small wetlands play in maintaining connections between habitats. For each of these studies, the authors' definition of small is described.

Studies of the relationship between wetland size and wildlife distribution have mostly focused on amphibians and birds. Few studies have examined how use of wetlands by mammals relates to wetland size, and no studies of this relationship were found for macroinvertebrates or reptiles. No studies were found that documented the role that small wetlands play in providing water quality or hydrologic functions. However, the degree to which small wetlands perform water quality or hydrologic functions is likely to be determined by site-specific characteristics (see Chapter 2) and can be estimated on a per-acre basis using some of the available function assessment methods.

5.3.3.1 Amphibians and Small Wetlands

Snodgrass et al. (2000) undertook a study of amphibian use of wetlands to address three commonly held beliefs about small wetlands (0.7 acres - 3 acres):

- They have short hydroperiods
- They support few species
- They support species that are also found in larger wetlands

Snodgrass et al. (2000) determined that amphibian species richness increases with length of hydroperiod. They also concluded that short-hydroperiod wetlands (smaller temporarily ponded wetlands) are also important in maintaining biological diversity in that they support species not found in larger wetlands with longer hydroperiods. The species they found in small wetlands were not a subset of those in larger wetlands but rather a unique group of species.

Similarly, amphibian richness in Puget Sound wetlands was found to have no correlation with wetland size (1 - 30 acres). High richness occurred in some of the smallest wetlands (Richter and Azous 1995). The study indicates that small wetlands that are vegetatively

simple can serve adequately as breeding habitats as long as favorable nonbreeding habitat is present nearby. Species richness also was not related to persistence of ponding.

Gibbs (1993) conducted a simulation model in Maine from which he theorized that small wetlands may be most important for wetland organisms with low population growth rates and low densities. The model demonstrated that the loss of small freshwater wetlands (less than approximately 5 acres [2 ha]) would result in a decline of total wetland area by 19% and total wetland number by 62%, while the average distance between wetlands would increase by 67% (Gibbs 1993). The model showed that the loss of small wetlands would result in a change (from 90% to 54%) of the area that would lie within the maximum migration distance of terrestrial-dwelling and aquatic-breeding amphibians. The risk of extinction would significantly increase for local populations of turtles, small birds, and small mammals that are currently stable even though the model showed no change in the risk of metapopulation extinction for salamanders or frogs. Amphibian populations in the study were buffered from the risk of extinction due to high rates of population increase. The model demonstrated that dispersal ability for amphibians is a predictor of population growth rate and density, not sensitivity of a population to loss of small wetlands.

5.3.3.2 Birds and Small Wetlands

Bird use of wetlands appears to have a stronger relationship to wetland size than that of amphibians. Bird richness was positively correlated with larger wetland size in a Puget Sound study of palustrine wetlands (Richter and Azous 2001b). This is attributed to the fact that larger wetlands in the study generally had greater structural complexity and a greater number of habitat types.

Martin-Yanny (1992) also found that bird species richness and abundance in wetlands of the Pacific Northwest are positively correlated with wetland size. However, Martin-Yanny noted that habitat heterogeneity was a more important determining factor than wetland area in influencing bird species richness. Wetlands in highly urbanized watersheds had fewer neotropical migrant species, fewer ground-nesting birds, and more edge-tolerant (habitat generalist) species. This is because urbanizing watersheds tend to have smaller wetlands (less than 10 acres [4 ha]) with more edge habitat, making birds more susceptible to competition, predation, and nest parasitism. The author recommends preserving large wetlands or complexes of smaller wetlands that are connected by extensive upland buffers.

In northern prairie marshes, bird species richness was also seen to increase with marsh size and to decrease as the wetland became more isolated (Brown and Dinsmore 1986). Marshes that were part of wetland complexes showed higher species richness than isolated wetlands. Certain bird species used smaller marshes only when the marshes were part of a wetland complex. Large isolated marshes in the study often had lower species richness than smaller marshes that were part of wetland complexes. While bird species richness increased, the rate of increase slowed as the marshes became larger. In other words, they concluded that prairie marshes in the size range of 49 to 74 acres (20 to 30 ha) were more efficient in preserving bird species than larger marshes.

A study of agriculturally disturbed wetlands in western Oregon reached similar conclusions in finding that larger wetlands support more bird species (Budeau and Snow 1992). These authors also showed that wetlands of all sizes were important to water-birds.

However, in eastern Washington, Foster et al. (1984) found that waterfowl breeding use of wetlands in the Columbia Basin was greatest in smaller wetlands (less than 1 acre [0.4 ha]).

5.3.3.3 Mammals and Small Wetlands

The study that modeled the effects of the loss of small wetlands in Maine showed that local populations of small mammals faced a significant risk of extinction following the loss of small wetlands (<5 acres) (Gibbs 1993). However, in a study of Puget Sound wetlands, Richter and Azous (2001c) concluded that wetland size alone was not a significant factor in determining mammal richness or abundance. They noted that small-mammal richness was most closely affected by the combined factors of:

- Wetland size
- Extent of retention of forest adjacent to the wetland
- Quantity of large woody debris within wetland buffers

In conclusion, the literature suggests that size is not a significant factor in contributing to most wetland habitat functions. Rather, habitat structure, connectivity, and wetland hydroperiod are much more significant factors in determining habitat functions than size alone. The literature emphasizes that small wetlands are critically important to amphibians, particularly when connectivity between wetlands and with adjacent uplands is maintained. However, none of the studies evaluated the role of wetlands less than 0.5 acre, so the implications of exempting wetlands less than 0.25 acre, as is commonly done in local wetland regulations, are unknown.

The next section deals specifically with isolated wetlands. The following excerpt from Moler and Franz (1987) describes small, isolated wetlands and sheds some light on the attributes of both size and isolation.

> *To a great extent, the unique values and functions of small, isolated wetlands have been overlooked. This oversight derives from several factors, perhaps foremost being the general tendency to think of small wetlands as being little more than subsets of larger wetlands. So long as the uniqueness of small wetlands is unrecognized, then it is intuitive to think of wetlands as declining in value directly as function of size. Similarly, so long as the unique values of isolated wetlands are unrecognized, it is understandable that connected wetlands might be considered of greater value. In reality, small isolated wetlands are biologically unique systems. Because of their isolation and small size, they support a very different assemblage of species than that found in*

larger, more permanently wet situations. The ephemeral nature of many small wetlands makes them unsuitable for species which require permanent water.

5.3.4 Isolated Wetlands

Isolated wetlands are being addressed in this document because of the recent Supreme Court decision to exclude many isolated wetlands from federal regulation. The Supreme Court decision regarding isolated wetlands was made based on a legal interpretation of jurisdiction under the federal Clean Water Act (Solid Waste of Northern Cook County v. United States Army Corps of Engineers). The key factor was the language in the Act that relates to navigable waters. The Court did not rule that isolated wetlands are less important than non-isolated wetlands, only that the intent of Congress in passing the Clean Water Act was to relate the protection of waters of the United States to navigability. The Court also did not provide any definition of what constitutes "isolation" for purposes of jurisdiction.

The Seattle District of the U.S. Army Corps of Engineers (Corps) does not have any national or regional guidance for making isolated wetland determinations. As of November 2004, if a wetland meets the test of "adjacency" (neighboring, bordering or contiguous) with any navigable water, or if the wetland has a surface outlet that drains to a navigable water, then the Corps does not consider it isolated (T.J. Stetz, U.S. Army Corps of Engineers, Seattle, personal communication 2004). Future court or administrative decisions may change how isolated wetlands are determined.

Much confusion has resulted from this decision, and some in the public have assumed that isolated wetlands are less important or less worthy of protection. Therefore, it is important to summarize some of the basic science on isolated wetlands, which is presented in the paragraphs that follow.

Much of the information comes from the work of Tiner et al. (2002) and a recent issue of *Wetlands* (Volume 23, #3, 2003) that includes numerous articles on isolated wetlands. Readers are directed to this work for more detailed information. Additionally, the work of Hruby et al. (1999, 2000) in developing assessment methods for wetland functions in Washington provides important scientific information on depressional wetlands in Washington, a wetland type that contains the majority of isolated wetlands in Washington.

Wetlands can be defined as isolated based on their geographic isolation, ecological isolation, or hydrologic isolation (Tiner et al. 2002). For this discussion, isolated wetlands are defined by a very specific type of hydrologic isolation—they do not have a surface outlet by which water leaves the wetland, even seasonally, to another water body. Although frequently described as closed depressions (Tiner et al. 2002, Winter and LaBaugh 2003), isolated wetlands can also be sloped wetlands where surface water, if present, re-enters the shallow groundwater zone at the base of the wetland and is not linked via surface flows to a downstream water body. Isolated wetlands are not

necessarily small. They can be large systems with substantial heterogeneity and diverse habitat types (Tiner et al. 2002, Leibowitz 2003).

Generally, isolated wetlands provide most of the same functions as non-isolated wetlands and do so for the same reasons: position in the landscape, hydrologic regime, and type of soils and vegetation present (Leibowitz 2003, Whigam and Jordan 2003, Liebowitz and Nadeau 2003). Basic functions of isolated wetlands as described by Hruby et al. (1999), Tiner et al. (2002), Leibowitz (2003), and Whigam and Jordan (2003) are presented below.

- **Water quantity (hydrologic functions).** Isolated wetlands have no surface outlet. Precipitation and local runoff entering the wetland must either return to the atmosphere by evapotranspiration or infiltrate into groundwater (Leibowitz 2003). As a result, their ability to retain surface water may be significant, depending upon the surrounding topography. This provides potential flood storage because no surface water leaves the wetland to cause potential flooding or erosion downgradient.

- **Water quality.** Because they lack an outlet, isolated wetlands function as sediment traps for contaminants that move into them. Isolated wetlands function as sinks for most dissolved and all sediment-associated nutrients and toxics because they have no outlets that allow materials to be transported downgradient (Hruby et al. 1999). A review of the literature by Whigam and Jordan (2003) concludes that isolated, depressional wetlands have been shown to improve water quality and to efficiently retain nutrients.

- **Wildlife habitat.** Isolated wetlands provide wildlife habitat functions similar to those of non-isolated wetlands (Liebowitz 2003), except in regard to habitat for migrating fish in Washington (Hruby et al. 1999). The habitat value of isolated wetlands is governed by the same factors as non-isolated wetlands (hydrologic regime, vegetation, habitat structure, connectivity to other habitats, etc.) (Liebowitz 2003, Gibbons 2003). Tiner et al. (2002) found that isolated wetlands provide essential habitat for a wide range of guilds and may be vital to maintaining viable, genetically diverse metapopulations. They state:

  > *From an ecological standpoint, isolated wetlands are among the country's most significant biological resources. In some areas, isolation has led to the evolution of endemic species vital for the conservation of biodiversity. In other cases, their isolation and sheer numbers in a given locality have made these wetlands crucial habitats for amphibian breeding and survival (e.g., woodland vernal pools and cypress domes) or for waterfowl and waterbird breeding (e.g., potholes). In arid and semi-arid regions, many isolated wetlands are veritable oases – watering places and habitats vital to many wildlife that use them for breeding, feeding, and resting, or for their primary residence.*

5.3.5 Delineation Methods

In addition to the definition of what constitutes a wetland, the U.S. Army Corps of Engineers (Corps) and Washington State Department of Ecology (Ecology) have provided guidance on how to determine the edge of a wetland (i.e., how to delineate the wetland boundary). Delineating a wetland's boundary is a necessary step in the regulatory process because it factors into calculations of potential wetland impacts and determines the starting point for buffers and setbacks.

The Corps published a federal manual to delineate wetlands in 1987 and another manual in 1989, jointly with the U.S. Environmental Protection Agency (EPA), Soil Conservation Service, and U.S. Fish and Wildlife Service. In subsequent years (1991, 1992, and with EPA in 1994) the Corps released updates to clarify questions and provide regional guidance.

In the early 1990s, there was substantial controversy over proposals to change the 1987 and 1989 federal delineation manuals. A substantial amount of literature was produced analyzing the effectiveness of the various delineation manuals for determining a wetland edge. In subsequent years, the use of the 1987 Federal Manual for Delineation of Wetland Areas became the required legal standard for the Corps.

As required by state legislation, Ecology issued the *Washington State Wetlands Identification and Delineation Manual* in 1996 (WAC 173-22-080, Ecology publication #96-94). Ecology's manual uses the original 1987 Corps of Engineers manual and incorporates changes in the manual made by the federal government since 1987. The state manual includes national guidance issued by the Corps in 1991 and 1992 (which is not present in the 1987 Corps manual), as well as regional guidance issued by the Corps and EPA in 1994. In addition, the state manual eliminated references and examples that were not relevant to Washington State and added examples and situations relevant to Washington. The 1996 state manual is required by statute (RCW 36.70A.175) to be used by local jurisdictions in implementing the Growth Management Act. Since the two manuals rely upon the same criteria and indicators for hydrology, soils, and vegetation, proper use of either manual should result in the same boundary.

5.3.6 Summary of Key Points

- Regulatory agencies define the term *wetland* in slightly different ways.
- Local jurisdictions often differentiate between "biological wetlands" and "regulated wetlands". The distinction is often based on the wetland rating and/or wetland size.
- The studies of the correlation of wetland size to wildlife use conflict somewhat in their findings, but most generally conclude that small wetlands are important habitats (particularly where adjacent buffer habitats are available) and that elimination of small wetlands can negatively impact local populations.

- Small wetlands provide habitat for a range of species that are not a subset of the species found in larger, more permanently inundated wetlands. Small wetlands do not just provide a smaller area for the same array of amphibian species found in larger wetlands.

- Small wetlands are very important in reducing isolation among wetland habitat patches. Smaller wetlands provide significant habitat for wildlife and affect the habitat suitability of larger wetlands by reducing isolation on the landscape.

- The presence of small wetlands reduces the distance between wetlands and thus increases the probability of successful dispersal of organisms. This, in turn, likely increases the number of individuals dispersing among patches in a wetland mosaic, thereby reducing the chance of population extinction.

- Isolated wetlands provide the same range of wetland functions as non-isolated wetlands. Isolated wetlands provide important water quantity, water quality, and habitat functions.

- The U.S. Army Corps of Engineers 1987 wetland delineation manual and the 1996 *Washington State Wetlands Identification and Delineation Manual* are the current standards to be used in determining the boundary of a wetland. Correct use of these two manuals should result in the same wetland boundary.

5.4 Wetland Rating Systems

Wetland rating systems (or categorizations) are one of the numerous procedures that have been developed to analyze wetlands, providing ways to identify, characterize, or rate wetland characteristics, functions, and social benefits (values). Categorizations, as well as other procedures such as function assessment, are used by natural resource managers and regulators in a variety of contexts for regulating, planning, and managing the wetland resource (Bartoldus 1999). In the context of local regulations, rating systems are used to categorize wetlands based on different needs for protection. However, rating systems can often be used as one means to analyze wetlands.

Many different procedures to analyze wetlands have been developed in the last three decades. These range from detailed scientific evaluations that may require many years to complete, to the judgments of individual experts during one visit to a wetland. For example, Bartoldus (1999) summarized 40 different tools that were developed up to 1998, and that are used to meet the needs of regulating and managing wetlands.

Although many different rating-type tools have been developed, the literature search for this document did not uncover any analyses of the effectiveness of rating systems at protecting the wetland resource. It is assumed that better protection for wetlands is provided with improved understanding of wetland functions and values (e.g., Roth et al. 1993, National Research Council 1995).

Scientific rigor is often time consuming and costly. For regulatory use, tools are needed that provide some information on the functions and values of wetlands in a time- and cost-effective way. One way to accomplish this is with an analytical tool that categorizes wetlands by their important attributes or characteristics based on the collective judgment of regional experts. Categorization methods, such as rating systems, are relatively rapid but can still provide some scientific rigor (Hruby 1999).

The rapid method most commonly used for analyzing wetlands in eastern and western Washington has been Ecology's wetland rating systems (Ecology 1991, 1993, Hruby 2004a,b). This rating system or some modification of it has been incorporated in the wetland regulations of at least 20 counties in the state and many cities and towns as well (Chris Parsons, Washington State Department of Community, Trade and Economic Development (CTED), personal communications and survey 1999, data are available on request from CTED).

In the first editions of the Washington State wetland rating systems, the term *rating* was not used in a manner that is consistent with its definition in the dictionary, and this has caused some confusion. The method does not rate the wetland and generate a relative estimate of value (e.g., high, medium, low). Rather, it is a categorization of wetlands based on specific criteria, such as sensitivity to disturbance and rarity in the landscape.

The rating systems were designed to differentiate between wetlands based on their sensitivity to disturbance, their significance, their rarity, our ability to replace them, and the functions they provide. However, the rating systems were not intended to replace a full assessment that may be necessary to determine the levels of performance for numerous functions or to plan and monitor a compensatory mitigation project. As noted in the wetland rating system for eastern Washington:

> *The rating categories are intended to be used as the basis for developing standards for protecting and managing the wetlands to minimize further loss of their resource value. The management decisions that can be made based on the rating include the width of buffers necessary to protect the wetland from adjacent development, the ratios needed to compensate for impacts to the wetland, and permitted uses in the wetland.* (Hruby 2004a)

The rating systems for both eastern and western Washington have been revised by Ecology in conjunction with teams of wetland experts and local planners in each region who provided technical input and field testing. The goal of the revisions is to reflect the best and most current science on wetlands and how they function (using three broad groups of functions—hydrologic, water quality, and habitat) while maintaining rapidity and ease of use. You can access the rating systems for eastern and western Washington at the following web site: http://www.ecy.wa.gov/programs/sea/wetlan.html.

Wetland rating systems used in other parts of the nation

Categorization systems have also been used in other parts of the United States to manage wetlands. Other states have wetland categorizations as part of their wetland laws and rules, and other jurisdictions have used them to help manage wetlands for specific projects. For example:

Vermont adopted a law (10 VSA Chapter 37, Section (a) (7-9)) mandating that rules be adopted to identify Vermont's significant wetlands. The rules categorize wetlands into three classes of which the first two are considered "significant" (Vermont Department of Environmental Conservation 1999).

New Jersey has a wetland categorization included directly in its law (NJAC 7:7A). Criteria are provided for categorizing wetlands into (1) freshwater wetlands of exceptional resource value, (2) wetlands of ordinary resource value, and (3) wetlands of intermediate resource value.

New York has adopted rules that categorize wetlands into four categories based on ecological associations, hydrologic features, pollution control features, cover types, and distribution and location (6 NYCRR Part 664.5).

West Eugene, Oregon developed a method for a plan based on "needs for protection" (City of Eugene 2002).

North Carolina created a GIS-based system that characterizes the "significance" of wetlands based on several landscape and function-based criteria (Gainey and Roise 1998).

5.4.1 Other Characteristics Used for Rating

Some wetlands in Washington are categorized in the Washington State wetland rating systems based on important characteristics that are not specifically related to functions. These characteristics include rarity on the landscape, sensitivity to disturbance, and difficulty in restoring or creating such wetlands through mitigation efforts (Ecology 1991, Hruby 2004a,b). The wetland types that have been defined for eastern and western Washington are listed below. Some of the types are unique to either eastern or western Washington (e.g., Wetlands in coastal lagoons are unique to western Washington):

- Bogs
- Alkali wetlands
- Mature and old-growth forested wetlands
- Vernal pools
- Wetlands identified by the Washington State Department of Natural Resources as "Natural Heritage" wetlands"

- Wetlands in coastal lagoons
- Interdunal wetlands
- Estuarine wetlands

Each of these types is described in more detail below.

5.4.1.1 Bogs

Many of the scientific studies of bogs have been published in Europe and the northern parts of the United States, such as Minnesota and Maine. There has not been extensive research on bogs in Washington State. This summary of the literature is not intended to be a thorough synthesis but provides basic background information regarding characteristics of bogs requiring special consideration for management.

Predominance of Organic Soils

Bogs are peatlands (wetlands with organic soils) that have been classified according to their shape, chemistry, plant species, and vegetation structure (Gore 1983). The common factor in bogs is the presence of organic soils or peat, which result from the accumulation of poorly decomposed plant material. The optimum conditions for peat formation occur in cool, humid climates in a location with poorly drained soil.

The rate of peat accumulation is generally quite low, although it can vary with site-specific factors. Heathewaite and Gottlich (1993) report rates of accumulation ranging from 2 to 4 inches (5 to 10 cm) every 100 years. Durno (1961) lists a range of 0.5 to 4.3 inches (1.2 to 11 cm) accumulation every 100 years. In Washington, Rigg (1958) reports peat accumulation of 1 inch (2.5 cm) in 40 years for the west side of the Cascades and 1 inch in 50 years on the east side. Peat can be as little as 8 inches (20 cm) deep to over 45 feet (15 m) deep (Heathewaite and Gottlich 1993).

The three ways that peat is formed, described below, illustrate the lengthy process of peat and bog formation and help explain why bogs are almost impossible to recreate through compensatory mitigation (see below and in Chapter 6).

- In a **filled-lake sequence**, open water progresses to a sedge or moss community that gradually builds a mat over the water, evolving into a bog, bog forest, and then climax community (Conway 1949).
- **Paludification** occurs when bogs invade the surrounding forest. Sphagnum species cause a rise in the water table as peat layers compress and impede drainage (Heathewaite and Gottlich 1993).
- A **flow-through succession** occurs when surface flows are modified. Organic matter builds up to the point where surface flows are diverted around the peat mound. As it builds, the mound becomes isolated from groundwater, relying solely on precipitation as its water source (Klinger 1996).

Studies have shown, on the other hand, that many bogs remain very stable for thousands of years as a sphagnum moss/shrub community, even though succession to a forested community can occur (Klinger 1996).

Acidity and Poor Nutrients

Bogs have unusual hydrodynamics and chemistry for wetlands. They typically only receive precipitation and very localized surface runoff as their sources of water. As a result, many essential nutrients, such as nitrogen, occur in low concentrations. The upper layers of peat, formed by slowly decomposing sphagnum, are often strongly acidic, usually with a pH of 4 or less.

Bogs typically support plant species that are specially adapted to these harsh growing conditions. Sphagnum moss, as well as other mosses, usually dominate the vegetation near the ground. Ericaceous shrubs, such as Labrador tea (*Ledum gladulosum*), are also common in bogs.

Trees can grow in bogs but at a very slow rate due to the poor growing conditions. In studies in the Pacific Northwest, Rigg (1918) found tree growth in sphagnum peat soils was slow. Rigg determined that hemlock (*Tsuga heterophylla*) grew in sphagnum soils at a rate that was only 27% of its growth rate in productive upland soils, and that Douglas-fir (*Pseudotsuga menziesii*) grew in sphagnum at only 16% of its growth rate in upland soils. He measured the annual growth of western red cedar (*Thuja plicata*) as only 0.02 inches (0.6 mm).

Although persistent wet conditions, low soil oxygen, and high acidity are important factors, it is actually the lack of available nutrients, or the inability of plants to absorb nutrients because of acidity (Moore and Bellamy 1974), that most influences the flora of bogs. Most bog species have developed special adaptations to these conditions and out-compete more common wetland plants (Mitsch and Gosselink 2000). Therefore, this makes bog species susceptible to nutrient loading and changes in acidity (as well as alterations in water source that can precipitate these changes) that would enable other species to establish and dominate.

Bogs in Western and Eastern Washington

In western Washington, Kunze (1994) characterized numerous types of peatlands, including bogs and fens. She identified 10 types of sphagnum bog communities in the Puget Trough region and 14 in the Olympic Peninsula/southwest Washington. They occur in the lowlands of the Puget Trough in depressions, oxbows, and old lake beds. These typically have a raised center with a moat around the edge. Bogs and fens also occur on the Olympic Peninsula and in southwest Washington where they can occupy basins, slopes, and flat to rolling ground, as well as forming along low-gradient streams. Bogs in the foothills of the Cascades include sloping bogs, which are influenced by both mineral soil water and precipitation.

Peatlands in eastern Washington have not been classified to the extent of those in western Washington. However, 50 peatlands were identified by Rigg (1958). Forty-four of those

identified were located in the northeastern corner of the state. They included fens associated with flowing water, and bogs formed in depressions or along lake margins. Six peat systems were found in scabland channels and depressions on the Columbia Plateau.

Difficulty in Restoring Bogs

Researchers in Northern Europe and Canada have found that restoring bogs is difficult, specifically in regard to plant communities (Bolscher 1995, Grosvermier et al. 1995, Schouwenaars 1995, Schrautzer et al. 1996), water regime (Grootjans and van Diggelen 1995, Schouwenaars 1995), and/or water chemistry (Wind-Mulder and Vitt 2000). In fact, restoration may be impossible because of changes to the biotic and abiotic properties (Shouwenaars 1995, Schrautzer et al. 1996).

It is apparent that true restoration of a raised bog ecosystem is a long-term process. In *Restoration of Temperate Wetlands*, Joosten (1995) states:

> *Long term studies in bog regeneration indicate that restoration of bogs as self-regulating landscapes after severe anthropogenic damage is impossible within human time perspective, because the necessary massive re-establishment of bog key species and renewed accumulation of peat require centuries.*

Refer to Chapter 6 for more information on the challenges in restoring bogs.

5.4.1.2 Alkali Wetlands

Alkali wetlands are characterized by the occurrence of non-tidal, shallow saline water. In eastern Washington, these wetlands contain surface water with specific conductance (a measure of salinity) that exceeds 3,000 micromhos per centimeter. These wetlands provide the primary habitat for several species of migratory shorebirds and are also heavily used by migrating waterfowl. They also have unique plants and animals that are not found anywhere else in eastern Washington. For example, the small alkali bee that is used to pollinate alfalfa and onion for seed production lives in alkali systems. This bee is a valuable natural resource for agriculture in the western United States and especially in eastern Washington (Delaplane and Mayer 2000). The "regular" bees which pollinate fruits and vegetables are generally too large to pollinate the small flowers of these commercially important plants.

The salt concentrations in alkali wetlands have resulted from a relatively long-term process of groundwater surfacing and evaporating. These conditions cannot be easily reproduced through compensatory mitigation because the balance of salts, evaporation, and water inflows is hard to reproduce, and no references were found suggesting this has ever been attempted. Alkali wetlands are also rare in the landscape of eastern Washington. Of several hundred wetlands that were surveyed and visited by wetland scientists during field work for the state's function assessment methods and the rating system for eastern Washington (Hruby et al. 2000, Hruby 2004a), only nine could be classified as alkali.

5.4.1.3 Mature and Old-Growth Forested Wetlands

No mature or old-growth forested wetlands have ever been successfully created or restored through compensatory mitigation. A mature forested wetland may require 80 years or more to develop, and the full range of functions performed by these wetlands may take even longer (Stanturf et al. 2001). The actual time required to reconstruct old-growth forests and their soil properties (in contrast to mature forests) is unknown (Zedler and Callaway 1999). These forested wetlands provide important functions associated with wetlands as well as habitat functions associated with mature and old-growth forests. (Washington State Department of Fish and Wildlife 1999a).

5.4.1.4 Vernal Pools

Vernal pool wetlands occur in eastern Washington and are formed when small depressions in bedrock or in shallow soils fill with snowmelt or spring rains. They retain water until the late spring when reduced precipitation and increased evapotranspiration lead to a complete drying out. The wetlands hold water long enough throughout the year to allow some strictly aquatic organisms to flourish but not long enough for the development of a typical wetland environment (Zedler 1987). Vernal pools often contain upland species during the summer after they dry out and may be difficult to identify as jurisdictional wetlands during part of the year.

Vernal pools in the scablands are the first to melt in the early spring. This open water provides areas where migrating waterfowl can find food while other, larger bodies of water are still frozen. Furthermore, the open water provides areas for pair bonding of waterfowl (R. Friesz, Washington State Department of Fish and Wildlife, personal communications 2000-2004). Thus, vernal pools in a landscape with other wetlands provide a critical habitat function for waterfowl (Hruby 2004a).

5.4.1.5 "Natural Heritage" Wetlands

"Natural Heritage" wetlands are those that have been identified by scientists of the Washington State Natural Heritage Program as high-quality, relatively undisturbed wetlands, and wetlands that support state threatened, endangered, or sensitive plant species.

The Natural Heritage Program has identified important natural plant communities and species that are very sensitive to disturbance or threatened by human activities and maintains a database of these sites. The program's web site states:

> *Some natural systems and species will survive in Washington only if we give them special attention. By focusing on species at risk and maintaining the diversity of natural ecosystems and native species, we can help assure our state's continued environmental and economic health.* (Washington State Department of Natural Resources No Date, http://www.dnr.wa.gov/nhp/about.html)

5.4.1.6 Estuarine Wetlands

Estuaries, the areas where freshwater and salt water mix, are among the most highly productive and complex ecosystems. Here, tremendous quantities of sediments, nutrients, and organic matter are exchanged between terrestrial, freshwater, and marine communities. A large number of plants and animals benefit from estuarine wetlands. Fish, shellfish, birds, and plants are the most visible organisms that live in estuarine wetlands. However, a huge variety of other life forms also live in an estuarine wetland, including many kinds of diatoms, algae and invertebrates.

Estuaries, of which estuarine wetlands are a part, are a "priority habitat" as defined by the state Department of Fish and Wildlife. Estuaries have a high fish and wildlife density and species richness, important breeding habitat, important fish and wildlife seasonal ranges and movement corridors, limited availability, and high vulnerability to alteration of their habitat (Washington State Department of Fish and Wildlife, http://www.wa.gov/wdfw/hab/phslist.htm , accessed October 15, 2003).

Estuarine wetlands are not freshwater wetlands, and therefore, information about them was not reviewed in Volume 1. They are included in this compilation of wetlands with special characteristics because they are included in the wetland rating System for western Washington (Hruby 2004b). They are often found adjacent to freshwater wetlands and should be managed in conjunction with freshwater wetlands. The methods for identifying estuarine wetlands and the rationale for protecting them are described in more detail in the rating system (Hruby 2004b).

5.4.1.7 Wetlands in Coastal Lagoons

Coastal lagoons are shallow bodies of water, like a pond, partly or completely separated from the sea by a barrier beach. They may, or may not, be connected to the sea by an inlet, but they all receive periodic influxes of salt water. This can be either through storm surges overtopping the barrier beach or by flow through the porous sediments of the beach. Coastal lagoons often contain vegetated areas that are jurisdictional wetlands. The wetlands associated with coastal lagoons are, therefore, included in the rating system as wetlands with special characteristics.

Wetlands in coastal lagoons probably cannot be reproduced through compensatory mitigation, and they are relatively rare in the landscape. No information was found on any attempts to create or restore wetlands in coastal lagoons in Washington that would suggest this type of compensatory mitigation is possible. Any impacts to lagoons will, therefore, probably result in a net loss of their functions and values.

In addition, coastal lagoons and their associated wetlands are proving to be very important habitat for salmonids. Unpublished reports of ongoing research in the Puget Sound (Hirschi et al. 2003, Beamer et al. 2003) suggest coastal lagoons are heavily used by juvenile salmonids.

5.4.1.8 Interdunal Wetlands

As defined in the western Washington rating system (Hruby 2004b), any wetlands that are located to the west of the Boundary Line of Upland Ownership as determined in 1889 are considered interdunal. The boundary line is a legally defined line along the Pacific Coast. Interdunal wetlands form in the "deflation plains" and "swales" that are geomorphic features in areas of coastal dunes. These dunes are the result of the interaction between sand, wind, water, and plants. The dune system immediately behind the ocean beach (the primary dune system) and its associated wetlands is very dynamic and can change from storm to storm (Wiedemann 1984). This means that the location of the wetlands is not fixed and may change from year to year.

Interdunal wetlands provide critical habitat for many species in this ecosystem (Wiedemann 1984). Although important, these wetlands constitute only a small part of the total dune system (Wiedemann 1984). No methods have been developed to characterize how well interdunal wetlands function so these wetlands cannot be rated by a score for their functions. In the absence of direct methods for characterizing their functions, the rating of interdunal wetlands is based on their documented importance as habitat in the coastal dune ecosystem.

5.4.2 Summary of Key Points

- Wetland rating systems provide a rapid method to identify, characterize, categorize, or estimate relative wetland functions and values. This information is used in regulating and managing wetlands.

- The rapid method most commonly used for analyzing wetlands in eastern and western Washington has been the Washington State wetland rating systems. The rating system was designed to differentiate between wetlands based on a broad grouping of functions that they provide (hydrologic, water quality, and habitat), as well as other characteristics (listed in the next bullet). However, this rating system does not replace the more robust function assessment methods developed for Washington State. The latter may be necessary to determine the level of performance for specific functions (such as the potential to remove sediment) or to plan and monitor a compensatory mitigation project.

- In the rating system, some wetlands are categorized because of their rarity on the landscape, sensitivity to disturbance, or difficulty in restoration or creation through mitigation efforts, and not because of the functions these wetlands perform. The wetland types in Washington that are included in the rating system because they have these other characteristics include bogs, alkali wetlands, mature and old-growth forested wetlands, vernal pools, estuarine wetlands, wetlands in coastal lagoons, interdunal wetlands, and "Natural Heritage" wetlands.

5.5 Buffers

Buffers are another common element of wetland regulations. Buffers are vegetated areas adjacent to an aquatic resource that can, through various physical, chemical, and/or biological processes, reduce impacts from adjacent land uses. Buffers also provide the terrestrial habitats necessary for wildlife that use wetlands to meet their life-history needs. In this document, we collectively call these processes that buffers provide the *functions* of buffers. Buffers and other adjacent upland areas provide habitat for other wildlife species that do not commonly use wetlands. This document does not address those functions of upland habitats.

The primary purpose of buffers is to protect and maintain the wide variety of functions and values provided by wetlands (or other aquatic areas). The physical characteristics of buffers—slope, soils, vegetation, and width—determine how well buffers reduce the adverse impacts of human development and provide the habitat needed by wildlife species that use wetlands. These characteristics are discussed in detail in this section.

The subject of buffers is well documented in the scientific literature. The research on buffers has occurred worldwide, and this section includes literature from a variety of regions when it was found to be relevant. In particular, a variety of literature related to agricultural practices and vegetated filter strips from the north-central United States and south-central Canada is directly relevant to some agricultural practices in Washington State, especially east of the Cascades. In addition, studies on buffers in urban and suburban settings conducted in the Pacific Northwest region are clearly relevant. However, many of the buffer studies conducted elsewhere in the U.S. and the world, as well as the many buffer synthesis documents, provide information relevant to the state of Washington.

The majority of research on buffers tends to focus on the processes that buffers provide to filter sediment or take up nutrients (i.e., their influence on water quality). Far fewer studies look at the influence of a buffer's physical characteristics on attenuating surface water flow rates, except as it relates to water quality. The long-term effectiveness of buffers in providing such mechanical and biological processes is not well documented in the literature and may represent a critical need for future research.

The literature on buffers related to wildlife is, in general, less focused. Most studies document the needs of a particular species or guild relative to distances for breeding or other life-history needs within a radius from aquatic habitats. There is substantial literature on the implications of habitat fragmentation and connectivity, some of it related specifically to agricultural practices, forestry practices, or the impacts of urbanization. This literature does not specifically address the role of buffers in providing connectivity between wetlands and other parts of the landscape. It does, however, unequivocally support maintaining connectivity between wetlands in order to maintain viable populations of species that are closely associated with wetlands. The reader is referred to Section 4.11 in Chapter 4, which discussed the effects of habitat loss and fragmentation as well as Section 5.5.4.3.

Older research studied the tolerance limits of wetland wildlife for disturbance—how closely a disturbance can approach animals before they are flushed from wetlands—with particular emphasis on waterfowl. These studies tend to be older than 1990 and focus on the prairie pothole region of North America. Where the findings are germane and where they have not been superceded by more recent work, they are included.

In addition to papers on specific research studies, multiple compilations and syntheses of literature on buffers have been completed since 1990. Synthesis papers were compiled by Castelle and other authors (1992b, 1994, and 2000) and another was compiled by McMillan (2000) as a master's thesis. These compilations include literature that was published prior to 1990, but much of the work they rely on is considered seminal to the effectiveness of buffers in protecting wetlands and contributing to habitat. Therefore these synthesis documents are used in this document as direct sources when no more recent research was found to supercede the earlier findings.

This section also cites literature related to stream buffers and riparian areas when the findings are relevant to the influence these areas have on the adjacent aquatic resource. The literature on stream buffers related to microclimate, water quality influences, and some habitat characteristics is particularly relevant because the ways buffers protect and maintain these functions is similar whether they are adjacent to streams or wetlands.

5.5.1 Terms Used to Describe Buffers

The scientific literature varies widely on the terms used to denote the area that serves to reduce impacts to wetlands from adjacent land uses and provide habitat for parts of the life-cycle of many species. Common terms include:

- Buffer
- Wetland setback
- Vegetated filter strip
- Buffer strip
- Riparian area
- Riparian zone
- Riparian corridor

These terms can be differentiated as those that are a product of regulations or policy language and those that define or describe an ecological condition or location (Castelle et al. 1994). Terms such as *buffer*, *wetland setback*, or *vegetated filter strip* are most commonly applied in an administrative context to denote the landscape immediately adjacent to an aquatic resource, the dimensions of which are legally determined. The terms *buffer strip* or *vegetated filter strip* may imply a relatively undisturbed, vegetated

area that helps attenuate the adverse effects of land uses adjacent to a wetland. For example, Norman (1996) provides this definition:

> *Buffer strips are strips of vegetated land composed in many cases of natural ecotonal and upland plant communities which separate development from environmentally sensitive areas and lessen these adverse impacts of human disturbance.*

The terms *riparian areas* or *riparian zones* are defined by many to denote ecologically discernable ecotones (transition zones) along aquatic resources where the presence or action of surface waters, or the presence and duration of shallow groundwater, influences the structure and composition of the vegetation community (Lowrance et al. 1995, Harper and MacDonald 2001). The term *riparian corridor* is defined by Naiman et al. (1993) as "encompass(ing) the stream channel and that portion of the terrestrial landscape from the high water mark towards the uplands where vegetation may be influenced by elevated water tables or flooding, and by the ability of the soils to hold water."

5.5.2 Functions Provided by Buffers

The literature is broadly consistent on the ways in which buffers can provide for the protection and maintenance of wetland functions. These include:

- Removing sediment
- Removing excess nutrients (phosphorous and nitrogen)
- Removing toxics (bacteria, metals, pesticides)
- Influencing the microclimate
- Maintaining adjacent habitat critical for the life needs of many species that use wetlands
- Screening adjacent disturbances (noise, light, etc.)
- Maintaining habitat connectivity

As noted by Castelle and Johnson (2000), buffers can be both ecological sources and sinks. They can control or limit the effects of land uses upslope of the aquatic resource (act as a sink), and they can contribute biological benefits to the aquatic resource (act as a source). Naimen et al. (1992) summarize the range of functions provided by buffers along streams as follows:

> *It is well known that riparian vegetation regulates light and temperature regimes, provides nourishment to aquatic as well as terrestrial biota, acts as a source of large woody debris,…regulates the flow of water and nutrients from uplands to the stream, and maintains biodiversity by providing an unusually diverse array of habitat and ecological services.*

These same functions can be attributed to wetland buffers (Castelle et al. 1992b, Desbonnet et al. 1994, McMillan 2000).

The literature also describes the physical, chemical, and/or biological characteristics of a buffer that determine the functions it provides. The most frequently cited physical characteristics that influence the effectiveness of a buffer are:

- Vegetation characteristics (composition, density, and roughness—for example, downed material)
- Percent slope
- Soils
- Buffer width and length (adjacent to the source of impacts)

Only two of the physical characteristics noted above can be easily managed (vegetation characteristics and buffer width/length), while the others are characteristics that do not lend themselves to manipulation.

By far the issue of greatest interest with respect to buffers is the question of how wide a buffer needs to be in order to be effective in protecting a wetland (or other aquatic resource). While the literature is unanimous that buffers provide important functions that protect wetlands and provide essential habitat for many species, there is wide-ranging discussion about how much buffer is necessary to be effective in providing a particular level of function (Young et al. 1980, Booth 1991, Castelle et al. 1994, Norman 1996, Dosskey 2000, McMillan 2000, Rickerl et al. 2000).

For ease of discussion as to the effective widths of buffers, the functions of buffers listed above are grouped into two major categories:

- Water quality (discussed in Section 5.5.3)
- Wildlife habitat (discussed in Section 5.5.4)

Buffers and their influence on wetland hydroperiod, as described in the few studies found on this subject, are summarized in the shaded box on the next page.

The following literature sources are generally consistent in describing what functions buffers provide to aquatic resources as well as the physical parameters that influence a buffer's ability to provide these functions: Budd et al. (1987), Phillips (1989), Castelle et al. (1992, 1994), Naiman et al. (1992), Belt and O'Laughlin (1994), Desbonnet et al. (1994), Norman (1996), Dillaha and Inamdar (1997), Dosskey (2000), Van der Kamp and Hayashi (1998), Liquori (2000), McMillan (2000), Todd (2000), Townsend and Robinson (2001), Dosskey (2001).

Buffers alone have limited influence on wetland hydroperiod

As described in detail in Chapter 3, human land uses, such as agricultural practices, clearing, and land development, alter the movement and storage of surface water and groundwater within a wetland's contributing basin. These changes can significantly affect the hydroperiod of wetlands and other aquatic resources, causing an adverse effect on many wetland functions (Azous and Horner 2001). There is little published literature on the effectiveness of buffers in ameliorating the effect of changes in land use within the contributing basin on wetland hydroperiod. Some of the literature indicates that wetland buffers are far less effective at maintaining wetland hydroperiod than other mechanisms, such as controlling impervious surfaces and utilizing effective stormwater management practices (Herson-Jones et al. 1995).

Research in the Puget Sound Basin has agreed that changes in the land cover type in the contributing basin have a stronger influence on the resulting hydroperiod of the wetland than the buffer does (Booth 1991, Azous and Horner 2001). An exception may be for wetlands that have a very small contributing basin. However, the rate and manner in which stormwater enters the wetland following land-use changes in the contributing basin will most often shift from sheet flow and interflow to one or more point sources, resulting in a potential change in hydroperiod. Based on hydroperiod models using the U.S. Environmental Protection Agency's Hydrologic Simulation Program Fortran (HSPF model) for areas west of the Cascades, the wetland will tend to receive more water more quickly in the fall and will receive less water for a shorter period in the spring, resulting in a shift in the seasonal hydroperiod.

Buffer width is usually not sufficient to counteract the influence of land-use changes and stormwater management facilities within the wetland's contributing basin.

5.5.3 Buffers and Protection of Water Quality

Buffers protect the water quality of wetlands through four basic mechanisms:

- They remove sediment (and attached pollutants) from surface water flowing across the buffer
- They biologically "treat" surface and shallow groundwater through plant uptake or by biological conversion of nutrients and bacteria into less harmful forms
- They bind dissolved pollutants by adsorption onto clay and humus particles in the soil
- They help maintain the water temperatures in the wetland through shading and blocking wind

Literature describing the different ways that buffers maintain and improve water quality in wetlands and other aquatic areas is abundant. There is also considerable research on the effective widths that provide a relative percentage of removal of sediments, nutrients, and some toxics emanating from various sources. Four categories of water quality improvement are discussed below:

- Removing sediment
- Removing nutrients
- Removing toxics and pathogens
- Maintaining microclimate

For each of these categories, a summary is provided on what the literature says about the relationship between buffer width (or other characteristics) and the buffer's effectiveness in providing that type of water quality improvement. A summary table is included that lists the range of buffer widths for each category and the literature references that substantiate those findings. However, the literature does not address the issue of "how much pollutant removal is acceptable." For each pollutant, there may be a maximum amount that a buffer can process before its ability to do so is overwhelmed. The literature does not provide any specific thresholds (See section 5.5.5.3 for more on this issue).

5.5.3.1 Removing Sediment

Characteristics that Influence a Buffer's Ability to Remove Sediment

A buffer's ability to remove sediment from surface water flows depends upon several physical characteristics of the buffer. Sediment removal occurs when (Castelle et al. 1992b, Dillaha and Inamdar 1997, Phillips 1989):

- Flows are slowed sufficiently to allow particles to settle out
- Physical filtering by vegetation and roots mechanically removes sediments from the water column
- The slope of the buffer is of a low enough gradient to preclude formation of rills and scouring
- There is large woody debris on the ground to create roughness
- The infiltration rate of the soils allows water to move through the soils rather than on the surface

The way sediment-laden water enters a buffer influences the ability of the buffer to slow the flows sufficiently to allow sediment deposition. Several studies noted that vegetated buffers are only effective at removing sediments if sediment-laden waters enter the buffer as sheet flow, rather than in channels or rivulets (Phillips 1989, Booth 1991, Castelle et

al. 1992b, Desbonnet et al. 1994, Belt and O'Laughlin 1994, Sheridan et al. 1999). Norman (1996) cites work conducted by Schueler in 1987 that found buffers in urban settings were most effective at removing sediments where slopes were less than 5%, and waters entered the buffer in shallow, dispersed sheet flow. Norman surmised that, "The rate of removal of pollutants appears to be a function of the width, slope, and soil permeability of the (buffer) strip, the size of the contributing runoff area, and the runoff velocity."

In other research, Sheridan et al. (1999) found that the greatest reduction in sediment loading occurs in the initial "treatment" stages using a vegetated filter strip that is managed and mowed. Their research found the greatest removal of sediments (56 to 72%) and reduction in flow rates occurs in the outer portion of a vegetated filter strip (the strip closest to the source of sediment). Grass filter strips provided removal ranging from 78 to 83% of suspended sediments.

The ability of a buffer to provide physical filtering of sediments also depends on the condition of the vegetation and the surface roughness. Belt and O'Laughlin (1994) noted that when vegetation, rocks, or other obstructions were eliminated from the buffer surface, sediment-laden waters flowed further into (or through) a buffer. Buffers were found to be effective in removing sediments only if flows were shallow and broad, not narrow and incised. The presence of woody debris and vegetative obstructions on the ground surface (roughness) was found to slow flows, inhibit the formation of rills, and facilitate sediment deposition.

In contrast, hydrologic models created by Phillips (1989) estimated that surface roughness would be of minor concern, and buffer width was not critical, as long as a minimum 49-foot (15 m) buffer was maintained. This study was based on estimated models, whereas Belt and O'Laughlin's work was based on field measurements.

Phillips (1989) also emphasized the importance of slope. He states, "Results show that where solid-phase pollutants transported as suspended or bed-load in overland flow are the major concern, slope gradient is the most critical factor, followed by soil hydraulic conductivity." Slope gradient is critical because, on slopes greater than 5%, sheet flow can start to become channelized. Channelized flows have faster rates, more erosive powers, and less contact with vegetation (Norman 1996). Faster moving water has the capacity to carry fine sediment particles farther than slower flows, even moving through dense vegetation.

In his research in urbanizing settings, Booth (1991) notes that buffers adjacent to aquatic resources may have limited ability to filter and slow flows caused by stormwater. He found that (1) in some instances the buffers no longer existed in a natural vegetated condition, (2) once development occurred, and the buffer was subdivided into multiple private ownerships, maintaining an intact buffer was not possible, or (3) the increased volumes and rates of flows were too significant to be controlled by conditions within a vegetated buffer.

Buffers were found to facilitate reduction of sediment from active agricultural fields in several studies:

- Welsch (1991) found that a three-tiered buffer system on a shallow slope, with the first tier (closest to the source of sediment) composed of dense herbaceous vegetation, maximized sediment removal (See Section 5.5.6 for a discussion of the three-tiered system).
- Dosskey (2001) noted in agricultural settings that vegetated buffers retain pollutants by reducing the flow rates and filtering surface runoff from fields.
- Assessing management options to control non-point-source pollution (sediment, nitrogen, and phosphorus) in agricultural settings, Yocom et al. (1989) recommended the use of vegetated filter strips between actively cropped land and adjacent wetlands.

Buffer Width and Effectiveness in Removing Sediment

As noted above, the ability of a buffer to remove sediment is based on the condition of the buffer and its slope, as well as the characteristics of the incoming sediment. The following variables all contribute to the sediment removal effectiveness of a buffer:

- The velocity of sediment transport (in surface water)
- The size of sediment particles from the source materials
- The density of the vegetation present
- The presence and extent of large woody debris
- Surface roughness within the buffer

However, the relationship between the width of the buffer and its effectiveness is non-linear. The largest particles and the greatest percentage of particles are dropped in the outer portions of the buffer (closest to the source of sediment). In these outer areas, the rate of surface flow begins to diminish as the water is slowed by vegetation and woody debris. Slower water movement allows particles to drop out of the water column.

This is graphically illustrated in the graph below (Figure 5-1). This table is included here for illustrative purposes only, to depict the non-linear nature of buffers in removing sediments. This graph is based on data from the buffer synthesis by Desbonnet et al. (1994).

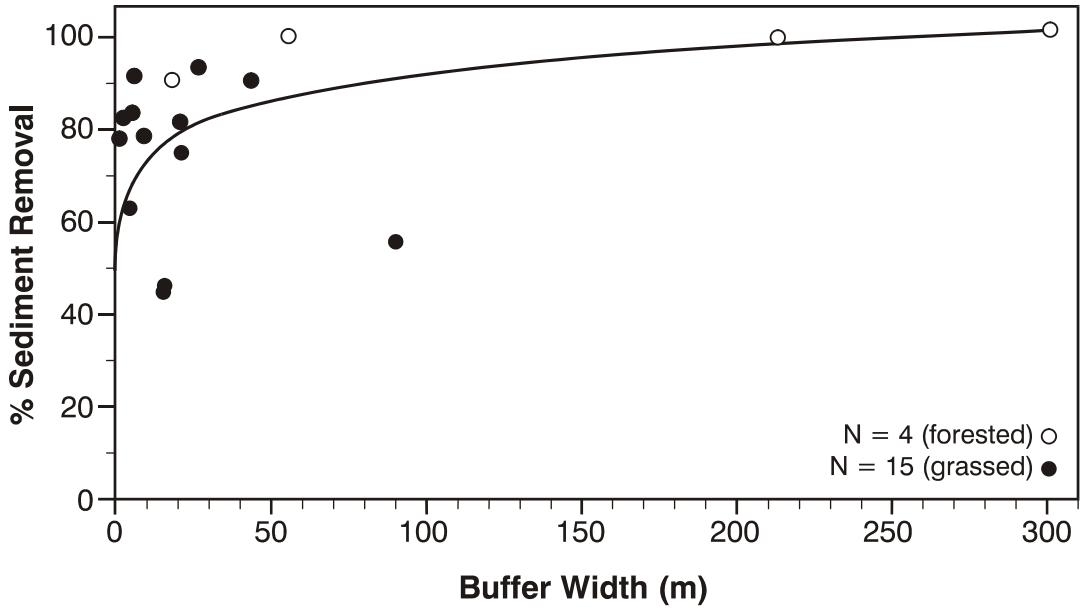


Figure 5-1. Relationship of percent removal to buffer width for the treatment of sediments contained in surface water runoff (Desbonnet et al. 1994).

In 1982, Wong and McCuen derived a formula to model a buffer's ability to remove sediments based on sediment particle size, the slope within the buffer, the rate of surface runoff, and the amount of vegetation and woody debris (roughness) in the buffer (Castelle et al. 1994). The model predicted that there would be a point of relative diminishing returns for function vs. width. For example, "If the sediment removal design criteria were increased from 90 to 95% on a 2% slope, then the buffer widths would have to be doubled from 30.5 to 61 m (100 to 200 ft)." In other words, the model predicted that the width of the buffer would have to double to achieve an additional 5% removal of sediment after 90% of it had already been removed from the water column. Desbonnet et al. (1994) determined that a small buffer (7 feet [2 m]) could effectively remove up to 60% of suspended sediment, while a buffer of up to 82 feet (25 m) would be needed to remove 80%.

These findings are consistent with others who have found that progressively larger buffer dimensions are required to filter out finer particles (Norman 1996). These and other studies are summarized in Table 5-1.

See Section 5.5.5 for discussion of the ability of buffers to continue providing sediment removal over the long term.

Table 5-1. Summary of studies on sediment control provided by buffers of various widths.

Author(s)	Date	Buffer Width	Comments
Broderson	1973	200 feet (61 m)	Effective sediment control "even on steep slopes"
Desbonnet et al.	1994	6.6 – 82 feet (2 – 25 m)	60% removal in 6.6 feet (2 m); 80% removal required 80 feet (25 m)
Desbonnet et al.	1994	16 – 49 feet (5 – 15 m)	On grassy buffers on slopes with less than 5% slope, removed all but the finest particles
Ghaffarzadeh et al.	1992	16 – 49 feet (5 – 15 m)	Found 85% removal in 30-foot (9.1 m) buffers
Horner and Mar	1982	200 feet (61 m)	80% of sediments. As cited by Castelle and Johnson (2000)
Lynch et al.	1985	98 feet (30 m)	75 to 80% removal of sediment from logging activities into wetlands
Norman	1996	9.8 feet (3 m): sands 49.9 feet (15.2 m): silts 400 feet (122 m): clays	Distances required for effective removal of progressively smaller particle sizes
Wong and McCuen	1982	100 – 200 feet (30.5 – 61 m)	90% at 100 feet (30 m), need 200 feet (61 m) to obtain 95% removal effectiveness
Young et al.	1980	80 feet (24.4 m)	92% sediment removal rate from feedlot through vegetated buffer strip

5.5.3.2 Removing Nutrients

Characteristics that Influence a Buffer's Ability to Remove Nutrients

Nutrients are transported into wetlands via sediment-laden water or dissolved in surface or shallow subsurface flows. The primary nutrients of concern are nitrogen and phosphorous. Buffers remove nitrogen and phosphorous through a variety of mechanisms that are similar to the mechanisms present within the wetland itself, as described in Chapter 2.

As much as 85% of phosphorous in surface waters is bound to sediments (Karr and Schlosser 1977) and thus can be removed via sediment removal in buffers. Phosphorus and other nutrients may be effectively reduced in surface waters by filtering and uptake; however, dissolved forms of nitrogen are not affected by surface processes and can be more effectively removed in the buffer through subsurface contact with fine roots (Muscutt et al. 1993, Townsend and Robinson 2001). Lowrance et al. (1995) confirm that the areas where improvements in water quality are the most effective are where precipitation moves across, through, or near the rooting zone of a forested buffer. These

findings are similar to those of Phillips (1989), who found that longer contact of dissolved pollutants through wider vegetated buffers was the most important factor for effective removal.

Buffer Width and Effectiveness in Removing Nutrients

It is difficult to compare studies of buffer width and effectiveness at removing nutrients because the basic parameters of the studies differ greatly. Some studies were conducted in field settings while others occurred in experimentally designed plots. There were differences in the loading rate of nutrients, the types of soils, and the vegetation in the buffers. Some studies examined only nitrogen or phosphorous removal, whereas others combined different nutrients. The result is that reported effectiveness of buffer widths for removing nutrients ranges from a few meters to hundreds of meters. Studies are listed in Table 5-2.

In a synthesis of research on nitrogen removal, McMillan (2000) found nitrogen can be effectively removed in buffer strips ranging from 20 to 98 feet (6 to 30 m) wide. He cites work by two research groups (Patty et al. 1997, Daniels and Gilliam 1996) that 47 to 99% removal of nitrogen can be achieved in buffers ranging from 20 to 66 feet (6 to 20 m) wide. This is not totally consistent with synthesis results presented by Desbonnet et al. (1994) that "well configured" buffers (with ideal slope, soils, and vegetation) as small as 30 feet (9 m) could reduce as much as 60% of nitrogen, while 197-foot (60 m) buffers would be necessary for 80% nitrogen removal.

A recent study from Oregon documented the role of red alder forests in exporting nitrogen to streams (Compton et al. 2003). They found that the percent of alder forest in a watershed was positively correlated with nitrate concentrations in surface water. This has implications for assuming that buffers with alder forests will help reduce the input of nitrogen from adjacent land uses into wetlands and other surface water.

The literature also describes a range of buffer widths necessary for phosphorus removal. Studies of buffer widths as small as 13 feet (4 m) and as large as 279 feet (85 m) found phosphorus removal rates of 50% to over 90% (see Table 5-2).

Overall, a consistent pattern emerges from the literature. The largest relative percent removal of phosphorus occurs within the outer portions of the buffer (closest to the source), while larger buffers are required to remove increasingly more of the nutrients. This consistency substantiates the conclusions of many that initial contact causes sediment-associated nutrients to be deposited, while dissolved nutrients require longer residence time and prolonged contact with vegetation for effective uptake (removal from the water column) to occur.

Castelle and Johnson (2000) surmised in their literature review that nutrient removal may have a similar non-linear relationship to buffer width as sediment removal. However, Phillips (1989) found that buffer width was a more critical element for dissolved nutrients (especially nitrogen), because wider buffers provided more prolonged contact with the rooting zone and time for uptake and conversion. Phillips did not report widths of buffers related to a certain percent of removal or effectiveness.

Limited research has been done on the long-term effectiveness of buffers for nutrient removal when there is an ongoing nutrient source present on the outside edge of the buffer. See Section 5.5.5.3 for a discussion.

Table 5-2. Summary of studies on nutrient removal provided by buffers of various widths.

Author(s)	Date	Width	Comments
Daniels and Gilliam	1996	20 – 66 feet (6 – 20 m)	47-99% removal of nitrogen
Desbonnet et al.	1994	30 feet (9 m): 60% removal 197 feet (60 m): 80% removal	Small buffers could have effective removal rates for nitrogen; much larger buffers are necessary for a significant increase in effectiveness
Desbonnet et al.	1994	Averages: 39 feet (12 m): 60% 279 feet (85 m): 80%	When all the findings from the literature synthesis were averaged, the average removal efficiencies were non-linear: larger buffers were needed for increases in effectiveness
Dillaha	1993	15 feet (4.6 m): 70% 30 feet (9.1 m): 84 %	Percent removal of suspended solids and their associated nutrients with vegetated filter strips. As cited in Todd (2000)
Dillaha	1993	15 feet (4.6 m): 61 % 30 feet (9.1 m): 79 %	Removal of phosphorus with vegetated filter strips. As cited by Todd (2000)
Dillaha	1993	15 feet (4.6 m): 54% 30 feet (9.1 m): 73%	Removal of nitrogen with vegetated filter strips. As cited by Todd (2000)
Doyle et al.	1977	12.5 feet (3.8 m) forested 13.1 feet (4 m) grass	Reduced nitrogen, phosphorus, and potassium levels
Edwards et al.	1983	98 feet (30 m)	50% removal rate of phosphorus
Lowrance	1992	23 feet (7 m)	Forested buffer zones were effective at removing nitrate through plant uptake and microbial denitrification
Lynch et al.	1985	98 feet (30 m)	Forested buffers reduced soluble nutrient levels from logging activities to "appropriate" levels
Patty et al.	1997	20 – 66 feet (6 – 20 m)	47 - 99% removal of nitrogen
Shisler et al.	1987	62 feet (19 m)	Forested riparian buffers effectively removed up to 80% and 89% of phosphorus and nitrogen, respectively
Thompson et al.	1978	39 – 118 feet (12 – 36 m)	Found a range of removal effectiveness of 44 to 70%

Author(s)	Date	Width	Comments
Vanderholm and Dickey	1978	> 853 feet (260 m)	Removal of 80% of nutrients, solids, and BOD from feedlot runoff with shallow (<0.5%) buffer slopes. Cited in Castelle et al. (1992b)
Young et al.	1980	69 feet (21 m): 67% removal 89 feet (27 m): 88% removal	Removal of phosphorus
Xu et al.	1992	33 feet (10 m)	Significant reductions in nitrate through a mixed herbaceous and forested buffer strip (as cited by Castelle and Johnson 2000)

5.5.3.3 Removing Toxics and Pathogens

Characteristics that Influence a Buffer's Ability to Remove Toxics and Pathogens

A buffer's ability to remove toxicants and pathogens is one of the least thoroughly studied. At this time, it represents a significant data gap. Castelle and Johnson (2000) note the lack of research on pathogens, toxicants and fecal coliform bacteria (an indicator of the possible presence of pathogens). Many of the studies they examined are quite old, but little recent research was found to supplement these older studies. Therefore, the conclusions presented from the synthesis of the previous work are provided here.

Gilliam (1994) also confirms in his work that little to no research is available on the effective removal of fecal coliforms or various pesticides. Much of the work assessed the effectiveness of removal of nutrients and toxics, without identifying a dimension of width necessary to provide that removal.

Toxics (pesticides and metals) can be removed by buffers through sedimentation, biological uptake by vegetation, adsorption onto clay or humus particles in the soil of the buffer, or degradation of the toxics through biochemical processes (McMillan 2000, Patty et al. 1997).

As mentioned in the discussion of sediment removal, Welsch (1991) described the use of a three-tier buffering system for the most effective removal of sediments and their associated toxics. The outermost tier (closest to the source of impacts) was a densely vegetated filter strip, managed to ensure no erosion or rill formation. He found the most effective removal of sediments and the toxics adhered to sediment particles was through surface sheet flows through the vegetated filter strip. The middle tier was subject to some management activities (limited agriculture or limited tree harvest), while the innermost tier was undisturbed natural vegetation. Dissolved nutrients and some toxics were not affected by physical filtering unless there was prolonged contact with the rooting zone through the shallow groundwater table. See Section 5.5.6 for further discussion.

Castelle and Johnson (2000) note that the apparent effectiveness of small buffers in removing toxics is due to the adsorption of many toxics to sediment particles. When vegetated buffers are effective at filtering sediments, they will also be effective at filtering those toxics and nutrients adhered to the sediments.

One study in Saskatchewan (Donald et al. 1999) found that the concentrations of agricultural pesticides and herbicides in wetlands were influenced by the timing of precipitation relative to the applications of the chemicals. They noted that buffer width may influence exposure of the wetland to these chemicals, but they did not quantify what buffer widths related to the effectiveness of removing chemicals.

Neary et al. (1993) reviewed studies in the Southeastern U.S. on the use of buffers in reducing contamination of water by pesticides. They found that cases of high concentrations of pesticides in water only occurred when no buffer was present or when pesticides were applied within the buffer. Regular use of buffer strips kept concentrations of pesticide residue within water-quality standards. Neary concluded that, generally speaking, buffer strips of 15 m (49 ft) or larger are effective in minimizing contamination of streams by pesticide residue.

Table 5-3 summarizes studies on the effectiveness of toxicant and pathogen removal provided by buffers of various widths.

Table 5-3. Summary of studies on pathogen control provided by buffers of various widths.

Author(s)	Date	Width	Comments
Doyle et al.	1977	12.5-foot (3.8 m) forested buffers 13.1-foot (4 m) grass buffers	Reduction in fecal coliform bacteria levels.
Grismer	1981	98-foot (30 m) grass filter strip	Removal of 60% of fecal coliform bacteria.
Young et al.	1980	115-foot (35 m) grass buffer	Reduced microorganisms to acceptable levels.

5.5.3.4 Maintaining Microclimate

The influence of buffers on microclimate is most often thought of in the context of shading for maintaining water temperature. This is well documented in the literature in relation to the effects on streams (Lynch et al. 1985, Johnson and Stypula 1993, Belt and O'Laughlin 1994, Castelle and Johnson 2000,). In those documents, literature focused on streams and their buffers is almost exclusively relied upon to discuss the influences of buffers on water temperature. No literature was found that specifically examined the influence of buffers on the water temperatures and microclimates within wetlands.

It may be tempting to deduce that the benefit of forested shade in moderating water temperatures is the same in wetlands as in streams. However, it is not reasonable to

apply to wetlands the findings on the widths used for stream buffers for the purpose of shading. As with streams, there are many variables that can influence how shading affects the water temperature in a wetland. These variables relate to differences in water budgets (e.g., the relative influence of groundwater on a seasonal basis, whether the wetland has an inlet/outlet, etc.). In addition, the physical configurations of a large open-water wetland, a small fully vegetated wetland, and a linear stream corridor may not provide reasonable parallels. With these limitations in mind, some relevant findings are provided below.

Forests can create shade and also block the wind, which can help moderate temperatures in adjacent aquatic systems (Oke 1987). Stable water temperature helps maintain water quality because cooler water can carry higher loads of dissolved oxygen, which is important for many aquatic biota. Warmer water can also result in a looser bond between sediment particles and nutrients, which could result in an increase in nutrient loading in warmer aquatic systems (Karr and Schlosser 1977).

Microclimate influences can also extend from large wetlands into the adjacent forests. Harper and MacDonald (2001) conducted research on boreal forests near lakes and found a "distinct lake edge community" of about 131 feet (40 m) width. The lake edge community tended to have greater structural diversity, less canopy cover, fewer snags, greater amounts of coarse woody debris, and greater number of saplings and mid-canopy trees than the interior forest. Changes in the distribution of vegetation species were along a shade tolerance gradient, but the authors postulated that moisture gradient or water table depth also had an influence. Their research was conducted within forests adjacent to open water lakes, but it would be valid to extrapolate their findings to forested communities adjacent to permanent, large open wetlands that would create the same "light and shade" effect. The findings imply that large open aquatic systems influence the adjoining upland community for approximately 131 feet (40 m) distance into the interior of the forested buffer. Thus, buffers not only influence temperatures and wind effects in a wetland, but research identifies that large aquatic systems may have a reverse positive influence on the vegetation structure and species diversity of the buffer. This can thereby affect some of the habitat discussed later in this chapter.

Table 5-4. Summary of a study on the influence of microclimate provided by buffers of various widths.

Author(s)	Date	Width	Comments
Harper and MacDonald	2001	Approx. 131 feet (40 m)	Influence of large aquatic systems on adjacent upland forest composition and structural complexity

5.5.3.5 Summary of Key Points

- The use of buffers to protect and maintain water quality in wetlands (removing sediments, nutrients, and toxicants) is best accomplished by ensuring sheet flow across a well vegetated buffer with a flat slope (less than 5%).

- Significant reductions in some pollutants, especially coarse sediments and the pollutants adhered to them, can be accomplished in a relatively narrow buffer of 16 to 66 feet (5 to 20 m), but removal of fine sediments requires substantially wider buffers of 66 to 328 feet (20 to 100 m).

- Removal of dissolved nutrients requires long retention times (dense vegetation and/or very low slope) and, more importantly, contact with fine roots in the upper soil profile (i.e., soils that are permeable and not compacted). Distances for dissolved nutrient removal are quite variable, ranging in the literature from approximately 16 to 131 feet (5 to 40 m).

- The literature is consistent in finding that it takes a proportionally larger buffer to remove significantly more pollutants because coarse sediments and the pollutants associated with them drop out in the initial (outer) portions of a buffer. It takes a longer time for settling, filtering, and contact with biologically active root zones to remove fine particles and dissolved nutrients.

- The role of buffers in protecting the microclimate of streams is well documented and may be applicable to wetlands, but no specific data on buffers and wetland microclimate maintenance were found.

5.5.4 Buffers and Wildlife Habitat

Wetland buffers are essential to maintaining viable wildlife habitat because they perform three overlapping functions:

- Buffers can provide an ecologically rich and diverse transition zone between aquatic and terrestrial habitats. This includes necessary terrestrial habitats for many wildlife species that use and/or need wetlands but also need terrestrial habitats to meet critical life requirements.

- Buffers can screen wetland habitat from the disturbances of adjacent human development

- Buffers may provide connectivity between otherwise isolated habitat areas

In regard to wildlife, most of the scientific research is not directly focused on the effectiveness of buffers for maintaining individuals or populations of species that use wetlands. Some of the research simply documents use of upland habitats adjacent to wetlands by wildlife to meet their life-history needs. For example, a substantial body of

research identifies the distances that amphibians may be found away from a wetland edge. However, the implications to amphibian populations of providing buffers that are smaller than those identified ranges are not well documented.

The following discussion summarizes the literature on buffers related to wildlife that use wetlands for the three essential functions listed above. Several documents are cited that represent a synthesis of scientific literature on the effectiveness of buffers for protecting wildlife-related functions of wetlands. Even though these documents include some research conducted prior to 1990, they have been included where relevant.

There is substantial literature on the implications to wildlife populations from fragmenting habitats as a result of human activities. However, this research was not necessarily conducted to address the effectiveness of various buffer widths. The literature on this topic is mentioned because of the management implications for the long-term viability of species that are closely associated with wetlands. The reader is referred to Section 4.11 in Chapter 4 and Section 5.5.4.3 for a detailed discussion of habitat fragmentation.

5.5.4.1 Maintaining Terrestrial Habitat Adjacent to Wetlands

Buffers provide a transition between aquatic and terrestrial environments and are a critical component of the habitat of wildlife that use wetlands. The specific habitat functions provided by wetland buffers include:

- Sites for wildlife for foraging, breeding, and nesting
- Cover for escape from predators or adverse weather
- Source of woody debris and organic matter that provides habitat structure and food, as well as moderation of water temperatures within adjacent wetlands to support species that are sensitive to temperature (e.g., fish, amphibians).
- Areas for dispersal and migration related to both individuals and populations; buffers may connect or be part of corridors

As defined previously, buffers are predominantly upland habitat communities that lie adjacent to aquatic habitats. They are a different habitat type than the wetland and their presence increases habitat heterogeneity by providing niches for more species. First described by Leopold (1933) as the "edge effect," and later by Odum (1959) as an "ecotone," this phenomenon features higher use of transition zones by wildlife, particularly between aquatic and terrestrial habitats. It has been demonstrated in studies of birds (Beecher 1942, McElveen 1977), mammals (Bider 1968), and amphibians (Bury 1988). The same pattern has been demonstrated in the Pacific Northwest in studies by Oakley et al. (1985), Knight (1988), and Cross (1988). Recent research conducted in the Puget Sound lowlands found that the greatest species richness of birds and small mammals in 50 foot wetland buffers was found when an additional 1,640 feet (500 m) of relatively undisturbed habitat was adjacent to the wetland buffer (Richter and Azous 2001b, 2001c).

Protection of upland areas adjacent to wetlands is critical to helping ensure that wildlife populations that are closely associated with wetlands have access to the habitat features necessary to meet their survival requirements. Species that are closely associated with wetlands, such as many amphibians, aquatic invertebrates, waterfowl, and some mammals, require access to wetlands for critical stages of their life-history. Many more species use wetlands, as well as other aquatic systems such as streams, lakes, or rivers, to meet various life-history needs. Research shows that species that were assumed to be dependent upon wetlands also depend upon adequate and appropriate upland habitats to maintain viable populations (Foster et al. 1984, Bury 1988, Washington Department of Wildlife in Castelle et al. 1992b, Semlitsch 1998, Semlitsch 2000).

In addition, vegetated buffers protect habitat in wetlands by maintaining the microclimate (through temperature moderation), as discussed previously, and by providing a source of organic matter to aquatic systems. This includes both large organic debris (e.g., logs, root wads, limbs), which provides habitat structure in aquatic environments, and particulate and dissolved organic matter, which provides a source of food for invertebrates (Brown 1985, Groffman et al. 1991a).

In coastal wetlands in South Carolina, Braccia and Batzer (2001) found that large woody debris within wetlands was critical for both aquatic and terrestrial invertebrate populations. They identified that the source of the large woody debris within the wetlands was from the adjacent uplands. The forest conditions in adjacent uplands, therefore, can have a significant influence on wetland biota because the aquatic invertebrates form the foundation of many food chains in aquatic settings (Castelle et al. 1994).

Buffer Width and Effectiveness in Protecting Wetland Habitat and Providing Habitat in Adjacent Uplands

This section summarizes the literature that identified ranges of widths of uplands that protect wetland habitat and/or that provide adjacent upland habitat for wildlife species that use wetlands. The literature presents findings in a variety of ways. Some studies identify the distance that target species range from a wetland source, while other researchers identified the distances that species travel between wetlands. Synthesis documents outlined recommendations for buffer widths based on a review of research findings. Some of the literature identified use of habitats by broad categories of wildlife guilds, while other studies focused on limited guilds or even individual species.

It is important to understand that the range of buffer widths identified and discussed in the literature is a reflection of many variables including the objectives of the research, the species/guilds studied and their varied life-history needs, and the methods of the research. Thus, it is not appropriate to choose a single study or buffer dimension to justify a buffer dimension, whether large or small. It is critical to incorporate the life-history requirements of the range of targeted species when considering buffer dimensions. Synthesis documents clarify that a range of upland habitat buffer dimensions may be appropriate depending upon site considerations, landscape context, and targeted species.

For example, in summarizing the literature he reviewed on buffer effectiveness, McMillan (2000) concluded, "An appropriate buffer to maintain wildlife habitat functions for all but the most highly degraded wetlands would be comprised of native tree and/or shrub vegetation and range from 30 to 100 meters [98 to 328 feet]." Other authors have reached similar conclusions, with their buffer recommendations varying depending on the type of wildlife, life-history stage, intensity of adjacent land use, and surrounding landscape (Groffman et al. 1991a, Castelle et al. 1992b, Desbonnet et al. 1994, Semlitsch 1998). Because there is often substantial information on the needs for some specific wildlife groups, the research findings that are relevant for birds, amphibians, reptiles, and mammals are provided below. Following this discussion, Table 5-5 provides a summary of literature on general habitat needs in relation to buffer sizes.

One consideration not found for this synthesis was the implication of the condition of the upland buffer relative to its provision of wildlife habitat. In several studies on the use of upland buffers by native species, the study identified that the buffer was upland forest. However, no studies were reviewed for this synthesis that compared wildlife use of mature forested buffers with buffers composed of meadow, shrubland, harvest forest, or younger forests. Some research has identified the importance of intact forest habitat to wetland-related species (Azous and Horner 2001, Richter 1997), but a comparison study was not found for this synthesis.

Generally, wildlife-species have varying needs for different types of adjacent habitat for different life needs, such as breeding, foraging, and resting (Brown 1985). This makes it difficult to prescribe one particular type of habitat as best for wildlife. Habitat is very species specific. However, as a general rule, most researchers have recommended that buffers be maintained or restored to a forested condition if only for the screening function they provide. (Obviously, this has little relevance to the shrub-steppe ecoregion in Eastern Washington, where trees are rarely found.)

Birds

The research on birds ranges from studies in individual species to summaries on bird species richness. A tremendous amount of research on waterfowl exists, with the majority being conducted in the prairie pothole region of the United States. This section focuses on studies or syntheses that are relevant to the Pacific Northwest.

The Puget Sound Stormwater Management Research Program found that a distance of 1,640 feet (500 m) from a wetland edge was necessary to account for total species richness of birds (Richter and Azous 2001b). In a study of bird use of freshwater wetlands in urban King County, Washington, Milligan (1985) determined that bird species diversity was strongly correlated with the percentage of the wetland boundary that was buffered by at least 49 feet (15 m) of trees and shrubs.

In eastern Washington, Foster et al. (1984) determined that 68% of waterfowl nests were in upland areas within 98 feet (30 m) of the wetland edge, whereas it would take a 312-foot (95 m) buffer to encompass 95% of the nesting sites.

Temple and Cary (1988) created a computer model whose results may relate to the breeding success of forest birds using wetland buffers. Estimating the effects of habitat fragmentation on birds breeding in the interior of forests in Wisconsin, their model predicted that nesting success was strongly correlated to distance to the edge of a forest. The computer model predicted a success rate of 70% for nests greater than 656 feet (200 m) from the forest edge, 58% for a distance of 328 to 656 feet (100 to 200 m), and only 18% for nests less than 328 feet (100 m) from the forest edge. Applying these findings to wetland buffers, those less than 100 feet (30 m) in width might not be expected to support bird species that nest in forest interiors. The authors concluded that, without "recruits" (birds moving into appropriate habitat niches from farther afield), the continued fragmentation of forest habitats could lead to local extinction of populations of birds that use the interior of forests.

Amphibians

The research on amphibians and buffers in relation to their habitat needs comes both from studies in the Pacific Northwest and literature summaries from around the United States. Findings are rather consistent in that amphibians range substantial distances from breeding locations in a wetland to fulfill their life-history needs. On the west side of the Cascades, there appears to be a preference for forested habitats adjacent to breeding sites. Urban land uses near breeding sites seem to have a negative influence on amphibian abundance.

Detailed findings include:

- A study in the Puget Sound lowlands documented a decline in amphibian richness in wetlands where forest in the contributing watershed was diminishing. Results were not linked to buffer dimensions (Richter and Azous 2001a).

- In a study in King County by Ostergaard (2000), the greatest use of stormwater ponds by native breeding amphibians was found when 3,280 feet (1,000 m) of forested habitat was available adjacent to the pond.

- A study of pond-breeding salamanders in the eastern U.S. found that a buffer of 534 feet (164 m) would be needed to encompass 95% of adult and juvenile salamanders. This buffer range may apply to other similarly mobile species (Semlitsch 1998). Buffers of 98 to 328 feet (30 to 100 m) were recommended along riparian zones, depending upon slope, stream width, and adjacent use (Semlitsch 1998).

- Salamanders use upland habitats over 1,969 feet (600 m) from the edge of wetlands for non-breeding life-history stages. Sustaining viable amphibian species closely associated with wetlands requires maintaining the connection between wetlands and terrestrial habitats (Semlitsch 1998).

See Table 5-5 for further information on these studies.

In addition, in the Midwestern U.S., Knutson et al. (1999) found a positive correlation between the presence of forest around the perimeter of the wetland and amphibian abundance, and a negative correlation to urban land uses on the perimeter.

Reptiles

Western pond turtles are associated with a variety of aquatic habitats, including wetlands, streams, and rivers. In a California study, western pond turtles were found to overwinter as far as 1,650 feet (500m) from water (Reese and Welsh 1997). An unpublished study done in Washington for the Washington Department of Wildlife found nest sites as far as 615 feet (187m) from water, usually in open areas with good sun exposure (Holland 1991).

Research on freshwater turtles in North Carolina found that turtles used a wide area for nesting and terrestrial hibernation in uplands surrounding the ponds where breeding occurred (Burke and Gibbons 1995). They found that a 902-foot (275 m) buffer was required to protect 100% of the nest and hibernation sites. Protecting 90% of the sites required a 240-foot (73 m) buffer. The authors concluded that most buffer requirements are inadequate to protect turtle habitat for all stages of their life-history.

Mammals

Use of wetlands by mammals depends upon adjacent uplands. The literature indicates that even a mammal that is closely associated with wetlands, such as a beaver, uses upland habitats an average of 100 feet (30 m) from the wetland edge in eastern Washington and over 300 feet (100 m) distant in western Washington (Castelle et al. 1992b). Research on small mammals found the greatest concentration of species near riparian corridors, with some species found within that riparian corridor that were not found farther away in upland habitats (Cross 1985).

Dimensions of effective buffers for mammals are more difficult to discern from the literature because they depend upon the species' life-history. Also, as discussed in Section 4.11 of Chapter 4, habitat linkages and fragmentation may be more critical for the sustainability of some populations.

As part of the Puget Sound Stormwater Management Research Program, Richter and Azous (2001c) found that the highest richness of small mammals was in wetlands with at least 60% of the first 1,640 feet (500 m) of buffer in forest cover. Other findings of this program include:

- The preservation of large woody debris within the wetland and adjacent upland forest is important for maintaining small-mammal habitat.
- Small-mammal richness was best associated with the combined factors of wetland size, adjacent forest, and the quantity of large, coarse woody debris within the wetland and its buffer.

- In southwestern Oregon, Cross (1985) conducted research on small mammals in "leave-strips" adjacent to streams within zones of forest that had been harvested. He found that the richness of small-mammal species was highest in the riparian zone closest to the stream, intermediate in the transition zone, and lowest in the upland zone. (The zones were defined by vegetation composition, not by dimension.) Because riparian habitats provide more niches for species, it is expected that such habitats would maintain greater species richness (Cross 1985).

Cross also found no species in the upland zone that were not found in the riparian zone, but he found five species present in the riparian zone that were not present in the upland or transition zones. A strip averaging 220 feet (67 m) wide supports mammal communities at similar numbers and richness to the nearby undisturbed riparian corridor. This study focused on small mammals which, relative to large mammals, have small home ranges. Therefore, the study is not broadly applicable to appropriate leave-strip dimensions for larger species.

Table 5-5 presents a summary of literature on wildlife and buffer/upland habitat use that was relevant to this synthesis. As noted previously, some of the research is specific to individual species, some is focused on a particular guild or group of similar species, some looks at life-history patterns (nesting distances), and some sources represent synthesis documents of buffer effectiveness. These distances do not necessarily reflect the literature relative to human disturbance and/or habitat fragmentation, which are discussed in the next sections.

It is difficult to synthesize the findings of the research on wildlife and the width of buffers into simple generalizations that can be readily applied. When looking at life-history needs (e.g., nesting sites, foraging ranges, etc.), the distances presented in the literature range from 98 feet (30 m) (Foster et al. 1984, Castelle et al. 1992b) to 3,280 feet (1,000 m) (Richter 1997). These distances, measured in the field, represent the distance that species ranged, nested, or foraged from a wetland edge.

Other authors have presented their own synthesis or recommendations of effective buffer ranges based on review of the literature. These range from 49 feet (15 m) (Desbonnet et al. 1994) to 328 feet (100 m) (Groffman et al. 1991a, Castelle et al. 1992b, Desbonnet et al. 1994, McMillan 2000). Note that Desbonnet et al. (1994) recommends a range of buffer dimensions based on site conditions, species of interest, and proposed adjacent land uses; hence, their studies are cited at both ends of the distance spectrum.

Table 5-5. Summary of studies on wildlife habitat provided by buffers.

Author(s)	Date	Width	Comments
Allen	1982	328 – 590 feet (100 – 180 m)	Mink use: generally concentrated within 330 feet (100 m) of water but will use upland habitats up to 590 feet (180 m) distant
Burke and Gibbons	1995	240 feet (73 m): 90% 902 feet (275 m): 100%	Buffer to encompass % nesting and hibernation of turtles in North Carolina

Author(s)	Date	Width	Comments
Castelle et al.	1992b	197 – 295 feet (60 – 90 m): Western Washington 98 – 197 feet (30 – 60 m): Eastern Washington	Range for all species they noted Range for all species they noted
Castelle et al.	1992b	263 feet (80 m) avg. - 590 feet (180 m)	Wood duck nesting locations from wetland edge (non-Washington data)
Castelle et al.	1992b	98 feet (30 m): Eastern Washington 328 feet (100 m): Western Washington	Distance of beaver use of upland habitats from water edge
Chase et al.	1995	98 feet (30 m) or more	100 feet (30 m) would be "adequate"; buffers larger than 100 feet needed to meet habitat needs, including breeding for birds and some mammals
Cross	1985	220 feet (67 m)	Forested "leave-strips" for small mammal richness adjacent to streams in SW Oregon
Desbonnet et al.	1994	49 – 98 feet (15 – 30 m): low intensity 98 – 328 feet (30 – 100 m): high intensity	Variable buffer widths using adjacent land uses as decision-making criteria
Fischer et al.	2000	98 feet (30 m) minimum	Literature review; majority of literature cited recommends buffer widths of 330 feet (100 m) for reptiles, amphibians, birds, and mammals
Foster et al.	1984	98 feet (30 m): 68% of nests) 312 feet (95 m): 95% of nests	Waterfowl breeding use of wetlands in the Columbia Basin greatest in smaller (<1 acre [0.4 ha]) wetlands; 68% of waterfowl nests within 100 feet (30 m) of wetland edge; to encompass 95% of waterfowl nests would require 310 feet (95 m) of buffer
Groffman et al.	1991a	197 - 328 feet (60 - 100 m)	For most wildlife needs
Groffman et al.	1991a	328 feet (100 m)	Neotropical migratory bird species
Howard and Allen	1989	197 feet (60 m)	For most wildlife needs
McMillan	2000	98 – 328 feet (30 – 100 m)	Based on a synthesis of literature
Milligan	1985	49 feet (15 m)	Bird species diversity strongly correlated with the percentage of the wetland boundary buffered by at least 50 feet (15 m) of tree and shrub vegetation
Norman	1996	164 feet (50 m)	To protect wetland functions; more buffer may be required for "sensitive wildlife species"

Author(s)	Date	Width	Comments
Ostergaard	2001	3,280 feet (1,000 m)	Forested habitat surrounding stormwater ponds, related to native amphibian richness
Richter	1996	3,280 feet (1,000 m)	Literature review and synthesis
Richter	1996	3,280 feet (1,000 m)	Native amphibian use
Richter and Azous	2001b	1,680 feet (512 m)	Distance from wetland edge necessary to include all bird richness in Puget Sound lowland wetlands
Richter and Azous	2001c	1,640 feet (500 m): 60%	Highest small-mammal richness when 60% of first 1,640 feet (500 m) of buffer was forest habitat
Semlitsch	1998	1,969 feet (600 m)	Salamanders
Semlitsch	1998	228 – 411 feet (69.6 - 125.3 m) 539 feet (164.3 m) for 95% of all species	Six species of adult salamanders and two species of juveniles; mean distance from wetland edge was 228 feet (juveniles) – 411 feet (adults). To incorporate 95% of all species, buffer mean would have to be 539 feet
Short and Cooper	1985	164 – 328 feet (50 – 100 m)	164 feet (50 m) for foraging
Temple and Cary	1988	> 656 feet (200 m): 70% success 328 – 656 feet (100 – 200 m): 58% success < 328 feet (100 m): 18% success	Nesting success rates for interior-dwelling forest birds related to distance into the interior of a forest from the forest edge

5.5.4.2 Screening Adjacent Disturbances

Wetland buffers screen wildlife from human activities. Disturbance from humans can come in the form of noise and light (indirect effects) or from human presence/movement (direct effects). Noise and light can disrupt feeding, breeding, and sleeping habits of wildlife. Many wildlife species in wetlands are disturbed by unscreened human activity within 200 feet (61 m) (Washington Department of Wildlife in Castelle et al. 1992b). Dense shrubs and trees in a wetland buffer can limit intrusion and screen out noise, light, and movement from adjacent human development (Castelle et al. 1992b).

In addition, domestic pets such as dogs and cats can adversely affect wetland wildlife by preying on some wildlife species and are particularly damaging to ground-nesting species (Churcher 1989). See Section 4.12.5 in Chapter 4 for further discussion.

The effect of noise on wildlife is a topic of growing concern. Little research exists on the effective buffer widths required to filter sounds for wildlife. See Section 4.12.3 in Chapter 4 for a discussion of current literature on the effects of noise on wildlife.

Groffman et al. (1991a) determined that 105 feet (32 m) of dense, forested buffer was necessary to reduce noise from commercial areas to background noise levels. Shisler et al. (1987) differentiated between the impacts of low-intensity land uses (agricultural, recreational, low-density housing) and high-intensity land uses (high-density residential, commercial/industrial). They found that low-intensity land uses could be effectively screened with vegetated buffers of 49 to 98 feet (15 to 30 m), while high-intensity land uses required buffers of 98 to 164 feet (30 to 50 m).

Direct sighting of humans approaching was found to disrupt birds (i.e., change their behavior or cause flushing) between 46 and 164 feet (14 to 50 m) (Shisler et al. 1987, Josselyn et al. 1989, Rodgers and Smith 1997). Looking specifically at great blue herons, Short and Cooper (1985) documented that they would flush from their nests if humans approached within 328 feet (100 m). Buffers between 46 and 164 feet (14 to 50 m) may be required to screen wildlife from direct observation of humans, while larger buffers (328 feet or 100 m) were documented as necessary to screen nesting herons.

Other researchers differentiated between the types of activities humans are engaged in and their effects on wildlife. Humans walking toward birds were studied to see how closely they could approach before birds flushed from perches or stopped foraging. In Florida, Rodgers and Smith (1997) found that humans could approach 46 to 112 feet (14 to 34 m) before flushing, but automobiles flushed birds at 61 to 78 feet (18.5 to 24 m). Interestingly, they found that bird-watching (as opposed to humans who were simply walking) had the greatest adverse impacts on birds. They surmised this was due to the human behavior of stopping and standing with binoculars at one point for a prolonged time.

Cooke (in Castelle et al. 1992b) analyzed 21 wetland sites in western Washington and concluded that buffers smaller than 50 feet (15 m) were generally ineffective in screening human disturbance from alterations such as noise, debris, and altered use of the buffer.

Table 5-6 summarizes the findings of the literature related to the disturbance limits or screening effects of a buffer for various wildlife species.

Table 5-6. Summary of studies on screening provided by buffers.

Author(s)	Date	Width	Comments
Castelle et al.	1992b	200 feet (61 m)	General wildlife considerations
Cooke	1992	50 feet (15 m)	Analyzed 21 sites in King County. Buffers less than 50 feet were often disturbed by human activities and were not effective at screening "human effects." Found in Castelle et al. (1992b)
Groffman et al.	1991a	105 feet (32 m)	Dense forest to filter sound from commercial land uses to natural background levels
Josselyn et al.	1989	49 – 164 feet (15 – 50 m)	Unscreened human activity within 50 – 164 feet was disruptive to waterbirds in San Francisco Bay area

Author(s)	Date	Width	Comments
Rodgers and Smith	1997	46 to 112 feet (14 –34 m) 61 to 78 feet (18.5 – 24 m)	Waterbirds in Florida: flushing distance from walkers 46 – 112 feet; flushing distance from autos 61 – 78 feet. Nature observation had greatest impact if involving walking activities. Nesting birds tolerated closer human approach than birds that were perching/foraging
Shisler et al.	1987	50 - 100 feet (15 – 30 m) 100 – 164 feet (30 – 50 m)	Low-intensity land uses (agriculture, recreation, and low density residential): 50 - 100 feet High-density residential housing and commercial/industrial: 100 - 164 feet Most effective buffers had steep slopes, dense shrubs
Short and Cooper	1985	328 feet (100 m)	328 feet to buffer nesting great blue herons from human disturbance

5.5.4.3 Maintaining Habitat Connections

Converting habitats to other uses directly increases the isolation of wetlands and the fragmentation of habitats (See Section 4.11 in Chapter 4 for further discussion of the impacts of fragmentation). Buffers can play a role in reducing habitat fragmentation by serving as upland habitat directly adjacent to a wetland. They can also provide an area that can connect, or be part of a corridor that connects, wetlands with upland habitats or other water bodies (National Research Council 2001). However, buffers, as applied in a regulatory context, are rarely designed to provide these connections. Typical buffer widths generally are insufficient to link wetlands to other habitats. In addition, maintaining linkages from one habitat type to another on individual parcels is often not a consideration when properties are reviewed case by case. The authors of Volume I believe that maintaining habitat connectivity is best accomplished through landscape-scale planning and protection measures.

In general, the literature states that for terrestrial species with wide-ranging habits, it is important to maintain connections between sites used for breeding, feeding, and refuge. This is critical for maintaining population viability (Bedford and Preston 1988, Gibbs 1993, Semlitsch and Bodie 1998, National Research Council 2001). One may assume that this applies only to large terrestrial mammals. However, research has shown that many native amphibians on the west side of the Cascades can range 3,280 feet (1,000 m) from source wetlands into other wetlands or surrounding upland habitats (Richter 1997). Ostergaard (2001) found the greatest amphibian richness in sites that had upland forest habitat surrounding the site by 3,280 feet (1,000 m). Richter and Azous (2001b) found that a radius of 1,680 feet (512 m) surrounding a wetland was necessary to include all the bird richness of species utilizing the source wetland.

5.5.4.4 Summary of Key Points

- There is no simple, general answer for what constitutes an effective buffer width for wildlife considerations. The width of the buffer is dependent upon the species in question and its life-history needs, whether the goal is to maintain connectivity of habitats across a landscape, or whether one is simply trying to screen wildlife from human interactions.

- The majority of wildlife species in Washington use wetland habitats for some portion of their life-history needs. Many species that are closely associated with wetlands (those that depend upon wetlands for breeding, brood-raising, or feeding) depend upon surrounding upland habitats as well for some life-history stages.

- Many terrestrial species that are dependent upon wetlands have broad-ranging habits, some over 3,280 feet (1,000 m) from the source wetland. Although this might be expected for large mammals such as deer or black bears, it is also true for smaller species, such as salamanders and other amphibians.

- Human access and land uses adjacent to wetlands influence the use and habits of wildlife through noise and light intrusions, as well as elimination or degradation of appropriate upland habitats. Even "passive" activities, such as bird/nature-watching, have been shown to have effects on roosting and foraging birds.

- Synthesis documents that evaluated many studies discussing the protection of habitat provided by wetland buffers generally recommend buffer widths between 50 and 300 feet (15 to 100 m), depending on specific factors. These factors include the quality of the wetland habitat, the species needing protection, the quality of the buffer, and the surrounding land uses.

5.5.5 Buffer Maintenance and Effectiveness over Time

Buffers can help to protect wetlands for as long as the buffers themselves remain intact. Buffer areas can be altered over time by human disturbance and natural events, such as windstorms. In addition, some researchers have raised the issue of whether buffers have a long-term, carrying capacity with regard to filtration and binding of pollutants. In other words, is there a maximum amount that can be processed before the buffer's ability is overwhelmed?

5.5.5.1 Human Alteration to Buffers

Human activities are the most common mechanism for altering buffers over time. Buffer functions can be reduced if vegetation is cut or trampled, soils are compacted, sediment loading surpasses the filtering capability of the vegetation, or surface-water flows create channels and subsequent erosion.

Cooke (in Castelle et al. 1992b) analyzed 21 wetland sites in western Washington and concluded that buffers less than 50 feet (15 m) wide were more susceptible to being reduced over time by human disturbance. Nearly all of the buffers they studied that were less than 50 feet (15 m) in width were significantly reduced in the few years the buffers had been present on the back of private lots. Some of the buffers were found to have been eliminated through complete clearing of native vegetation. Of the buffers wider than 50 feet (15 m), most still had some portion intact and, overall, showed fewer signs of human disturbance. Cooke also found that fencing buffers (without a gate allowing access) was effective at reducing the alteration of buffers by humans.

In a study in the Monterey Bay area of California, Dyste (1995) examined 15 wetlands with buffers. All of the buffers suffered from human alteration including cutting of vegetation, soil compaction, and dumping of garbage.

5.5.5.2 Loss of Trees to Blowdown

In the Pacific Northwest, forested buffers are often leave-strips around wetlands or along streams when the surrounding forest is cleared for land development. These forested strips are then exposed to winter windstorms, which are common, often resulting in substantial loss of large trees due to blowdown.

Pollock and Kennard (1998) concluded that trees in narrow forested buffers (less than 76 feet [23 m] wide) have a much higher probability of suffering significant mortality from windthrow and blowdown than trees in wider buffers. They conclude that buffers in the range of 76 to 115 feet (23 to 35 m), created when the surrounding forest is cut, are the minimum width that can be expected to withstand the effects of wind in the long term.

5.5.5.3 Reduced Capacity for Sediment/Nutrient Removal

Many of the studies described earlier assessed the effectiveness of buffers in removing sediments and nutrients for short durations (on the order of one to two years, if the time period was discernable in the methods sections of the literature). One study that assessed water quality improvement over longer periods found that effectiveness diminished as the outer margins of the buffers became saturated with sediment (Dillaha and Inamdar 1997). Their findings suggest that buffers have a limited carrying capacity for sediment removal (a maximum amount of sediment that can be removed) and that larger buffers and other methods may be required to ensure long-term control of sediment.

Similarly, Todd (2000) cites work by Dillaha in 1993 that found less than 10% of grass filter strips were effective after three to five years. The grass filter strips became channelized and surface flows were no longer passing through as sheet flow that would allow contact with vegetation to remove sediments and nutrients. Todd emphasizes that, for buffers to be effective, they have to be sustainable over time, and this must be a factor when determining buffer widths.

5.5.5.4 Summary of Key Points

- Human actions can reduce the effectiveness of buffers in the long term through removal of buffer vegetation, soil compaction, sediment loading, and dumping of garbage.
- Buffers may lose their effectiveness to disperse surface flows over time as flows create rills and channels, causing erosion within the buffer.
- Leaving narrow strips of trees can result in tree loss due to blowdown.
- Buffers may become saturated with sediment over time and become less effective at removing pollutants. The literature indicates that this should be considered when determining buffer widths.

5.5.6 Summary of Buffer Ranges and Characteristics from the Literature

The following discussion summarizes the many suggestions and recommendations in the literature for how buffer widths can be established. Many of these were found in synthesis documents that summarize scientific literature on buffers and then draw general conclusions. The recommendations in most of these syntheses are remarkably consistent. Taken together with the great number of site-specific studies cited in the syntheses, they present what should be considered "fundamental principles" for buffers.

At its most basic level, the science on wetland buffers identifies four criteria that should be considered in determining the width of a buffer (Castelle et al. 1992b, Desbonnet et al. 1994, Norman 1996, McMillan 2000, Todd 2000):

- The functions and values of the aquatic resource to be protected by the buffer
- The characteristics of the buffer itself and of the watershed contributing to the aquatic resource
- The intensity of the adjacent land use (or proposed land use) and the expected impacts that result from that land use
- The specific functions that the buffer is supposed to provide; for habitat functions this includes the targeted species to be managed and an understanding of its habitat requirements

The feasibility or possibility of incorporating those four considerations into determining buffer dimensions is dependent upon the jurisdiction in question. Ideally, buffer widths should be tailored to these four factors. However, the authors that recommend considering these factors also acknowledge that the scientific basis for determining the width of a buffer is often superseded by political expediency. Buffers are more often

determined administratively as standard or fixed dimensions that may, or may not, be correlated with the criteria listed above.

Table 5-7 presents a summary of the buffer ranges recommended by the authors who conducted literature reviews or syntheses on buffer effectiveness. Minimums ranged from 25 feet (8 m) to 197 feet (60 m). Maximums ranged from 98 feet (30 m) for some land uses to 350 feet (107 m).

Table 5-7. Summary of recommendations for buffer dimensions from the literature.

Author(s)	Date	Minimum Buffer	Maximum Buffer	Comments
Castelle et al.	1994	50 to 100 feet (15 - 30m)		"Minimum buffers necessary to protect wetlands and streams under most circumstances"
Fischer et al.	2000	98 feet (30 m)	328 feet (100 m)	Larger buffer for reptiles, amphibians, birds and mammals
Groffman et al.	1991a	197 feet (60 m)	328 feet (100 m)	For most wildlife needs
Howard and Allen	1989	197 feet (60 m)		For most wildlife needs
McMillan	2000	25 feet (8 m)	350 feet (107 m)	Case by case, using a rating system and the intensity of proposed or existing land use for protecting most wetland functions
Norman	1996	164 feet (50 m)		To protect wetland functions; more may be required to protect more "sensitive wildlife species"

Table 5-8 is taken from one of the most comprehensive buffer syntheses published (Desbonnet et al. 1994). The authors of the synthesis looked at several hundred articles and reports on buffers. This table presents the information in a format that outlines the general effectiveness of different buffer widths at removing pollutants and providing habitat.

Table 5-8. A summary of the effectiveness of pollutant removal and the value of the wildlife habitat of vegetated buffers according to buffer width (Desbonnet et al. 1994).

Buffer Width in Feet (Meters)	Pollutant Removal Effectiveness	Wildlife Habitat Value
16 feet (5 m)	Approximately 50% or greater sediment and pollutant removal	Poor habitat value; useful for temporary activities of wildlife
32 feet (10 m)	Approximately 60% or greater sediment and pollutant removal	Minimally protects stream habitat; poor habitat value; useful for temporary activities of wildlife
49 feet (15 m)	Greater than 60% sediment and pollutant removal	Minimal general wildlife and avian habitat value
66 feet (20 m)	Greater than 70% sediment and pollutant removal	Minimal wildlife habitat value; some value as avian habitat
98 feet (30 m)	Approximately 70% or greater sediment and pollutant removal	May have use as a wildlife travel corridor as well as general avian habitat
164 feet (50 m)	Approximately 75% or greater sediment and pollutant removal	Minimal general wildlife habitat value
246 feet (75 m)	Approximately 80% or greater sediment and pollutant removal	Fair to good general wildlife and avian habitat value
328 feet (100 m)	Approximately 80% or greater sediment and pollutant removal	Good general wildlife habitat value; may protect significant wildlife habitat
656 feet (200 m)	Approximately 90% or greater sediment and pollutant removal	Excellent general wildlife value; likely to support a diverse community
1,968 feet (600 m)	Approximately 99% or greater sediment and pollutant removal	Excellent general wildlife value; supports a diverse community; protection of significant species

Castelle et al. (1994), summarizing research conducted primarily before 1990, concluded "buffers necessary to protect wetlands and streams should be a minimum of 49 to 98 feet (15 to 30 m) in width under most circumstances." They note that the lower end of the spectrum is the minimum necessary to maintain physical and chemical processes, while the upper end of the spectrum may be the minimum necessary to maintain biological processes. The Castelle et al. report of 1994 does not identify appropriate maximums. McMillan (2000) recommends an approach to determining buffers that attempts to balance predictability with flexibility by setting standard buffer widths that can be altered on a case-by-case basis to adapt to site-specific factors. This approach for determining buffer width incorporates a rating system for wetlands, plus an assessment of the intensity of proposed or existing adjacent land use, to establish buffer widths ranging from 25 to 350 feet (8 to 107 m). It is perhaps the method that is closest to fitting the four bulleted criteria outlined at the beginning of this section. It incorporates an understanding of the condition of the wetland, the buffer, and the proposed adjacent land use.

Several other authors also suggest that considering site-specific factors enhances the effectiveness of buffer strips over using fixed-width buffers (Steinblums et al. 1984,

Norman 1996, Todd 2000). Belt and O'Laughlin (1994) note that, "The fixed minimum-width approach enjoys the virtue of simplicity in application, but has the potential for providing either not enough or too much protection."

Liquori (2000) also cautions against using fixed buffer widths to protect long-term ecological functioning of buffers and their associated aquatic resources. He notes that many of the functions that buffers provide are directly related to physical characteristics and biological processes within the buffers. Informed with site-specific information, a case-by-case argument could be made for establishing buffer widths. "The nature of the [functions a buffer provides] may significantly depend upon riparian structure both locally and as a mosaic over the watershed scale."

In urban settings, larger buffer widths are often prescribed in anticipation of future impacts from adjacent land use and activity upstream in the watershed. The most important criterion for determining buffer width is identification of the various functions the buffer is expected to provide (Todd 2000).

In agricultural lands, Welsch (1991) identifies a three-zone approach for establishing buffers:

- **Zone 1** consists of riparian-type trees and shrubs immediately adjacent to the stream, water body, or wetland. It should be a minimum 13 feet (4 m) wide, or adjusted to include the entire riparian area (the area with year-long or seasonal soil-moisture regime influenced by the stream or water body). Minimum length should be the length of the proposed disturbance outside the riparian management zones, or "the longest distance possible."

- **Zone 2** extends upslope from Zone 1 and consists of vegetation that may be periodically harvested as it matures. A minimum distance of 20 feet (6 m) should be allowed for this zone for small streams or water bodies; for larger streams or water bodies the total of Zones 1 and 2 can be increased up to 98 feet (30 m) or 30% of the geomorphic floodplain (whichever is less). Minimum length should match that of Zone 1. Zone 2 can be an active harvest zone, but trees and vegetation need to be left to provide soil holding and filtering capacity.

- **Zone 3** is added upslope of Zone 2 if adjacent land (away from the aquatic resource) is cultivated cropland or another land use with the potential for erosion or sediment production. Zone 3 is a vegetated filter strip and should be wide enough to control "concentrated flow erosion from cultivated cropland." Zone 3 vegetation should be established prior to the establishment of Zones 1 and 2.

This zonal approach is recommended for active agricultural activities, which implies the regular creation of conditions with high erosion potential (grazing or tilling). It also allows more active use of the central portion of the buffer and active management of the outer area of the buffer.

Townsend and Robinson (2001) build on this zonal approach and recommend guidance on maintenance of canopy coverage and closure. They suggest using species that readily

resprout from stumps or roots in the areas nearest the stream channels (to allow the vegetation to respond to flood damage and/or beaver activity). They stress the need for ongoing maintenance, especially in Zone 3, to ensure that erosive flows are not causing rills or channelized flows into Zone 2. They also note that, while most of these buffers will be applied on an ownership basis, greater benefit would be realized if the concept of zoned buffers were applied on a watershed basis.

Other recommendations are based on wildlife species of particular interest. Based on their study of waterbirds in Florida, Rodgers and Smith (1997) recommend a buffer width of 328 feet (100 m) to ensure that birds will not be triggered into an "approach" response, a state which occurs prior to actual flushing. They derived this figure by analyzing the flushing distance from human approach for 16 species, then adding 131 feet (40 m) to that distance. The 131-foot (40 m) distance was derived from previous work which found that birds became alert (stopped their ongoing behavior and focused on the approaching human) in a range of 82 to 131 feet (25 to 40 m).

5.5.6.1 Summary of Key Points

- Many researchers have recommended using four basic criteria to determine the width of a buffer:
  - the functions and values of the aquatic resource to be protected by the buffer
  - the characteristics of the buffer itself and of the watershed contributing to the aquatic resource
  - the intensity of the adjacent land use (or proposed land use) and the expected impacts that result from that land use
  - the specific functions that the buffer is supposed to provide including the targeted species to be managed and an understanding of their habitat needs
- Protecting wildlife habitat functions of wetlands generally requires larger buffers than protecting water quality functions of wetlands
- Effective buffer widths should be based on the above factors. They generally should range from:

  25 to 75 feet (8 to 23 m) for wetlands with minimal habitat functions and low-intensity land uses adjacent to the wetland

  75 to 150 feet (15 to 46 m) for wetlands with moderate habitat functions and moderate or high-intensity land uses adjacent to the wetland

  150 to 300+ feet (46 to 92+ m) for wetlands with high habitat functions, regardless of the intensity of the land uses adjacent to the wetland
- Fixed-width buffers may not adequately address the issues of habitat fragmentation and population dynamics. Several researchers have recommended

a more flexible approach that allows buffer widths to be varied depending on site-specific conditions.

5.6 Chapter Summary and Conclusions

Wetlands are defined using well established language that is generally consistent between federal and state laws. However, certain wetland types are sometimes excluded from regulation. These include small wetlands, isolated wetlands, and wetlands that are designated as Prior Converted Croplands (PCC). The scientific literature makes clear that small wetlands and isolated wetlands provide important functions and does not provide any rationale for excluding these wetlands from regulation. Little scientific information is available on PCC, but there is no evidence to suggest that they are unimportant in providing wetland functions. They retain many of the characteristics necessary to provide multiple wetland functions.

Wetland delineation is conducted according to either the federal or state delineation manual. These manuals are consistent and, when applied correctly, will result in the same wetland boundary. Wetland rating systems are a useful tool for grouping wetlands based on their needs for protection. The most widely used method in Washington is the state's rating system which places wetlands in categories based on their rarity, sensitivity, irreplaceability, and functions.

Wetland buffers are a critical tool for protecting wetland functions. Findings regarding buffer functions and effectiveness are consistent in recommending that the width of a buffer should be related to the wetland functions that need protection, the land-use activities from which the wetland is being buffered, and the characteristics of the buffer itself. These factors, derived from the many studies of wetland buffers and other aquatic resources, can be thought of as the "fundamental principles" that are recommended to determine the widths and characteristics of buffers.

The literature confirms that for water quality improvement (e.g., sediment removal and nutrient uptake) there is a non-linear relationship between buffer width and increased effectiveness. Sediment removal and nutrient uptake are provided at the greatest rates within the immediate outer portions of a buffer (nearest the source of sediment/nutrient), with increasingly larger widths of buffers required to obtain measurable increases in those functions. Additionally, the long-term effectiveness of buffers in providing such mechanical and biological processes is not well documented in the literature. However, the literature suggests that buffers may have a carrying capacity or limit to their ability to remove pollutants. Future research on this topic is needed.

Compared to the widths needed for sediment removal and nutrient uptake, the literature has documented the need for significantly wider buffers to protect or maintain habitat functions for wildlife species that are closely associated with wetlands, as well as for populations that use wetlands. Research confirms that many wildlife species and guilds are dependent upon wetlands for only portions of their life cycles, and that they require upland habitats adjacent to the wetland to meet all their life needs. Without adequate

upland habitat adjacent to wetlands, these habitat functions are lost. Some species use upland habitats that are far from the source wetland. The literature documents that, without access to appropriate upland habitat and the opportunity to move between wetlands and other habitats across a landscape, it is not possible to maintain viable populations of many species. Beyond simply providing adequate upland habitat adjacent to a single wetland, the literature on the maintenance of wildlife populations finds that it is necessary to link habitat types, including wetlands and uplands, across a landscape in order to maintain genetically viable populations.

Several authors who suggested recommendations for buffer widths based on their own synthesis of the literature have recommended variable widths based on the conditions of the wetland, the conditions of the buffer, the proposed land uses adjacent to the buffer, and what functions are intended to be managed. For protection and maintenance of wildlife habitat functions of wetlands, these studies suggest that effective buffer widths should be based on the above factors and generally should range from: 25 to 75 feet (8 to 23 m) for wetlands with minimal habitat functions and low-intensity land uses adjacent to wetlands; 50 to 150 feet (15 to 46 m) for wetlands with moderate habitat functions and moderate or high-intensity land use that is adjacent; and 150 to 300+ feet (46 to 92+ m) for wetlands with high habitat functions depending on the intensity of the adjacent land use. However, several authors noted that protection and maintenance of viable wildlife populations for many species requires habitat connections via corridors and large habitat patches.

Chapter 6 continues the discussion of regulatory tools used to manage wetlands by discussing wetland compensatory mitigation and its effectiveness.

Chapter 6

The Science and Effectiveness of Wetland Mitigation

6.1 Reader's Guide to this Chapter

This chapter synthesizes the scientific literature regarding compensatory mitigation and its effectiveness at reducing the severity of activities that detrimentally affect wetlands. It also reports the suggestions made by various authors regarding ways to improve compensatory mitigation.

6.1.1 Chapter Contents

Major sections of this chapter and the topics they cover include:

Section 6.2, Introduction and Background to Wetland Mitigation describes wetland mitigation sequencing, which encompasses a series of actions that requires addressing each action, or step, in a particular order. Compensation for wetland impacts is just one of these steps.

Section 6.3, Success of Compensatory Mitigation Wetlands synthesizes the literature on the biological, ecological, or functional success of compensatory mitigation projects. This section does not specifically evaluate the successful compensation for wetland area; that is discussed in Section 6.7.

Section 6.4, Compliance with Permit Requirements describes studies that evaluated several aspects of how well compensatory mitigation projects met legal or permit requirements. These included whether projects were completed or installed according to plan, whether they attained the required wetland acreage, whether performance standards were achieved, whether the project was monitored or maintained, and whether the regulatory agencies followed-up on the project.

Section 6.5, Types of Compensatory Mitigation discusses the use and effectiveness of restoration, creation, enhancement/exchange, preservation, mixed compensatory mitigation, mitigation banking, and in-lieu fees.

Section 6.6, Replacement Ratios describes the rationale for the use of ratios in determining the acreage required as compensation for a given area of wetland impact. It synthesizes the literature on the ratios that were required and those actually achieved for numerous projects. This section also discusses approaches proposed in the literature to more effectively determine compensatory mitigation ratios.

Section 6.7, Replacement of Wetland Acreage summarizes the results of studies examining whether compensatory wetland mitigation is actually replacing the acreage of wetland losses authorized. This includes both evaluations of overall permitting programs and of specific compensation projects in compensating for wetland acreage.

Section 6.8, Functions and Characteristics Provided by Created, Restored, or Enhanced Wetlands describes the ability of mitigation wetlands to provide wildlife habitat, plant communities, adequate soil conditions, and water quality/quantity functions. Compensation wetlands were often compared with pre-existing or reference wetlands in these studies.

Section 6.9, Reproducibility of Particular Wetland Types summarizes the literature regarding whether and how easily certain wetland types, such as bogs, fens, vernal pools, alkali wetlands, and mature forested wetlands, can be reproduced or restored.

Section 6.10, Suggestions from the Literature for Improving Compensatory Mitigation summarizes numerous recommendations made by researchers to improve the success of compensation projects—ranging from improvements to regulations and site selection, to better performance standards, to a broader landscape approach, to mitigation banking.

Section 6.11, Chapter Summary and Conclusions ties together the major concepts presented in the chapter.

6.1.2 Where to Find Summary Information and Conclusions

Each major section of this chapter concludes with a brief summary of the key points resulting from the literature review on that topic in a bullet list format. The reader is encouraged to remember that a review of the entire section preceding the summary is necessary for an in-depth understanding of the topic.

For summaries of the information presented in this chapter, see the following sections:

- Section 6.3.2
- Section 6.4.9
- Section 6.5.8
- Section 6.6.4
- Section 6.7.3
- Section 6.8.6
- Section 6.9.5
- Section 6.10.7

In addition, Section 6.11 provides a summary of the chapter and conclusions about the overarching themes gleaned from the literature and presented in this chapter.

6.1.3 Sources and Gaps in Information

The synthesis in this chapter is based on more than 50 articles, government reports, and conference proceedings that have been published since about 1990 on the topic of compensatory mitigation. (The literature did not address the other types of mitigation listed in Section 6.2.1.)

The information resulted from studies conducted in various states and countries, including several studies from the Pacific Northwest. Environmental conditions may vary in other states and countries. However, the information resulting from these studies is relevant to compensatory wetland mitigation in Washington State for the following reasons:

- The general principals and techniques used to restore, create, and enhance wetlands are similar
- The regulatory approaches and requirements are similar
- Most importantly, the studies provide similar and consistent results

Geographic location of the studies cited in this chapter

The articles and reports that evaluated the effectiveness of individual compensatory mitigation projects focused on a variety of locations, including Washington, Oregon, California, Louisiana, Michigan, Indiana, Ohio, New Jersey, Massachusetts, Maryland, Tennessee, and Florida.

Studies that assessed specific functions performed by wetlands that were sites for compensatory mitigation and non-regulatory restoration were located in: Washington, Oregon, Wyoming, Iowa, Minnesota, Wisconsin, Illinois, Ohio, New York, Pennsylvania, Connecticut, West Virginia, South Carolina, Florida, Canada, Sweden, Spain, Austria, and central Europe.

The information synthesized in this chapter covers a range of topics and issues relating to compensatory wetland mitigation (refer to Chapter Contents, Section 6.1.1). Yet there are some topics and issues for which no scientific information was found. For example, studies were found that examined whether compensation projects had performance standards and whether the performance standards were met. However, no studies were found that explored why performance standards were not met. Other examples of data gaps include studies that:

- Determined the effectiveness of local critical area ordinances at replacing permitted wetland losses
- Examined the effect of construction inspections, monitoring, maintenance, or performance bonding on the success or level of compliance of projects
- Compared the level of success of newly installed versus more established compensation sites

- Looked specifically at the quality and effectiveness of preservation sites
- Focused specifically on wildlife habitat provided by restored, created, or enhanced wetlands in urban settings
- Examined the effects of mitigation decisions on a watershed scale
- Looked at the reproducibility of alkali wetlands

The articles and reports reviewed used a variety of terms to define what they were assessing or evaluating. For the purposes of this synthesis, *effectiveness* is used as a general term referring to how compensatory wetland mitigation was doing overall, including evaluations of success, compliance, and functions and characteristics. These terms will be defined more precisely in subsequent sections.

6.2 Introduction and Background to Wetland Mitigation

6.2.1 Wetland Mitigation Sequence

Mitigation is a series of actions that requires addressing each action, or step, in a particular order. This sequence of steps is used to reduce the severity of negative impacts from activities that potentially affect wetlands. When a change in land use has the potential to adversely affect a wetland, regulatory agencies require the applicant to illustrate how the project has considered the six sequential steps of mitigation. According to the rules implementing the Washington State Environmental Policy Act (Chapter 197.11 WAC), mitigation involves the following:

1. *Avoiding the impact altogether by not taking a certain action or parts of an action;*

2. *Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;*

3. *Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;*

4. *Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;*

5. *Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or*

6. *Monitoring the impact and taking appropriate corrective measures* (WAC 197.11.768).

The authors of Volume 1 provide a brief explanation and examples of the steps in the mitigation sequence in the following paragraphs.

Avoidance is the first step in the mitigation sequence. Avoidance of impacts means that there is no direct loss of wetland area and functions. Avoidance does not, however, eliminate indirect losses of wetland function. For example, consider a hypothetical proposal to develop a 5-acre parcel of land. The parcel contains 2 acres of wetland. The development is designed around the wetland and will therefore avoid any direct loss. Avoidance has occurred. Yet if buildings and parking lots surround the wetland, indirect impacts to wildlife habitat and hydrology may occur in the form of fragmentation and altered hydroperiod.

Minimization of adverse impacts is the second step. It can reduce the extent of wetland impacts when a project is redesigned to lessen wetland alteration. However, it does not eliminate the direct or indirect loss of area and/or functions.

Rectification, the third step, assumes that losses in wetland area and/or function at the impact site are temporary and can be restored. For example, projects such as installing or maintaining an underground pipeline that passes through a wetland typically use rectification as a mitigation measure. In the example of the underground pipeline, vegetation, soil, and water movement may be disturbed and altered. The wetland area and/or functions are temporarily changed or lost. Rectification would entail replacing the soil, restoring the water movement, and restoring the vegetation.

The fourth step of the mitigation sequence is not generally relevant to wetlands, and therefore, no examples of its application are provided.

Compensation for unavoidable adverse impacts, the fifth step, involves restoring, creating, enhancing, or preserving wetland area to replace or make-up for the wetland area and functions that were lost or altered. It is discussed in much greater detail in the following sections.

Monitoring, step 6, is used to address the potential impact to wetlands that may result from a project when specific impacts are not known. If impacts are observed during or after project completion, actions should be taken to address the loss of wetland functions. For example, if a bridge is built over a river fringed by wetlands, the bridge may shade portions of the wetlands. Though no wetlands would be filled during construction, the shading could alter the performance of functions, thereby resulting in impacts to wetlands. To address the potential risk of impacts to wetlands, the project could be monitored to determine the effect of shading on the riverine wetlands. If monitoring reveals that the functions of the riverine wetlands were adversely altered, then compensation might be required.

The scientific literature reviewed for this synthesis did not contain information on the use or effectiveness of any of the mitigation measures defined above, except compensatory mitigation, which is the focus of the remainder of this chapter.

6.2.2 The Emergence of Compensatory Wetland Mitigation

The term *compensatory mitigation* refers to the compensation stage of the mitigation sequence (number 5 in the list of steps described earlier). Compensatory wetland mitigation generally entails performing one or more of the following types of compensation:

- Restoring wetland conditions (and functions) to an area
- Creating new wetland area and functions
- Enhancing functions at an existing wetland
- Preserving an existing high-quality wetland to protect it from future development

The term **compensatory mitigation** refers to the compensation stage of the mitigation sequence (number 5 in the list of steps on the previous page). Because the regulatory requirements and policies tend to focus on the compensation stage, the term "mitigation" is often used to refer to compensation, which is just one part of the overall mitigation sequence.

The use of compensatory mitigation for wetland loss emerged in the 1980s (Roberts 1993, National Research Council 2001). The U.S. Army Corps of Engineers considered the process of mitigation as part of the National Environmental Policy Act of 1969. However, it wasn't until 1980 when the U.S. Environmental Protection Agency (EPA) issued new guidelines for Section 404(b)(1) of the Clean Water Act that mitigating for wetland losses by creating or restoring another wetland as compensation became widely acceptable (National Research Council 2001). Compensatory mitigation was seen as a way to speed up an arduous process of documenting avoidance and minimization efforts, while satisfying concerns about the loss of ecosystems and functions (Roberts 1993). Creating or restoring wetland area to compensate for permitted wetland losses was viewed and publicized as a way to allow development while preventing a net loss of wetland areas.

By the late 1980s, studies of the effectiveness of compensatory mitigation were emerging, with mixed results. The primary indication was that replacing or replicating an existing wetland was difficult, if not impossible (Kusler and Kentula 1990, National Research Council 2001). However, some wetland types and functions could be approximated given the proper conditions (Kusler and Kentula 1990, National Research Council 2001). This chapter focuses on studies published since 1990 that examined the effectiveness of compensatory mitigation.

6.3 Success of Compensatory Mitigation Wetlands

Compensatory mitigation "success" is poorly defined and often contentious (Kentula 2000). The literature refers to legal success, biological success, ecosystem success (Wilson and Mitsch 1996), functional success (Mockler et al. 1998), or some combination of these.

Compliance generally means the same as "legal success." It is evaluated by comparing the actual on-the-ground, or as-built, conditions against what was required in the permit. Studies describing legal success are referred to as compliance in this document, and they are discussed in Section 6.4.

This section will focus on "biological, ecological, or functional success." Therefore, when the term *success* is used in this chapter, it refers exclusively to biological, ecological, or functional success. Success involves an evaluation of the factors that characterize a wetland (e.g., hydroperiod, vegetation, soils), the performance of functions, or both. Best professional judgment and/or one of a variety of function assessment methods have been used by researchers to evaluate success.

The authors of Volume 1 have observed two main problems with evaluating the success of compensatory mitigation projects. First, success is often confused with compliance, and it is assumed that they must go hand in hand. In some cases, compliance and success may be separate considerations. For example, a compensation site may be in compliance with its permit requirements and not be considered a success because it does not replace the functions of the wetland that was lost. On the other hand, a site may fall short of meeting its permit requirements, perhaps because performance standards were unrealistic. The site is therefore not in compliance, yet it may still be determined a success because it compensates for the wetland functions lost.

The second problem involves time; when should a project be evaluated for success? For example, two years after installation a compensation site may not be meeting its performance standards, perhaps because the site has too much bare ground, percent aerial cover of native vegetation is too low, or cover by invasive plant species is too high. The site is, therefore, neither in compliance nor a success. However, looking at the same site five or six years after installation, the site may have experienced rapid growth of native shrubs and trees, native volunteer species may have colonized the bare ground, and maintenance activities may have controlled invasive plants. At this time, the site could be evaluated as a success and considered to be in compliance.

Rather than judging the success or failure of a compensatory wetland mitigation project at a single point in time, Zedler and Callaway (2000) proposed evaluating how a project progresses over time. The authors suggest that a focus on progress would encourage proponents to acknowledge problems occurring at a site and look for solutions. Zedler (2000) proposes that more compensation projects should be viewed as experiments without a specific desired outcome. In lieu of attaining a specific level of performance, projects would be monitored as experiments for at least 25 years. The regulatory framework currently in place, however, does not support this method of evaluation due to the relatively short timeframe allowed for monitoring and assessing the compliance of compensation projects (Breaux and Serefiddin 1999, Zedler 2000).

Refer to Section 6.10.4 for more information on performance standards. Specifically, Section 6.10.4.1 discusses shortcomings of existing performance standards, and Section 6.10.4.3 discusses the need for longer monitoring periods.

6.3.1 Results of Literature Studies

Several studies determined the level of success of compensatory mitigation projects (Table 6-1). Though the data indicated that some projects were successful and some projects were unsuccessful, most compensation projects had an intermediate level of success, meaning they were neither fully successful nor completely unsuccessful.

- 25 to 66% of projects were determined to have an intermediate level of success
- 3 to 43% of projects achieved full success
- 7 to 97% of projects were unsuccessful, though half of the studies found that at least 20% of projects were unsuccessful (Johnson et al. 2002, Michigan Department of Environmental Quality 2000, Mockler et al. 1998, Sudol and Ambrose 2002)

The methods used to evaluate the success of compensatory wetland mitigation projects varied from best professional judgment (Storm and Stellini 1994) to function assessments (Wilson and Mitsch 1996, Balzano et al. 2002), to quantitative measures of vegetation cover and survival (Allen and Feddema 1996), or some combination (Michigan Department of Environmental Quality 2000, Johnson et al. 2002). Though the methods of evaluation differed, most studies considered similar variables such as wetland area, hydrologic conditions, wildlife suitability, vegetation, and soils.

Table 6-1. Results of studies examining the success of compensatory mitigation.

Location of Study	No. of Projects Evaluated	Level of Success	Evaluation Criteria
Washington State (Johnson et al. 2002)	24	13% fully successful 33% moderately successful 33% minimally successful 21% not successful	Wetland acreage, performance standards, goals/objectives, contribution to functions, comparison with wetland lost
Washington/ King County (Mockler et al. 1998)	38	3% successful 97% not successful	Replacing the functions of the wetland lost. Examined vegetation survival and areal coverage, hydrology, soil, wetland and buffer condition assessment, wildlife habitat, and invasive species
Western Washington (Storm and Stellini 1994)	17	23% functioned well ecologically 65% functioned poorly 12% were not completed	Vegetation diversity, non-native plant dominance, structural diversity, wildlife use, adjacent land uses, vegetation cover vs. open water

Location of Study	No. of Projects Evaluated	Level of Success	Evaluation Criteria
Southern California (Allen and Feddema 1996)	75	32 successful 9 mostly successful 10 half successful 5 unsuccessful 8 under construction 5 not initiated 6 did not require mitigation	Project installed according to plan; percent cover of vegetation (dead, living, and invasive)
California/ Orange County (Sudol and Ambrose 2002)	55	16% successful 58% partially successful 26% failures	Qualitative evaluation based on habitat quality (e.g., vegetation density and diversity, invasive species, tree height)
Ohio (Wilson and Mitsch 1996)	5	1 high 2 medium to high 1 medium 1 medium to low	WETII evaluation (Adamus et al. 1989) - hydrology, soils, vegetation, wildlife, water quality
New Jersey (Balzano et al. 2002)	74	Wetland Mitigation Quality Assessment scores were indexed from 0 (low) to 1 (high). The average score was 0.51, and the range was 0.25 to 0.83	Hydrology, soils, vegetation, wildlife suitability, site characteristics, and landscape features
Michigan (Michigan Department of Environmental Quality 2000)	69	22% successful overall 78% unsuccessful overall	Project's legal rating (permit compliance) and biological rating (wetland acreage). Does not include enhancement

6.3.2 Summary of Key Points

- Success is defined as meeting biological or ecological criteria, which may include an assessment of functions.
- The majority of compensatory wetland mitigation projects were found to be neither fully successful nor completely unsuccessful, meaning that most projects had an intermediate level of success, relative to biological or ecological functions.
- Though the methods used to evaluate project success differed, the studies considered similar criteria, such as vegetation, soils, and hydrologic conditions.

6.4 Compliance with Permit Requirements

Regulatory agencies typically require wetland compensation for authorized, unavoidable wetland impacts. A wetland mitigation plan is reviewed and approved as part of the permit approval process. It outlines how wetland impacts will be compensated for. The mitigation plan identifies how the project will be designed. It addresses wetland acreage, hydroperiod, vegetation, goals, objectives, performance standards, monitoring, maintenance, contingency actions, and long-term protection. These are the parameters by which regulators often measure compliance.

According to the Merriam-Webster dictionary, compliance means "conformity in fulfilling official requirements." Regarding compensatory wetland mitigation, compliance means that a project has satisfied or is satisfying the legal requirements and obligations identified in a permit.

Most studies that examined compliance investigated how well a compensatory wetland mitigation project complied overall (i.e., with all applicable permit requirements). Several of these studies only reported the results of the overall evaluations. Other studies evaluated how well projects complied with individual requirements, such as:

- Installation – whether the project was installed
- Installation according to plan – whether the project was constructed according to the approved mitigation plan and design
- Wetland area establishment – whether the project obtained the acreage of wetland that was required
- Performance standards/goals/objectives attainment – whether the project performed as anticipated
- Monitoring – whether the project was monitored as required (or was required to be monitored)
- Maintenance – whether project maintenance was performed (or required)

Studies also reviewed regulatory follow-up - whether any regulatory agencies made an attempt to track an individual project after the permit was issued.

Each of these types of evaluations is discussed in subsequent sections.

6.4.1 Compliance Overall

Several studies attempted to determine how well a project complied with several or all of its permit requirements. Because permit requirements vary by state and over time, not all compliance evaluations considered the same criteria or requirements. Where specified, the requirements evaluated by a given study are identified in Table 6-2.

Twelve studies evaluated overall compliance with regulatory requirements for compensatory wetland mitigation projects (Table 6-2). In Washington State four studies that evaluated compliance were conducted in the past decade (Storm and Stellini 1994, Mockler et al. 1998, Johnson et al. 2000, Johnson et al. 2002), and two studies were conducted in Oregon (Gwin and Kentula 1990, Shaich and Franklin 1995).

The studies in Washington found that 29% of compensation projects complied with their regulatory requirements. In Oregon, studies revealed that compliance of projects ranged from zero to 36%.

Studies from other states demonstrated more variability in levels of compliance. Results ranged from less than 20% to about 80% of projects in compliance (Holland and Bossert 1994, De Weese 1998, Morgan and Roberts 1999, Michigan Department of Environmental Quality 2000, Brown and Veneman 2001, Balzano et al. 2002, Sudol and Ambrose 2002).

More recent studies (published in 2000 or after) did not report higher levels of compliance than studies conducted in the 1990s. One might therefore assume that compensation projects have not improved over the years. However, it is important to realize that as knowledge of wetland science and compensatory mitigation has improved and evolved, permit requirements have likewise evolved (Kentula 2000). More recent studies may have been evaluating compensation projects that were being held to a higher standard than projects permitted and evaluated in the 1990s (Sudol and Ambrose 2002). However, a study by Cole and Shafer (2002) in Pennsylvania observed that permit requirements had not changed noticeably over the 14-year range of permits they evaluated (1986-1999).

Table 6-2. Level of overall compliance of compensation projects.

Location of Study	No. of Projects Evaluated	% of Projects in Compliance with all Requirements	Evaluation Criteria
Washington (Johnson et al. 2000)	45	29%	• Project installed • Installed according to plan • Meet performance standards
Washington (Johnson et al. 2002)	24	29%	• Establish required wetland acreage • Meet performance standards • Meet goals/objectives
Washington/western (Storm and Stellini 1994) [a]	17	18%	• Installation of both development and compensatory mitigation projects as required

Location of Study	No. of Projects Evaluated	% of Projects in Compliance with all Requirements	Evaluation Criteria
Washington/King County (Mockler et al. 1998)[b]	29 (38)	21% (16%)	• Meet performance standards - vegetation survival, areal cover, invasive species • Design - hydrology, slopes • Installation - soil • Maintenance - mowing, weeding
Oregon/Portland metro area (Shaich and Franklin 1995) [c]	72	36%	• Project installed • Upland buffer area/vegetation requirements • Requirements for timing of project construction • Wetland vegetation requirements • Hydrology requirements • Requirements for water control structures • Fencing requirements
Oregon/Portland metro area (Gwin and Kentula 1990)	11	0%	• Construction plans match permit specs • As-built matches permit specs: wetland area/shape • Actual slopes match planned slopes • Vegetation established as planned
California/ Orange County (Sudol and Ambrose 2002) [d]	57	53%	• Project installed • Meet performance standards/ permit conditions
California/ vernal pools (De Weese 1998)	25	83%	• Attaining performance standards required by Corps
Massachusetts (Brown and Veneman 2001) [e]	109 (7)	43% (100%)	• Project installed • Compensation project of required size • Water inputs sufficient for wetland conditions • At least 75% cover wetland plants (FAC or wetter)
Tennessee (Morgan and Roberts 1999)	50	12%	• Establish required acreage of wetland • Meet performance standards

Location of Study	No. of Projects Evaluated	% of Projects in Compliance with all Requirements	Evaluation Criteria
Michigan (Michigan Department of Environmental Quality 2000) [f]	74	18%	• Mitigation acreage requirement • Implementation of approved mitigation plan • Conservation easement • Submittal of as-built plans • Monitoring • Placement of elevated wildlife structures • Construction schedule with specified completion date • Prohibited actions • Corrective measures identified • Financial assurances
Louisiana (Holland and Bossert 1994)	9	78%	• Meet Corps of Engineers permit conditions
New Jersey (Balzano et al. 2002)[g]	88	48% weighted average	• Grading (56% concurrence) • Hydrology (47% concurrence) • Soil (51% concurrence) • Vegetation cover (39% concurrence) • Vegetation survival (28% concurrence) • Design (56% concurrence)

[a] Compliance not determined for 53% of projects due to lack of information.

[b] 38 projects examined; 9 not completed. Compliance information for 38 projects is in parentheses.

[c] Not all projects had requirements for all criteria (e.g., only 8% had a requirement for fencing).

[d] Calculated from data provided.

[e] 5 projects did not result in wetland impact and were subtracted from the project total. Results were recalculated from the data provided. Parentheses = data for variance projects (received more oversight).

[f] Permit conditions from the criteria list were considered if specified in permit.

[g] Evaluated concurrence with applicable criteria. Percent = average concurrence score for 88 projects. Average concurrence score for each criterion provided in parentheses.

6.4.2 Project Installation

A number of studies investigated whether mitigation projects had even been constructed or installed. In these studies, mitigation projects were either randomly selected from a database or a complete inventory of all projects permitted during a specific timeframe was conducted. Four studies were conducted in Washington. Studies in seven other states, including Oregon, also investigated whether mitigation projects had been installed.

Results indicated that most projects were installed (Table 6-3). The four studies from Washington found that 74 to 93% of compensatory mitigation projects had been installed. Studies from most of the other states showed similar results (64 to 99%). However, studies performed in Florida and Tennessee revealed that less than half of the compensatory wetland mitigation projects had been installed (Erwin 1991, Morgan and Roberts 1999).

Due to the relatively high percentage of projects that were installed, one could assume that the low levels of overall compliance result from inadequate design, installation, maintenance, follow-up, or some combination.

Table 6-3. Percent of compensatory mitigation projects that were installed.

Location of Study	No. of Projects Evaluated	Percent of Projects Installed
Washington (Johnson et al. 2000)	45	93%
Washington/ King County (Mockler et al. 1998)	38	76%
Washington/ western (Storm and Stellini 1994)	17	88%[a]
Washington (Kunz et al. 1988)	35	74%
Oregon/ Portland metro area (Shaich and Franklin 1995)	90	99%
California/ southern (Allen and Feddema 1996)	75	93%
California/ Orange County (Sudol and Ambrose 2002)	57	96%[a]
Michigan (Michigan Department of Environmental Quality 2000)	159	85%
Indiana (Robb 2002)	333	64%
Massachusetts (Brown and Veneman 2001)[b]	109	77%
Tennessee (Morgan and Roberts 1999)	100	47%
Florida (Erwin 1991)	NA	~40% [c]

[a] Calculated from data provided.

[b] Five projects did not result in wetland impact and were subtracted from the project total. Results were recalculated from the data provided.

[c] "Out of more than 100 permitted projects requiring wetland mitigation only 40 had undertaken any mitigation activity."

6.4.3 Installation According to Plan

Another aspect of determining mitigation compliance is evaluating whether a mitigation project has been installed according to its approved plan. When compensatory wetland mitigation is necessary to offset proposed wetland losses, regulatory staff generally

require a wetland mitigation plan. The mitigation plan should provide specific information about project construction, including detailed design drawings. Approval of a permit for wetland loss is often contingent upon approval or acceptance of the wetland mitigation plan.

It is commonly assumed that a project will be built exactly as it is designed. However, many factors during construction and installation can influence what is actually built on the ground. Therefore, permit requirements often require (or recommend) submittal of an as-built plan or report that documents the final installed conditions of a site after construction is complete. When available, as-built drawings are used to document the baseline conditions for monitoring of a site.

Three studies evaluated whether compensation projects were installed according to approved plans (Table 6-4). Results from both Washington and New Jersey indicate that more than half of the compensatory mitigation projects were installed according to requirements (Johnson et al. 2000, Balzano et al. 2002). Johnson et al. (2000) found that 55% of the projects were installed to plan. For those that submitted an as-built plan or report, 88% of the projects were installed according to plan. A study in Oregon, however, determined that none of the projects were implemented according to plan (Gwin and Kentula 1990). All three studies mentioned grading and vegetation as the elements of the plan that were not implemented according to the approved plan.

It can be hypothesized that the divergent results noted in the studies above might be the result of an increase of knowledge and expertise over time. For instance, the projects reviewed by Gwin and Kentula (1990) were designed, permitted, and constructed in the early 1980s. Since that time much has been learned by those who design, construct, and regulate compensatory mitigation projects. It is possible that improved designs, experience and skill in implementing the designs, and improved regulatory follow-up have resulted in a higher percentage of projects being installed according to plan by the mid- to late 1990s. The current scientific literature does not address this possibility.

Table 6-4. Percent of compensatory mitigation projects installed according to plan.

Location of Study and Reference No.	No. of Projects Evaluated	Percent Installed to Plan	Aspects Not Installed to Plan
Washington (Johnson et al. 2000)	42	55%	Mainly vegetation, also grading, misc. plan elements (e.g., fences, signs)
Oregon/ Portland metro area (Gwin and Kentula 1990)	11	0%	Size, shape, slopes, and vegetation
New Jersey (Balzano et al. 2002)	88	56%	Incorrect elevations, sizes, and/or shapes

6.4.4 Establishment of Wetland Acreage

Compensatory wetland mitigation projects are intended to compensate for the loss of wetland area and functions. Hence, permits and mitigation plans often identify a specific acreage of compensation required to offset those losses. Establishing the required acreage is therefore an important criterion of regulatory compliance. (Functions provided by compensatory mitigation projects are discussed in Section 6.8.)

Thirteen studies examined compensatory wetland mitigation sites to determine if the acreage of wetlands required by the permits had been established (Table 6-5). The studies presented the data from these investigations in two ways.

- **The percentage of projects establishing the required wetland acreage.** Researchers determined if each project met its required wetland acreage, then reported how many projects actually met the wetland acreage requirement as a percentage of the total number of projects considered. A few studies mentioned a specific threshold, such that a project had to be smaller than required by a specific acreage or percentage in order to fail to meet its wetland area (Brown and Veneman 2001, Johnson et al. 2002, Morgan and Roberts 2003).
- **The percentage of compensatory wetland acreage established.** Researchers determined the total acreage of compensatory mitigation that was verified as wetland for all the projects considered. The study then reported the total acreage of wetland compensation that was established as a percentage of the total acreage that was required for all the projects considered.

Over half of projects achieved the required wetland area in Washington and Oregon (Shaich and Franklin 1995, Johnson et al. 2002). In fact, the majority of studies determined that about half of the compensation projects established the required acreage of wetland. However, three studies found that less than 30% of projects met their acreage requirements (McKinstry and Anderson 1994, Balzano et al. 2002, Morgan and Roberts 2003). In New Jersey only 7% of projects achieved the wetland acreage requirements (Balzano et al. 2002).

For the total acreage of wetland achieved versus required, a study from Washington determined that 84% of the required acreage of compensatory wetlands was established (Johnson et al. 2002), while a study in Oregon found about 70% of the required wetland acreage was established (Gwin and Kentula 1990). Results from other states indicated between 44 and 74% of the required wetland acreage had been established.

Why is there a discrepancy between the percent of projects achieving acreage and the percentage of total acreage established? New Jersey, for example, found that only 7% of compensation projects achieved the required wetland acreage, yet 63% of the total required wetland acreage was established. It can be hypothesized that this is due to small, individual projects that establish a portion of the required acreage but fall short of the total amount required. For example, a site that was required to provide 1 acre of mitigation but only provided 0.8 acre would not meet the acreage criteria. However, the 0.2-acre difference may represent a very small fraction of the total acreage of compensation evaluated for a large study, thereby affecting the total acreage percentage very little.

Table 6-5. Establishment of required wetland acreage.

Location of Study	No. of Projects Evaluated	% of Projects Achieving Required Wetland Area	% of Required Wetland Area that Was Established
Washington (Johnson et al. 2002)[a]	24	58%	84%
Oregon/Portland metro area (Shaich and Franklin 1995)[b]	72	53% [e]	NA
Oregon/Portland metro area (Gwin and Kentula 1990)	11	NA	71%
California/southern (Allen and Feddema 1996)[c]	75	NA	69%
California/Orange County (Sudol and Ambrose 2002)	55	52%	NA
Wyoming (McKinstry and Anderson 1994)	64	14% [e]	NA
New Jersey (Balzano et al. 2002)	85	7%	63%
Tennessee (Morgan and Roberts 1999)	50	28%	68%
Ohio (Wilson and Mitsch 1996)	5	40%	66%
Indiana (Robb 2002)	31	NA	44%
Michigan (Michigan Department of Environmental Quality 2000)	159	50%	NA
Massachusetts (Brown and Veneman 2001)[d]	109	46%	NA
Florida (Erwin 1991)	NA	NA	74%

NA= information not available

[a] West of the Cascades, projects established 92% of the required acreage; east side projects established 25% of the required acreage.

[b] Compensation wetlands were 16 acres (6.5 ha) short of the 69 acres required.

[c] Projects > 8.5 acres (3.4 ha) resulted in a net gain of 17 acres (6.9 ha) of wetland area, while projects < 8.5 acres resulted in a net loss of almost 25 acres (10 ha).

[d] Five projects did not result in wetland impact and were subtracted from the project total. Results were recalculated from the data provided.

[e] Calculated from data provided.

6.4.5 Attainment of Goals, Objectives, and Performance Standards

Another critical component of compliance for a compensatory wetland mitigation project is determining whether the project has met its goals, objectives, and/or performance standards. Goals, objectives, and performance standards are generally included as part of an approved wetland mitigation plan. Goals and objectives are intended to provide a blueprint for what the project proposes to accomplish in terms of anticipated wetland type, specific habitat, functions, and/or values. The performance standards are intended to provide measurable criteria to determine if the project has accomplished its goals and objectives (Hruby et al. 1994, Ossinger 1999).

Two separate factors were investigated in the studies reviewed:

- Whether a project had goals, objectives, and performance standards
- Whether projects were meeting their goals, objectives, and performance standards

Data in Table 6-6 indicate that at least three-quarters of projects had goals, objectives, or both (Erwin 1991, Storm and Stellini 1994, Johnson et al. 2002). However, fewer projects met the goals/objectives (10 to 38%) according to the two studies that reported this information (Erwin 1991, Johnson et al. 2002).

In general, performance standards were specified less frequently than goals and objectives, though at least half of the projects had them (Erwin 1991, Storm and Stellini 1994, Mockler et al. 1998, Johnson et al. 2000, Cole and Shafer 2002). Two studies conducted in Washington determined that 21% of projects met their performance standards (Mockler et al. 1998, Johnson et al. 2002), while a third study from Washington found that 35% of projects met performance standards (Johnson et al. 2000).

A review of the articles suggests that the percent of projects with performance standards increased with more recent projects. For example, Storm and Stellini (1994) and Cole and Shafer (2002) evaluated compensation projects that were permitted in the mid to late 1980s or early 1990s. Performance standards may not have been as rigorously required (Cole and Shafer 2002) or they may not have been specifically identified as performance standards. For example, of 10 projects that did not contain performance standards, 30% were permitted in the late 1980s and 80% were permitted prior to 1995, while 20% were permitted in the late 1990s (Cole and Shafer 2002).

Data suggest (Table 6-6) that the more recent projects did not appear any more likely to meet performance standards than earlier projects (Mockler et al. 1998, Johnson et al. 2000, Cole and Shafer 2002, Johnson et al. 2002). Some believe that performance standards have become more rigorous overtime, and more recent projects have been held to a higher standard. Cole and Shafer (2002), however, did not find that performance standards noticeably changed in terms of content from projects permitted in the late 1980s to the late 1990s. Therefore, one can conclude that the year of permitting does not appear to be a factor in whether projects met their performance standards.

More information on performance standards is provided in Section 6.10.4.

Table 6-6. Attainment of goals, objectives, and performance standards.

Location of Study	No. of Projects Evaluated	% of Projects w/ Goals or Objectives	% of Projects w/ Performance Standards	% of Projects Meeting Goals or Objectives	% of Projects Meeting Performance Standards
Washington (Johnson et al. 2000)	34	NA	87%[a]	NA	35%
Washington (Johnson et al. 2002)	24	92%	NA	38%	21%
Washington/ King County (Mockler et al. 1998)	29	NA	100%	NA	21%
Washington/ western (Storm and Stellini 1994)	17	76%	53%	NA	NA
Pennsylvania (Cole and Shafer 2002)	23	NA	57%	NA	62%
Florida (Erwin 1991)	40	85%	60%	10%	NA

NA = information not available.

[a] Calculated from data provided.

6.4.6 Monitoring

To determine if a compensatory wetland mitigation project is in compliance, it is necessary to monitor the project over time. Monitoring requirements are typically identified in the wetland mitigation plan. The duration, frequency, and methods of monitoring should depend on the goals, objectives, and performance standards for the project.

Monitoring is the process through which data about site conditions is gathered. Monitoring data is used to determine whether a project is achieving its performance standards, and therefore its goals and objectives, within a predicted timeframe. Monitoring also provides critical information about whether a site requires maintenance or contingency actions. Monitoring is therefore essential for a project to achieve compliance.

The studies investigating whether compensatory wetland mitigation projects were required to be monitored and whether monitoring actually occurred are summarized in Table 6-7. In general, studies conducted more recently found that monitoring was required for a greater percentage of projects. Data from four studies indicate monitoring

was required for at least three-fourths of projects (Erwin 1991, Morgan and Roberts 1999, Johnson et al. 2000, Michigan Department of Environmental Quality 2000). The remaining two studies, which examined compensation projects permitted in the late 1980s and early 1990s, found that monitoring was required for a third to half of projects (Holland and Kentula 1992, Storm and Stellini 1994).

Less than half of the projects had monitoring data. However, the studies did not determine whether the monitoring was not conducted or whether there was simply no record of the monitoring reports on file with the regulatory agencies. Since over half of the studies mentioned difficulty finding complete project information from the agency files (Storm and Stellini 1994, Morgan and Roberts 1999, Johnson et al. 2000, Cole and Shaffer 2002), it is possible to conclude that monitoring reports may have been submitted to the appropriate agencies but the reports were lost due to a lack of follow-up and poor file maintenance. If monitoring is not conducted there is no means to trigger maintenance or contingency actions. The consequence of inadequate follow-up by regulatory agencies is discussed in Section 6.4.8.

Table 6-7. Percent of projects requiring monitoring and those actually monitored.

Location of Study	% of Projects Requiring Monitoring	% of Projects Monitored
Washington (Johnson et al. 2000)	71%	33%
Washington/ western (Storm and Stellini 1994)	53%	18%
California (Holland and Kentula 1992)	32%	NA
Michigan (Michigan Department of Environmental Quality 2000)	87%	35%
Pennsylvania (Cole and Shafer 2002)	NA	<10%
Tennessee (Morgan and Roberts 1999)	89%	43%
Florida (Erwin 1991)	98%	38%[a] (62%)[b]

[a] Represents projects that were adequately monitored.

[b] Calculated from Erwin (1991) indicating all projects that received some level of monitoring.

6.4.7 Maintenance

Compensatory wetland mitigation sites require maintenance to help ensure that goals and performance standards will be achieved. Maintenance includes implementing corrective actions to rectify problems, such as an insufficient water supply or inappropriate water regime, invasive species infestation (e.g., reed canarygrass, bull frogs), trash, vandalism, or anything else that may result in non-compliance with permit requirements. Johnson et al. (2002) observed that a lack of maintenance was one of the main reasons for poor success of mitigation projects.

Results revealed that permitting agencies did not require all compensation projects to provide maintenance. Studies discovered that permits required site maintenance for 41 to 78% of projects (Erwin 1991, Storm and Stellini 1994, Michigan Department of Environmental Quality 2000). However, even fewer projects (20 to 60%) complied with their maintenance requirements (Erwin 1991, Michigan Department of Environmental Quality 2000).

The research did not investigate the reasons for low compliance with maintenance provisions. One may assume that it is linked to inadequate monitoring, lack of regulatory follow-up, or a lack of cooperation from the owner of the site.

6.4.8 Regulatory Follow-Up

Once compensatory wetland mitigation is required, it is the responsibility of the regulatory agencies to track the project over time and determine if it complies with permit requirements. A regulatory agency follows up on compensatory mitigation projects by:

- Ensuring that the compensation project is constructed as designed and approved, or that the applicant documents, through "as-built" reports why approved plans were modified during installation
- Ensuring that required monitoring reports are submitted on schedule
- Performing site visits to confirm monitoring results and attainment of performance standards
- Ensuring maintenance actions are undertaken on schedule
- Ensuring that appropriate contingency measures are enacted
- Ensuring the compensation site is protected over the long-term (i.e. through a legal protection mechanism such as a conservation easement)

Studies in Washington and Oregon indicated that about half of compensatory wetland mitigation projects received some regulatory follow-up in the form of site visits, phone calls, or letters (Kentula et al. 1992, Johnson et al. 2002). In Michigan only about a quarter of projects received any kind of follow-up after the permit was issued (Michigan Department of Environmental Quality 2000).

A few studies also examined the effect of regulatory follow-up on project compliance, success, or both. Robb (2002) alluded to the fact that the high number of non-compliant compensation projects resulted from a lack of follow-up and enforcement actions. In Washington a study noted that all of the projects lacking regulatory follow-up were either minimally or not successful, while two-thirds of the projects receiving some kind of follow-up were either fully or moderately successful (Johnson et al. 2002).

One team of researchers observed:

> *The most ecologically successful sites were generally those that had received follow-up work in the form of maintenance, replanting, or improvements to grading or water control structures in accordance with recommendations made by NJDEP [New Jersey Department of Environmental Protection] and other regulatory agencies after initial compliance inspections revealed problems* (Balzano et al. 2002).

Studies indicated that regulatory follow-up can help to ensure the success of compensation sites (Johnson et al. 2002, Balzano et al. 2002). It is assumed that applicants will be more likely to abide by permit requirements and submit monitoring reports if regulatory agencies are actively following up on projects. Since monitoring reports are meant to identify what is working and where there are shortfalls, maintenance actions can be initiated or contingency measures can be triggered to correct the shortfalls and problems as soon as possible. Therefore, one can conclude that agency follow-up improves the compliance and success of compensation projects.

6.4.9 Summary of Key Points

- Most compensatory wetland mitigation projects were installed. However, compliance levels overall were generally low.
- Two out of three studies found that more than half of projects were installed according to plan. Projects not installed to plan most often did not comply with grading and vegetation requirements.
- The majority of studies found that about 50% of projects achieved their required wetland acreage.
- Even if individual projects did not fully achieve their required acreage, most studies found that at least 66% of the overall required acreage of compensation had been established.

- The requirement for monitoring as a regulatory condition seems to be increasing in more recent studies (30 to 50% in the early 1980s; 75% in more recent studies).
- Over 50% of the studies noted that it was difficult to find complete project files, thereby making it difficult to document if monitoring was occurring or being tracked by regulatory staff.
- The research found that 41 to 78% of projects required maintenance; however, only 20 to 60% of projects complied with maintenance requirements.
- Studies in Washington and Oregon found that approximately half of projects received some regulatory follow-up.
- Two studies suggested that follow-up had a positive influence on the level of compliance and success for compensatory wetland mitigation projects.

How is compensatory wetland mitigation doing in Washington?*

Five studies of compensatory wetland mitigation have focused on projects in Washington State during the past decade[1]. The studies examined success, ecological functioning, permit compliance, and achievement of required wetland area, though not all studies looked at the same factors in the same way. The results suggest that compensatory mitigation in Washington is neither fully successful nor completely unsuccessful.

Most studies found that less than half of wetland compensation projects are fully effective. In the most recent and comprehensive evaluation of compensation projects, Johnson et al. (2002) found that 13% of compensatory wetland mitigation projects were fully successful and 33% were moderately successful. In western Washington, Storm and Stellini (1994) determined that 24% of compensation projects functioned well. In King County, Mockler et al. (1998) indicated that 3% of projects replaced lost wetland functions.

In terms of compliance, Johnson et al. (2000) determined that 29% of projects were in full compliance, while for King County Mockler et al. (1998) found that 21% of projects were meeting their required performance standards.

Kentula et al. (1992) examined Section 404 permit decisions for Washington from 1980 through 1986. Data indicated that permit decisions resulted in a wetland loss of 40 acres (16 ha). Johnson et al. (2002) determined that 24 acres (10 ha) of wetland were lost due to projects that did not successfully establish wetland area and the frequent use of existing wetlands for enhancement.

[1]All studies, except Kentula et al. (1992), sampled a sub-set of the applicable mitigation projects.
*Results have been simplified for this summary. Please refer to Sections 6.3 and 6.4 for complete information.

6.5 Types of Compensatory Mitigation

When discussing compensatory mitigation it is important to have a common understanding of the types of compensation that can be used to mitigate for wetland losses. This is difficult because various agencies and organizations often define types of compensation differently (Morgan and Roberts 1999). An added difficulty is that each type of compensation represents a range of activities on a continuum rather than a distinct procedure.

This section describes several types of compensatory mitigation:

- Restoration
- Creation
- Enhancement/exchange
- Preservation
- Mixed compensatory mitigation
- Wetland mitigation banking
- In-lieu fee programs

Definitions given to each of the mitigation types are discussed below, followed by a description of how frequently each type is used and its relative effectiveness.

6.5.1 Restoration

Of the types of compensation, restoration has the widest variety of definitions. The most general is the reestablishment of wetland conditions (i.e., area, functions, and values) at a location where they formerly existed but no longer exist (Johnson et al. 2000, Jones and Boyd 2000). Activities associated with this definition could include removing fill material, plugging ditches, or breaking drain tiles. Other definitions involve returning a site to some historic condition. The following are examples of other definitions.

- Re-establishing historic hydrologic processes (National Research Council 2001) or hydrogeomorphic (HGM) classes (Johnson et al. 2000). Activities associated with this definition typically involve removing a levee or breaching a dike to reconnect an area to the floodplain or to tidal influence.
- "Return of an ecosystem to a close approximation of its condition prior to disturbance (NRC 1992). Restoration requires knowledge of the wetland type prior to disturbance and has the goal of returning the wetland to that type" (Gwin et al. 1999).
- Returning an altered wetland "to a previous, although altered condition (Lewis 1990)" (Gwin et al. 1999).
- "The process, or the result of the process of returning an area or ecosystem to some specific former condition" (Munro 1991).

Perhaps as a result of the numerous definitions, confusion about what constitutes restoration versus other types of compensatory mitigation can occur in regulatory permits and mitigation plans. The last three definitions in the list above could just as easily describe enhancement activities. For example, planting trees in a degraded wet pasture, often considered enhancement, could be an attempt to return an ecosystem (the pasture) to an approximation of its prior condition (forested wetland).

In their study of compensatory wetland mitigation projects in Tennessee, Morgan and Roberts (1999) mentioned that several projects were classified as restoration. Based on the activities specified, however, enhancement would have been a more appropriate term. Similar confusion occurred between restoration and creation. As a result of this confusion, the effectiveness of restoration, as a type of compensation, is difficult to assess.

6.5.1.1 Use of Restoration

For compensatory mitigation, restoration is often cited as the highest priority or most recommended type of compensation "because it offers the highest probability of success (Kruczynski 1990, Kusler and Kentula 1990, USDA-SCS 1992)" (Morgan and Roberts 1999). In addition, the National Academy of Sciences recommended restoration over creation. "Restoration of wetlands has been observed to be more feasible and sustainable than creation of wetlands" (National Research Council 2001).

This emphasis on restoration is not reflected in the number of freshwater, compensatory restoration projects implemented on the ground. Restoration tends to be one of the least utilized types of compensation (Jones and Boyd 2000). In fact, two studies mentioned that none of the projects involved restoration (Shaich and Franklin 1995, Gwin et al. 1999). Most of the studies that specifically mentioned the number or percentage of projects using a particular type of compensation found that 20 to 30% of projects involved some restoration of wetland acreage (Morgan and Roberts 1999, Johnson et al. 2000, Johnson et al. 2002). Projects employing restoration as the sole form of compensation are even fewer (Shaich and Franklin 1995, Johnson et al. 2000, Johnson et al. 2002).

In a departure from the other studies, Holland and Kentula (1992) found that 65% of permits required restoration. However, 42% of the compensatory wetlands they looked at were estuarine or marine. If estuarine and marine projects are subtracted, the percentage of restored, freshwater wetlands is similar to the other studies.

Morgan and Roberts (1999) suggest that the lack of compensatory wetland restoration projects is due to the fact that "most suitable restoration sites are 'prior converted' farmland and because sizable acreages are being restored under the Wetland Reserve Program . . . sites available for compensatory mitigation may be limited." In Washington, however, the authors of Volume 1 believe that restoration is used infrequently because most wetland impacts are relatively small (less than 2 acres [0.8 ha]), and it is very difficult to find restoration opportunities for small sites that are not cost prohibitive. Restoration is typically most feasible and cost effective if done over a

large area. In addition, some regulatory requirements, particularly for local governments, direct applicants to provide compensation on-site, which often precludes an opportunity for restoration.

6.5.1.2 Effectiveness of Restoration

While it is widely stated that restoration is the most effective approach, the data to substantiate this claim are sparse. Studies indicate that there is a limited use of restoration for compensatory mitigation in freshwater wetlands. Thus, there is a substantial lack of data with which to evaluate its effectiveness as a type of compensation.

In Washington Johnson et al. (2000) found that one of three restoration projects was in full compliance. Johnson et al. (2002) found that one of two restoration projects established the required acreage of wetland and was fully successful. In Florida, Erwin (1991) found that restoration successfully established 88 acres (36 ha) more wetland area than was required. The limited existing data appear to suggest that when wetlands are restored, they are relatively effective at compensating for permitted losses.

6.5.2 Creation

It is generally agreed that creation involves establishing wetland conditions (area, functions, and values) in a location where wetland conditions previously did not exist (Johnson et al. 2000) or "that was not a wetland in the recent past (within the last 100-200 years) (Kruczynski 1990, Lewis 1990)" (Gwin et al. 1999). "Typically, a wetland is created by excavation of upland soils to elevations that will support the growth of wetland species through the establishment of an appropriate hydroperiod (Kruczynski 1990, Lewis 1990)" (Gwin et al. 1999).

Gwin et al. (1999) made a distinction between creating a wetland that is isolated from existing wetlands (creation) and creating a wetland that is immediately adjacent to an existing wetland, thereby enlarging the existing wetland (expansion). No other studies made this distinction.

The U.S. Army Corps of Engineers' Regulatory Guidance Letter -02-2 uses the term *establishment* rather than the previously accepted term *creation*. Federal agencies, as well as the Department of Ecology, have started using the term *establishment*. However, this document synthesizes studies and documents written before this regulatory guidance letter was produced. Therefore, this document uses the term *creation* rather than *establishment*.

6.5.2.1 Use of Creation

Seven studies discussed how frequently creation was required as compensation. All noted that at least 30% and in some cases more than half of compensatory wetland projects were created or involved some creation (Holland and Kentula 1992, Shaich and Franklin 1995, Gwin et al. 1999, Morgan and Roberts 1999, Johnson et al. 2000, Jones and Boyd 2000, Johnson et al. 2002).

6.5.2.2 Effectiveness of Creation

In Washington, Johnson et al. (2000) found that 10% of created wetlands were in compliance. Seventy percent of creation projects established the required acreage of wetland, and 60% of created projects were either fully or moderately successful (Johnson et al. 2002).

In other states, however, created wetlands did not perform as well. Creation projects failed to establish 527 acres (213 ha) of required wetland area in Florida (Erwin 1991). In Tennessee, Morgan and Roberts (1999) found, "Most creation projects…were only partially successful because they failed to develop wetland characteristics throughout… Problems with created wetlands were numerous and involved both site design and vegetation establishment."

The results on the effectiveness of creation are mixed. Though projects in Washington have poor compliance, other aspects of effectiveness are relatively good. However, other states found poor effectiveness for created wetlands. The data therefore suggest that further study is warranted.

6.5.3 Enhancement/Exchange

Enhancement involves modifying a specific structural feature of an existing degraded wetland to improve one or more functions or values based on management objectives (Gwin et al. 1999, Johnson et al. 2000). Enhancement typically consists of:

- Planting vegetation
- Controlling non-native, invasive species
- Modifying site elevations or the proportion of open water to influence hydroperiods

Gwin et al. (1999) defined exchange as:

> *Enhancement taken to the extreme (Kruczynski 1990), with most or all of the wetland converted from one type to a different type. For example, resource managers may intend to enhance habitat value for waterfowl by excavating an area of open water within an existing emergent marsh. However, if the open water area replaces the emergent wetland or a large proportion of it, wetland types have been exchanged.*

Because enhancement involves altering an existing wetland to compensate for the loss of other wetlands, the scientific literature mentions three main concerns regarding its use.

- Enhancement fails to replace lost wetland area (Shaich and Franklin 1995, Morgan and Roberts 1999). For this reason, the state of Michigan does not allow the use of enhancement for compensatory mitigation (Michigan Department of Environmental Quality 2000).

- Enhancement may fail to replace wetland functions, since "a positive change in one wetland function may negatively affect other wetland functions (Kruczynski 1990, Lewis 1990)" (Gwin et al. 1999). In addition, "there commonly is disagreement about whether or not the practice implemented actually enhances conditions at a site" (Morgan and Roberts 1999).

- Enhancement may result in a conversion of HGM and/or Cowardin classes, typically producing a compensation wetland without natural analogues (Shaich and Franklin 1995, Gwin et al. 1999, Johnson et al. 2002). When enhancement is used for compensation in such cases:

  A single Section 404 decision results in the destruction of the wetland for which the permit was issued, along with the conversion of a second wetland to a different, often atypical, HGM type. This 'double whammy' means that exchange [enhancement] *explicitly does not fulfill the objective of 'no-net-loss' of wetlands but, instead, ensures loss of wetland area, additional wetland disturbance, and changes in overall ecological function* (Gwin et al. 1999).

6.5.3.1 Use of Enhancement

Studies indicated that more than one-third of compensation projects used enhancement of existing wetlands as compensatory mitigation (Shaich and Franklin 1995, Gwin et al. 1999, Morgan and Roberts 1999, Johnson et al. 2000, Johnson et al. 2002).

6.5.3.2 Effectiveness of Enhancement

The effectiveness of enhanced compensation wetlands was evaluated by only two studies, both conducted in Washington. The researchers found less than 13% of enhanced wetlands were in complete compliance, while 56% of enhanced wetland projects met the requirement for acreage of compensation. (For projects that proposed to enhance existing wetlands, establishing the required acreage of wetland compensation entailed implementing the proposed actions to enhance the mitigation site.) Furthermore, none of the enhanced compensation wetlands were fully successful, while 89% were minimally or not successful (Johnson et al. 2000, 2002). For more information refer to Section 6.3.1 and Table 6-1.

Johnson et al. (2002) suggested two main reasons for the low level of success among enhancement projects.

- The enhancement project did not achieve the proposed vegetative structure, diversity, or both (the planted trees and shrubs did not survive or did not grow). Thus the project did not establish the required acreage of compensation, did not meet performance standards, or both.

- The enhancement project achieved the proposed structure/diversity, but despite this, it did not adequately compensate for the wetlands lost because the contribution of the enhancement to the performance of wetland functions was low.

The enhanced wetlands evaluated by Johnson et al. (2002) were all in the ground for less than eight years. Their study confirmed that for the projects they evaluated, eight years was not sufficient time to achieve the structural and species complexity of shrub and forested habitats. When structurally complex habitats are the goal of a compensatory mitigation design, studies continue to show that longer timeframes are necessary to begin to provide some of the attributes of those functions (National Research Council 2001). If structurally complex habitats are altered, it is possible to conclude that the delay in replicating those functions results in a prolonged temporal loss of functions on the landscape. This is equally true for projects proposing to restore or create wetlands.

Wetland creation vs. enhancement: Which contributes greater functions?

Johnson et al. (2002) determined that created wetlands were significantly more successful than enhanced wetlands. These researchers assessed the potential of compensation wetlands to perform wetland functions. They then determined how much the activities associated with the type of compensation contributed to, or improved, the level of wetland function. For creation/restoration projects it was assumed that if wetland conditions were achieved then the compensation activities were responsible for providing the assessed level of wetland functions. Enhanced wetlands performed some wetland functions prior to implementation of compensation activities. The authors believed it was important to determine how much enhancement activities contributed to, or improved, the level of performance of functions at a compensation wetland. The authors believed this was particularly important since enhancement, as a compensation tool, is based on improvement of wetland functions.

The study compared the contribution of created sites and enhanced sites for three function categories. Results indicated that over half of the created sites provided high or moderate contributions to wildlife habitat, water quality, and water quantity functions. Over half of the enhancement projects provided minimal to no contribution to wetland functions. The vast majority of enhancement actions were targeted at improving wildlife habitat functions. However, the enhanced wetlands were typically surrounded by development and lacked the buffers and connectivity necessary to improve habitat for most wildlife. In addition, most of the wetlands that were enhanced already provided some water quality functions. Thus, creation of wetlands provided a significantly greater contribution to the performance of water quality functions than enhancement of wetlands. Contribution to wetland functions was one element of overall success.

It is important to note that many created wetlands and some enhanced wetlands resulted in Cowardin and hydrogeomorphic (HGM) classes that were not typical for the landscape. This is discussed in more detail in Sections 6.8.2.2 and 6.8.5.1, respectively. Also, because enhancement provides less gain in function per acre than creation or restoration, replacement ratios are generally higher; refer to Section 6.6 for more information.

6.5.4 Preservation

Preservation means "the protection of an existing and well-functioning wetland from prospective future threats" (National Research Council 2001). Preservation, therefore, provides the opportunity to protect wetland areas that might otherwise be in jeopardy. Like enhancement, preservation does not produce any new wetland acreage; for that reason, some concerns have been raised regarding its use as compensation for permitted wetland loss.

- Preservation results in a net loss of wetland acreage.
- Preserved wetlands are generally not large enough to protect ecosystems and biodiversity over the long term (Whigham 1999).
- Preserved areas may not be checked by regulatory agencies to verify that they contain the specified acreage of wetland. For example, Morgan and Roberts (1999) observed that one of the larger preserved wetlands in their study was predominantly upland and "did not meet the criteria for being considered a jurisdictional wetland."

On the other hand, if an area can be verified as wetland, "Preservation of an existing wetland removes the uncertainty of success inherent in a wetland creation or restoration project and requires no construction to complete" (Washington State Department of Transportation 1999). Preservation, therefore, eliminates the risk of failure and temporal loss of wetland functions since the preserved area is already an existing wetland.

6.5.4.1 Use of Preservation

The studies generally found that preservation was required as compensation for less than one-quarter of projects (Holland and Kentula 1992, Morgan and Roberts 1999, Johnson et al. 2000, Jones and Boyd 2000). Preservation generated about 2% of the compensatory wetland acreage in a study from San Francisco, California (Breaux and Serefiddin 1999). A report from the Washington State Department of Transportation (1999) indicated that 76% of state transportation departments in the United States use preservation as at least one component of compensatory mitigation and 38% use it as a stand-alone form of compensation.

6.5.4.2 Effectiveness of Preservation

There is a general lack of information about the effectiveness of preservation. Only one study examined the effectiveness of preservation as a type of compensatory mitigation. In Washington, Johnson et al. (2000) determined that all four of the projects involving preservation as the sole form of compensation were in compliance. Compliance for preservation projects entailed verifying that the area was preserved and free from development and that a deed restriction or conservation easement was in place to legally protect the parcel from future development.

6.5.5 Mixed Compensatory Mitigation

Mixed projects involve more than one type of compensatory mitigation. For example, a common proposal in the Pacific Northwest entails enhancing an existing wetland and creating additional wetland area immediately adjacent to it. Mockler et al. (1998) observed, "most sites consist of creation—a small pool graded for open water and emergents—and enhancement, typically of wetland buffer." Mixed compensation, however, can also occur on separate sites, such as a created wetland adjacent to the development site and a preserved wetland some distance away.

Several studies identified mixed compensation projects (Mockler et al. 1998, Gwin et al. 1999, Johnson et al. 2000, Johnson et al. 2002). For their studies of compensation wetlands, Mockler et al. (1998) and Johnson et al. (2002) classified compensation wetlands according to their dominant type of compensation. However, some projects lacked sufficient information to make this determination, while other projects lacked dominance by any one type of compensation.

6.5.5.1 Use of Mixed Compensation Projects

In the six studies that discussed how frequently mixed compensatory mitigation was required, results ranged from 13% (Johnson et al. 2002) to 43% (Johnson et al. 2000). Most studies found that mixtures were used for less than a third of projects (Holland and Kentula 1992, Shaich and Franklin 1995, Gwin et al. 1999, Morgan and Roberts 1999).

6.5.5.2 Effectiveness of Mixed Compensation Projects

Only two studies, both from Washington, examined the effectiveness of projects utilizing a mixture of compensation types. Johnson et al. (2000) found that 32% of mixed projects were in compliance. Johnson et al. (2002) determined that all of the mixed projects were moderately successful.

6.5.6 Wetland Mitigation Banking

Mitigation banking is defined as "the practice of restoring, creating, enhancing, or preserving off-site wetland areas to provide compensatory mitigation for authorized impacts to wetlands" (Environmental Law Institute 2002). Wetland banking provides an alternative to traditional, concurrent, compensatory wetland mitigation, and its acceptance and use continue to grow.

Typically a public agency, organization, or private entrepreneur establishes a bank on a large area to be used to compensate for a number of smaller wetland impacts. Banks are generally established as compensation in advance of authorized impacts to wetlands at another site. One may conclude that this practice could provide advantages over traditional compensatory mitigation by reducing the temporal loss of wetland functions.

6.5.6.1 Use of Wetland Banking

Mitigation banking was used for about 7% of Section 404 permits in California issued from 1971 to 1987 (Holland and Kentula 1992). For permits issued from 1996 to 1998 which required mitigation, the Corps District of Norfolk, Virginia reported about 10% of projects purchased bank credits for use as compensation (Jones and Boyd 2000).

By the beginning of 1996, Brown and Lant (1999) determined that 68 banks had been established across the country, totaling nearly 41,000 acres (16,590 ha). A recent survey by the Environmental Law Institute (2002) determined that 219 banks had been approved across 40 states, totaling more than 139,000 acres (56,250 ha). Though 22 of the 219 banks have already sold all their eligible compensatory wetland acreage/credits, the remaining 197 banks were active, meaning they had credits/acreage that had not yet been purchased for use as compensation (Environmental Law Institute 2002).

Since wetland bank credits result from one or more of the previously mentioned types of compensation, the Environmental Law Institute (2002) investigated how frequently each type was used in mitigation banking. Results indicated that 78% of banks involved multiple types of compensation and that enhancement and restoration are the most commonly used. Of the banks that relied on a single type of compensation, about a third was restoration; another third was creation, while enhancement and preservation were each used on 16% of the banks.

6.5.6.2 Effectiveness of Wetland Mitigation Banks

Only one study has examined the effectiveness of wetland mitigation banks. Brown and Lant (1999) examined banks that had been established by the beginning of 1996. Overall, they found there would be a net loss of over 21,000 acres (8,450 ha) of wetland due to the use of enhancement and preservation at banks. The authors also discovered that eight banks did not provide the functions required or specified, while four banks used or sold more acreage for compensation of wetland loss than was eligible from the bank (in other words, the bank was overdrawn).

Wetland mitigation banking is increasingly being used to compensate for wetland losses. Yet the only study investigating the effectiveness of banks raises concerns about its use. Further study will therefore be critical to determine the level of compliance and success of mitigation banks in providing functions.

Please refer to Section 6.10.6 Mitigation Banking for more information on wetland banking as it relates to improving compensatory mitigation. In addition, the *Draft Programmatic Environmental Impact Statement: Washington State's Draft Rule on Wetland Mitigation Banking* (Driscoll and Granger 2001) contains a more in-depth discussion of the issues involved in mitigation banking (available at: http://www.ecy.wa.gov/biblio/0106022.html).

6.5.7 In-Lieu Fee Programs

In-lieu fee programs provide an additional option for compensatory mitigation. They allow permit applicants to compensate for wetland losses by paying a fee to a third party such as a government agency or conservation organization (U.S. General Accounting Office 2001, Environmental Law Institute 2002). The fees are intended to be used to restore, create, enhance, or preserve wetlands (U.S. General Accounting Office 2001).

Generally, in-lieu fee contributions are collected in advance of wetland losses. These funds are accumulated until they are sufficient to design and implement a wetland compensation project (Environmental Law Institute 2002).

6.5.7.1 Use of In-Lieu Fee Programs

A recent survey by the Environmental Law Institute (2002) determined there were 87 active in-lieu fee programs across 27 states. "Through fiscal year 2000, developers used the in-lieu-fee option to fulfill mitigation requirements for over 1,440 acres [583 ha] of adversely affected wetlands, and paid over $64.2 million to in-lieu-fee organizations" (U.S. General Accounting Office 2001).

6.5.7.2 Effectiveness of In-Lieu Fee Programs

Two studies discussed the effectiveness of in-lieu fee programs. However, neither study provided information on the level of compliance or ecological success of these programs.

A study by the U.S. General Accounting Office (2001) examined the effectiveness of in-lieu fee programs used by the U.S. Army Corps of Engineers (Corps) to compensate for wetland losses permitted through the Section 404 program. Of the 17 Corps districts using in-lieu fees, 65% did not require a specific timeframe for spending or obligating the fees received, and a few districts had not spent or obligated any funds though they had been collecting fees as compensation for wetland losses for at least three years (U.S. General Accounting Office 2001). The study found that three districts used the fees for research and/or education, rather than on-the-ground activities to compensate for wetland loss. In-lieu fee programs in 30% of the districts restored, created, enhanced, or preserved wetland acreage equal to or greater than the wetland acreage lost. The remaining districts either had used the fees to implement wetland activities that did not compensate for the wetland acreage lost, or they did not have any data (U.S. General Accounting Office 2001).

A study by the Environmental Law Institute found that 45% of in-lieu fee programs lacked the data necessary to determine their effectiveness. In-lieu fees replaced more wetland acreage than was lost in 56 programs, while "thirteen in-lieu-fee programs reported replacing fewer acres than had been impacted" (Environmental Law Institute 2002).

These studies paint a rather grim picture of the effectiveness of in-lieu fee programs as compensation for wetland loss. However, both in-lieu fees and mitigation banking can

provide a mechanism to compensate for regulated wetland impacts that are so small they currently do not require compensation, because compensation for such small wetland losses was not considered viable or practical (Shabman et al. 1993). In the year 2000 federal guidance on the use of in-lieu fee arrangements for compensatory mitigation was issued, while prior to this there were no federal requirements for in-lieu fee programs (Environmental Law Institute 2002). Further study will be needed to ensure that abuses of in-lieu fee compensation are not occurring.

6.5.8 Summary of Key Points

- The variety of definitions or criteria associated with types of compensatory mitigation has led to confusion in permitting and evaluating projects. For instance, comparing the effectiveness of one type of compensation with another is impossible when it is not clear if a project involved creation, restoration, enhancement, or some combination thereof.

- Restoration has been recommended as the "highest priority" method for compensation. Research in Washington has found that it is the least used, though one of three projects was in compliance and one of two projects was fully successful.

- Creation was used in one-third to one-half of compensation projects. In Washington, 10% of creation projects were in compliance, 60% were at least moderately successful. Studies from other states indicated that creation projects experienced major problems such as a failure to establish vegetation and produce wetland conditions.

- Enhancement was used for compensation in more than one-third of compensation projects. Research in Washington found that less than 13% of enhancement projects were in compliance. There were no fully successful enhancement projects, while 89% were minimally or not successful.

- The low level of success for enhancement projects was attributed to an inability to achieve the proposed vegetative structure/diversity, a minimal gain in functions, or both. This may partially be a factor of time: There will be continued temporal loss of some functions until young sites mature to more complex structural conditions.

- Two studies from Washington indicated that mixed compensation projects had a higher level of compliance than either creation or enhancement, and all mixed projects were moderately successful.

- Preservation can result in permanent protection of existing wetland resources, but compliance was found to be variable. One study found a large area of preserved wetland was actually predominantly upland habitat. However, a study in Washington found that 100% of preservation sites were in compliance.

- Studies of wetland mitigation banking and in-lieu fee programs focused on whether the goal of preventing the net loss of wetlands had been achieved on paper. The results indicated that a net loss of wetland area was occurring. A few banks were overdrawn, and some of the in-lieu fee programs had not used the money collected to implement compensation activities. No studies determined their effectiveness on the ground.

Does size influence the effectiveness of compensatory wetland mitigation projects?

Studies of the effect of wetland size on compensation projects revealed mixed results.

Two studies indicated that larger projects, which probably involved more planning and regulatory oversight, had a higher level of compliance (Brown and Veneman 2001) or success (Allen and Feddema 1996). Allen and Feddema (1996) noted that large projects (greater than 8.6 acres [3.5 ha]) resulted in a net gain of wetland acreage, while the smaller projects resulted in a net loss of wetland acreage. Though Brown and Veneman (2001) indicated larger projects had a higher level of compliance, larger projects were no more successful at replacing the plant communities or wildlife functions that were lost than the smaller compensation wetlands.

Two other studies determined that no statistically significant correlation existed between wetland size and compliance or success (Balzano et al. 2002, Johnson et al. 2002). Raw data from Johnson et al. (2002) implied that compensatory mitigation projects 5 acres (2 ha) or larger were less successful than smaller projects. Balzano et al. (2002) found that larger compensation wetlands tended to be more successful at establishing the required wetland acreage. However, this trend was attributed to one large site (over 40 acres [16 ha]) that established more wetland acreage than was required.

The Committee on Mitigating Wetland Losses determined that wetland size does affect wetland functions (National Research Council 2001). For example, "for water quality purposes, many small wetlands would be more effective than one large wetland covering the same area." The committee therefore concluded that "replacement area should be proportional to the area required to replace the functions lost" (National Research Council 2001).

6.6 Replacement Ratios

A replacement ratio, or compensation ratio, is an approach used to determine appropriate reparation for permitted wetland losses. Not all regulatory agencies use this approach. For example, the U.S. Army Corps of Engineers, Seattle District considers the needs for compensation on a project-specific basis rather than assigning replacement ratios.

The replacement ratio reflects the acreage of a particular type of compensatory mitigation (creation, restoration, enhancement, or preservation) required to make up for the loss of an acre of wetland (King et al. 1993, McMillan 1998). For example, a permitted loss of one acre may be compensated with two acres of restoration, thus requiring a 2:1 replacement ratio. The rationale for requiring more than 1:1 replacement for wetland impacts is provided in Section 6.6.1.

This section provides the following information:

- The rationale for using replacement ratios
- A summary of the literature regarding what replacement ratios are being required and if they are being achieved
- Some of the methods used to determine appropriate replacement ratios

6.6.1 Rationale for the Use of Replacement Ratios

When compensatory wetland mitigation was first required, the loss of an acre of wetland would simply require an acre of compensation (McMillan 1998). A simple 1:1 replacement ratio generally is no longer considered appropriate (Castelle et al. 1992a, King et al. 1993, National Research Council 2001) for the following reasons:

- **Risk of failure.** It is possible that compensation projects will not perform as proposed (King and Bohlen 1994) and may fail to compensate for wetland losses (Castelle et al. 1992a).
- **Temporal loss.** It may take anywhere from several years to several decades for a compensation project to achieve ecological equivalency (National Research Council 2001) and to develop the proposed/required wetland structures and/or functions (Castelle et al. 1992a).

Because of the risk of failure and temporal loss, "replacement ratios greater than 1:1 are used as a means of equalizing the tradeoff. While the goal is always to replace the lost functions at a 1:1 ratio, it is almost always necessary to increase the replacement acreage in order to accomplish this" (McMillan 1998).

A literature review performed by Castelle et al. (1992a) concluded that:

> *The risks of project failure and the time it takes for a created wetland to represent a fully functioning ecosystem should be factored into replacement ratios which exceed 1:1…*
>
> *Replacement ratios of 2:1 or greater are necessary to compensate for our current rate of failure to achieve permit compliance of basic wetland community structural objectives within attempted mitigation projects, neither of which are accurate measures of functional equivalency.*

An additional consideration is that there are many types of wetlands and various degrees of degradation. As a result, not all wetlands provide the same levels of functions or values. Replacement ratios, therefore, should take into account the type and quality of the wetland and the functions and values that would be lost. For example, the loss of a high-quality forested wetland would require a higher replacement ratio than the loss of a highly degraded wet pasture (Breaux and Serefiddin 1999).

Also, the type of compensation can influence the replacement ratio. Johnson et al. 2002 found that the use of enhancement not only results in a net loss of wetland area but provides a limited increase in wetland functions. Therefore, enhancement typically requires higher replacement ratios than restoration or creation (McMillan 1998).

Higher replacement ratios result in more area for compensatory mitigation, but unfortunately size does not guarantee success or quality. A study conducted by the National Academy of Sciences concluded that attempts to compensate for rare wetland types by requiring high replacement ratios yielded wetlands of a common type at a low ratio. Rather than replicating the rare wetland type, a more common wetland type was substituted. "In effect, the regulatory program may reassemble the landscape with a different habitat mix than the wetlands being lost" (National Research Council 2001).

6.6.2 Replacement Ratios Required and Achieved

Table 6-8 summarizes the overall or average replacement ratios that were required for compensatory wetland mitigation projects. A wide range of replacement ratios was required—from 0.66:1 to 5.9:1 (Kunz et al. 1988, Johnson et al. 2000). These are the extremes. The low end represents projects from the early to mid 1980s, when compensatory mitigation was still a relatively new idea. The higher ratios reflect more recent projects using predominantly enhancement and/or preservation, which typically require higher replacement ratios.

Between these extremes, the remaining studies noted ratios ranging from 1.5:1 to 2.7:1 (Wilson and Mitsch 1996, Morgan and Roberts 1999, Michigan Department of Environmental Quality 2000, Balzano et al. 2002, Johnson et al. 2002, Robb 2002).

Actual replacement ratios that were achieved for the projects studied are also shown in Table 6-8. None of the studies found that the required ratios had been realized. In fact, Balzano et al. (2002) determined that forested compensation wetlands achieved only 1/100th of an acre for every acre lost despite the fact that over 2 acres of forested wetland were required. Achieved ratios ranged from 0.7:1 to 1.9:1 (Wilson and Mitsch 1996, Morgan and Roberts 1999, Balzano et al. 2002, Johnson et al. 2002, Robb 2002).

As mentioned in the previous section, replacement ratios typically require greater than 1:1 replacement to factor in the risk of failure. Table 6-8 demonstrates the utility of this approach since all of the studies indicated that the achieved ratios were smaller than those required. All but one of the studies found the achieved ratios were greater than 1:1, though not by a substantial margin. But two of these studies included enhancement of existing wetlands.

Ratios are a tool to address the temporal loss of wetland functions and the historic failure of replicating wetland acreage and functions. The results indicate an inability of compensation projects to achieve their required replacement ratios. It is assumed that this inability reflects the same problems and shortfalls associated with compensation project success and compliance (see Section 6.4).

Table 6-8. Comparison of replacement ratios that were required and achieved.

Location of Study and Reference No.	No. of Projects Evaluated	Replacement Ratio Required	Replacement Ratio Achieved	Comments
Washington (Johnson et al. 2002)	24	2.2:1[a]	1.87:1 [a]	Enhancement accounted for 65% of the established acreage
Washington (Johnson et al. 2000)	45	5.9:1 [a]	NA	Acreage predominantly preservation and enhancement
Washington (Kunz et al. 1988)	35	0.66:1	NA	Corps and EPA data 1980 to 1986
Michigan (Michigan Department of Environmental Quality 2000)	76	1.82:1 (average)	NA	Required ratios ranged <1:1 to >5:1; study did not include enhancement
Indiana (Robb 2002)	31	2.5:1	1.1:1	Achieved ratios for specific Cowardin classes ranged from 0.48:1 for PFO to 45:1 for POW; study did not include enhancement
Ohio (Wilson and Mitsch 1996)	4 (5)	1.5:1 (1.7:1) [a]	1.4:1 (0.7:1) [a]	Study reviewed 5 projects, results and conclusions focus on 4; parentheses reflect results for all 5
New Jersey (Balzano et al. 2002)	75	1.8:1 (average) 2.04:1 PFO 2.78:1 PSS 1.85:1 PEM 1.07:1 POW	0.78:1 (average) 0.01:1 PFO 0.91:1 PSS 1.29:1 PEM 0.28:1 POW	Sites proposing POW did not achieve the required acreage. However, POW was on sites that did not propose to have open water; thereby resulting in three times more POW acreage than required
Tennessee (Morgan and Roberts 1999)	47	2.7:1	1.9:1	Ratio = 0.88:1when enhancement and preservation are excluded

NA = not available

PFO = palustrine forested; PSS = palustrine scrub-shrub; PEM = palustrine emergent; POW = palustrine open water

[a] Calculated from data provided.

6.6.3 Approaches for Determining Replacement Ratios

King et al. (1993) proposed a framework for calculating replacement ratios, "based on the idea that compensatory mitigation involves trading one form of environmental capital for another and that full compensation requires increases in environmental functions and values from the compensation wetland that are sufficient to make up for the decline in functions and values resulting from the loss of existing wetland." The authors mentioned five parameters to consider when determining an appropriate replacement ratio.

- The pre-existing level of wetland function per acre at the site proposed for wetland compensation. In the case of enhancement, this ensures that an applicant does not get mitigation credit for functions that were already being provided by a pre-existing wetland.
- The maximum level of function anticipated to be provided by the wetland compensation project.
- The number of years after construction that will be required for the wetland compensation project to reach its anticipated or sustainable level of function.
- The number of years between the loss of the original wetland and the completion of construction of the compensation wetland (temporal loss). Mitigation could be done concurrent with impacts, in advance, or delayed after impacts occur.
- The likelihood that the project will not achieve its anticipated level of function.

King et al. (1993) suggested entering the values for each of the five parameters into an analytic model that then calculates an appropriate compensation ratio for the project-specific information provided. King and Bohlen (1994) provided easy to use tables of replacement ratios that would result from a variety of values for the five parameters identified above. Using parameters comparable to King et al. (1993) for determining appropriate compensation, Rheinhardt et al. (1997) described an approach based on function assessment. The authors proposed the following steps.

1. Develop a function assessment method for the specific regional conditions, including identification of reference wetlands.

2. Assess wetlands proposed to be lost, thereby determining the level of each wetland function that will be lost.

3. Assess potential compensatory mitigation sites to evaluate their current level of function and predict future conditions and levels of function that would result from mitigation activities within the timeframe required for regulatory monitoring.

4. Calculate ratios for compensation for each function "by dividing the degree to which a function is reduced through project alteration by the degree to which a function is increased through restoration" (Rheinhardt et al. 1997).

The ratio "varies among functions and is influenced by (1) the magnitude to which any given function occurs at a project site both before and after the site is altered, (2) the magnitude to which any given function occurs at a compensatory mitigation site both before and after restoration is applied, and (3) the rate at which any given function is restored" (Rheinhardt et al. 1997). The goal of this approach is not just to ensure no net loss of wetland functions but also to restore wetland ecosystems (Rheinhardt et al. 1997).

In contrast, Breaux and Serefiddin (1999) argue that "there has not been any single, universally accepted assessment procedure to determine wetland functions and values (Kusler 1997)." As a result they suggest that "the quantitative measure of area provides a degree of certitude that should be taken advantage of" (Breaux and Serefiddin 1999). In other words, assessing or determining the level of functions provided by a wetland can be time-consuming to near impossible, while acreage provides an easy measurement. The authors mention a few conditions that may require greater than 1:1 replacement ratios (for example 2:1 or 3:1):

1. *If it is determined that the area lost includes functions and values of high quality…*

2. *If… the replacement area is outside the watershed, sub-watershed, or county;*

3. *If the replacement area involves a high risk of failure or uncertain outcome,*

4. *If there are high temporal losses…*

5. *If the habitat loss is likely to be substantially greater than the creation of new habitat; or*

6. *If the connection between two wetland sites is severed or a large site is divided* (Breaux and Serefiddin 1999).

Robb (2002) also proposed using an acreage-based system for determining appropriate replacement ratios. However, where the previous studies did not base ratios on the type of wetland, his system focused on developing replacement ratios for each Cowardin class. This approach resulted from a delineation of 31 compensatory mitigation sites in Indiana. Robb (2002) compared the required acreage of each Cowardin class with the acreage that was established. For example, results indicated that 71% of the required acreage of palustrine forested wetlands was not established (a 71% rate of failure). The ratio recommended to overcome this failure was calculated by dividing the required acreage by the acreage actually established. Using these data, the ratio for palustrine forested wetlands should therefore be 3.5 acres of compensation for every acre of wetland lost. The rationale was that for every 3.5 acres constructed that were intended to be palustrine forested wetland, 1 acre would actually become forested wetland. Proposed ratios for other wetland types included:

- 1.8:1 for scrub-shrub
- 7.6:1 for wet meadow
- 1.2:1 for shallow marsh
- 1:1 for open water

Robb (2002) conceded that his study did not consider the quality of the compensation wetlands or whether they replaced the functions lost. The author mentioned that more regulatory follow-up could result in more successful projects and therefore lower replacement ratios.

6.6.4 Summary of Key Points

- Replacement ratios provide a means of taking into account the potential failure and temporal loss of functions as well as the potential change in acreage or functions to be provided by the compensation project.
- Several methods are available to calculate replacement ratios on a case-by-case basis. Examples of some of the criteria used to determine ratios include the functions proposed to be provided at the compensation site, the functions anticipated to be lost at the impact site, size, landscape position, and relative chance of success.
- Required replacement ratios vary from one state to another, based on the type of compensation proposed, and based on project-specific circumstances.
- Studies found that compensation projects did not achieve their required replacement ratios. In some cases this resulted in less than 1:1 acreage replacement.

6.7 Replacement of Wetland Acreage

This section summarizes the results of studies examining whether compensatory wetland mitigation is replacing the acreage of authorized wetland losses. Replacement of wetland acreage is similar to "no net loss," which refers to a goal for the nation and Washington State to ensure there will be no overall net loss in acreage and function of the remaining wetland resource base (The Conservation Foundation 1988, McMillan 1998). The no-net-loss goal, however, "does not mean that no further wetlands will be lost; rather, that mitigation and non-regulatory restoration will offset wetland losses" (McMillan 1998). Replacement of wetland acreage, on the other hand, focuses on wetland losses and gains associated with compensatory wetland mitigation.

Replacement of wetland acreage provides a measurable and consistent method for evaluating and comparing the effectiveness of compensatory mitigation programs (Kusler 1988). The scientific literature contained two types of information on this topic.

- Studies that evaluated how well permitting programs (e.g., Section 404) achieved replacement of wetland acreage. Most of these studies used information from permit files and databases.

- Studies that evaluated how well compensation projects achieved the replacement of wetland acreage on the ground. These studies were conducted in the field and typically involved the delineation of wetland boundaries.

6.7.1 Programmatic Evaluations of Acreage Replacement

Programmatic evaluations, in contrast to most of the studies mentioned thus far, are not concerned with the effectiveness of individual compensatory mitigation projects. Instead, programmatic evaluations focus on whether a permitting agency or permit program is requiring sufficient wetland acreage compensation to replace the authorized wetland losses occurring over a specified time.

In a programmatic evaluation, wetland acreage replacement is determined by comparing the acreage of wetlands lost, or adversely altered, with the acreage of wetlands required for compensatory mitigation in a specific geographic area. These evaluations typically rely on information from permit files and databases, rather than verification of on-the-ground, as-built conditions.

Five studies examined the effectiveness of wetland permitting and compensatory mitigation programs (Table 6-9). The earliest study reviewed Section 404 permit data from Washington, 1980 to 1986, and Oregon, 1977 to 1987, "to describe how permit decisions affect the wetland resource" (Kentula et al. 1992). Results indicated that in Washington 39 acres (16 ha) of wetland were not replaced, while in Oregon 79 acres (32 ha) of wetland were not replaced. The authors also observed, "In Washington, approximately 3 percent of the permits issued required compensatory mitigation" (Kentula et al. 1992).

The results of this study should be considered within the context of the Seattle District Corps of Engineers regulatory program in the early 1980s. The authors of Volume 1 observed that in the early 1980s compensatory mitigation, when it was required, was only required for projects that triggered an individual permit. The threshold for wetland fill under a Nationwide Permit 26 (a general permit for headwaters and isolated waters discharges) was 10 acres (4 ha), therefore an individual permit was only required for projects with greater than 10 acres of wetland fill. Fill of 10 acres or less in isolated wetlands was permitted outright. It is therefore possible to conclude that the 40 acres of wetland identified by Kentula et al. (1992) as "not replaced" very likely represents but a fraction of the total acreage of permitted wetland losses that were not compensated for at that time.

A study of Section 404 permitting from southern California noted that 8 acres (3 ha) of wetland were not replaced (Allen and Feddema 1996). The study also determined that "freshwater wetlands are experiencing a disproportionately greater loss of area and that riparian woodland wetlands are most often used in mitigation efforts. The net result of these accumulated actions is an overall substitution of wetland types throughout the region" (Allen and Feddema 1996).

Two of the remaining studies generally found that permitting programs required a net gain from compensatory mitigation (Table 6-9). Gains in acreage ranged from about 47 acres (19 ha) (Torok et al. 1996) to nearly 197 acres (80 ha) (Holland and Kentula 1992). However, the study of the effectiveness of the New Jersey Freshwater Wetlands Protection Act (Torok et al. 1996) mentioned compensatory mitigation acreage only for individual permits. It was not clear from the article if any of the 3,003 general permits, resulting in over 600 acres (243 ha) of wetland loss, required any compensatory mitigation. Furthermore, Holland and Kentula (1992), in their evaluation of Section 404 permitting in California, noted that data on acreage of impacts and compensation were lacking in about 40% of the permit files.

The fifth study focused on the Norfolk Corps District (Jones and Boyd 2000). The authors indicated that new wetland acreage produced by creation or restoration did not fully replace the permitted wetland losses, thereby resulting in a loss of about 260 acres (105 ha) (Jones and Boyd 2000). However, preservation, mitigation bank credits, and substantial in-lieu fee contributions provided additional compensation. If acreages from all types of compensatory mitigation are included, the authors assumed there was a gain of at least 1,500 acres (607 ha). Despite the fact that only 24% of the permits required compensation, the authors concluded that replacement of wetland acreage was achieved, at least on paper (Jones and Boyd 2000).

The results (Table 6-9) indicate that since the early 1980s, permitting programs have required an increasing amount of acreage to compensate for wetland losses. It can be inferred that permits from the mid-1980s did not require the replacement of acreage for wetland losses, whereas permits from the mid- to late 1990s appear to have required replacement of wetland acreage.

Table 6-9. Permitted wetland loss compared to required wetland compensation.

Location of Study	No. of Permits	Wetland Area Lost	Area of Compensation Required	Comments
Washington (Kentula et al. 1992)	35	152 acres (61.4 ha)	112 acres (45.5 ha) created	Section 404 permits 1980-1986
Oregon (Kentula et al. 1992)	58	183 acres (73.9 ha)	103 acres (41.8 ha) created	Section 404 permits 1977-1987
California (Holland and Kentula 1992)	324	2,907 acres (1,176.3) ha	3,103 acres (1,255.9 ha)	Section 404 permits 1971-1987; data on acreages was often lacking

Location of Study	No. of Permits	Wetland Area Lost	Area of Compensation Required	Comments
California/ southern (Allen and Feddema 1996)	75	199 acres (80.5 ha)	191 acres (77.3 ha) completed	Section 404 permits 1987-1989; permits required 276 acres (111.6 ha) of compensatory mitigation
Norfolk Corps District (Jones and Boyd 2000)	1692	863.8 acres (349.6 ha)	538.6 acres created (218.0 ha) 65.5 acres restored (26.5 ha) 1,537.2 acres preserved (622.1 ha) 200.8 bank credits $2,574,966 in lieu fee	Section 404 permits 1996-1998
New Jersey (Torok et al. 1996)	3003 (107)	602 acres (243.8 ha) *164 acres (66.5 ha)*	NA *171 acres (69.2 ha) created;* *41 acres (16.5 ha) restored*	New Jersey Freshwater Wetlands Protection Act permits 1988-1993. *Numbers in italics are individual permits; all other numbers are state general permits.*

6.7.2 Project-Specific Evaluations of Acreage Replacement

Studies that examined the effectiveness of compensation projects often assessed whether the projects achieved replacement of wetland acreage. The assessment generally involved determining how much wetland acreage the compensation projects provided. The wetland compensation acreage produced on the ground was then compared to the acreage of wetland loss associated with those projects. If the compensation acreage was less than the wetland acreage lost, a net loss of wetland occurred. Seven studies analyzed compensatory wetland mitigation project data to determine whether replacement of wetland acreage was achieved.

Four studies either focused on creation or restoration, or they did not mention the type of compensation. The studies noted that the acreage of wetland compensation was less than the acreage of wetland loss by as much as 34%, thereby resulting in a net loss of up to 8 acres (3 ha) (Gwin and Kentula 1990, Allen and Feddema 1996, Wilson and Mitsch 1996). However, a study conducted for the South Florida Water Management District found that creation and restoration activities resulted in 106% of the wetland acreage lost—a net gain of almost 65 acres (26 ha) of wetlands (Erwin 1991).

One issue that emerges when considering replacement of wetland acreage is the use of enhancement and preservation as wetland compensation. Three studies noted that enhanced or preserved wetlands accounted for 45 to 65% of the acreage of compensation (Shaich and Franklin 1995, Morgan and Roberts 1999, Johnson et al. 2002). In Washington nearly two-thirds of the established acreage of compensation involved

enhancing existing wetlands, while creation and restoration of wetland area replaced only 65% of the permitted wetland losses (Johnson et al. 2002).

Some authors discounted the acreage provided by enhancement and preservation. Enhancement and preservation are often not included in determining net loss or gain because neither type of compensatory mitigation produces any new wetland acreage (Breaux and Serefiddin 1999). When acreage provided by enhancement and preservation are disregarded, three studies found wetland losses of 22, 11, and 24 acres (9, 4, and 10 ha) respectively (Shaich and Franklin 1995, Morgan and Roberts 1999, Johnson et al. 2002). This equaled 58, 12, and 41% of the authorized wetland losses, respectively (Shaich and Franklin 1995, Morgan and Roberts 1999, Johnson et al. 2002).

6.7.3 Summary of Key Points

- Programmatic evaluations have documented an increase in the acreages of wetland compensation required since the early 1980s. However, the acreage of wetland replacement may include preservation, enhancement, or both.
- Project-specific data revealed that compensation wetlands did not replace the acreage of wetlands that were lost. Even larger losses occurred if the acreages of enhancement and preservation were discounted.

6.8 Functions and Characteristics Provided by Created, Restored, or Enhanced Wetlands

This section describes the functions and characteristics provided by wetlands created, restored, or enhanced for compensatory mitigation and non-regulatory projects.

- The capacity of created and restored wetlands to provide wildlife habitat for invertebrates, amphibians, and birds. Wildlife habitat was evaluated through direct observations or evidence of wildlife use, the presence of structural indicators, or comparison to reference wetlands.
- The ability of created, restored, or enhanced wetlands to develop plant communities and vegetative characteristics. Studies involved comparisons with reference wetlands and investigations of factors affecting vegetation.
- The importance of soil conditions, particularly as they relate to establishing vegetation and improving water quality. Soil properties of created and restored wetlands were compared with reference wetlands.
- The ability of created and restored wetlands to provide water quality functions.
- The importance of water regime and how the creation and enhancement of compensation wetlands can result in atypical water regimes.

The scientific literature indicated that the ability of compensatory wetland mitigation projects to perform wetland functions is not noticeably different from that of non-regulatory restoration or creation projects. Newly implemented wetland sites face similar challenges and develop in similar ways regardless of whether they were legally required or voluntarily initiated.

Refer to Chapter 2 of this document for a discussion of the functions that wetlands provide.

In Section 6.8, use of the terms "**significant**" and "**significantly**" implies statistical significance that was determined by the authors of the specific study being discussed.

6.8.1 Wildlife Habitat

Most articles focused on the ability of a created or restored wetland to provide habitat for one specific guild or group of animals, such as invertebrates, amphibians, or birds. Information on other habitat functions provided by created or restored wetlands was lacking.

6.8.1.1 Invertebrates

Several studies have compared the invertebrate communities of created or restored wetlands with those of reference wetlands. Most of these determined that reference wetlands were more diverse, had greater taxon richness, or had higher density of species than created or restored sites (Brown et al. 1997, McIntosh et al. 1999, Fairchild et al. 2000, Dodson and Lillie 2001). One study, however, found "no convincing differences" in fly (dipteran) densities between created and reference wetlands (Streever et al. 1996). None of these studies were conducted in the Pacific Northwest. However, the results should be broadly applicable to wetlands anywhere.

The age of the wetland, or the amount of time elapsed since restoration occurred, was an important factor influencing invertebrate taxon richness, abundance, and/or diversity (Brown et al. 1997, Fairchild et al. 2000, Dodson and Lillie 2001). For example, "insects with aerial dispersal capability rapidly colonized the restored habitats, but some less mobile forms (non-insects and some hemipterans [true bugs]) either colonized more slowly or not at all" (Brown et al. 1997). Dodson and Lillie (2001) determined that a newly restored site would require 6.4 years for the zooplankton taxon richness to resemble that of a minimally disturbed reference wetland.

The growth and development of vegetation also appears to affect invertebrate communities (Chovanec 1994, Brown et al. 1997, Chovanec and Raab 1997, McIntosh et al. 1999, Fairchild et al. 2000). For example, certain predatory groups of beetles were early colonists at young sites with limited development of vegetation, while herbivorous beetle groups occurred at older sites after specific types of vegetation had developed (Fairchild et al. 2000). McIntosh et al. (1999) concluded, "wetlands at different

successional stages may contain very distinct aquatic macroinvertebrate assemblages which may be important to the food web and other functional processes of wetlands."

6.8.1.2 Amphibians

The amphibian habitat present in created or restored wetlands has been compared with that of reference wetlands in several studies. On the east slope of the Cascade Range in the Teanaway and lower Swauk River drainages of Kittitas County, Quinn et al. (2001) found no difference in species richness of amphibians between created and reference wetlands, "although sample sizes may have been too small for differential species-use patterns to emerge." Other authors determined that created and restored wetlands differed from reference wetlands in terms of amphibian community structure, species richness, or stomach content (Bursey 1998, Lehtinen and Galatowitsch 2001, Pechmann et al. 2001).

Though created or restored wetlands provide habitat for some amphibian species, conditions within the wetland and conditions outside the wetland may limit productivity, dispersal, colonization, or all three. Conditions within a wetland that appear to affect amphibian communities include hydroperiod, substrate, presence of emergent vegetation, presence of fish, and the availability of an invertebrate prey source (Bursey 1998, Baker and Halliday 1999, Monellow and Wright 1999, Pechmann et al. 2001).

Conditions outside of a restored or created wetland that affect amphibian communities include distance to other wetlands, connectivity between habitats, and the land use of the surrounding terrestrial habitats (Baker and Halliday 1999, Monellow and Wright 1999, Lehtinen and Galatowitsch 2001, Pechmann et al. 2001). For example, Baker and Halliday (1999) observed that two species of amphibians dispersed to new ponds only if they were within 1,312 feet (400 m) of an existing pond, while two other species colonized new ponds up to 3,117 feet (950 m) from an existing pond.

Monellow and Wright (1999) concluded, "The interconnectiveness of amphibian habitat is an essential element in sustaining amphibian populations because it allows amphibians to overcome large population fluctuations and recolonize areas where populations have been extirpated."

Lehtinen and Galatowitsch (2001) found that the wetlands restored in urban areas had the lowest amphibian species richness. However, authors of a study of wetlands created in a recreational area in an intensively used urban site near Vienna, Austria observed all seven of the amphibian species known to occur in the area. As many as six species were breeding (Chovanec 1994).

6.8.1.3 Birds/Waterfowl

All of the studies that examined the ability of created or restored wetlands to provide habitat for birds focused on non-regulatory projects. Therefore this section does not contain information on the ability of compensatory wetland mitigation projects to provide habitat for birds. However, the information is still relevant based on the similarity of

results among compensatory and non-regulatory projects for the other studies of functions. None of the studies cited below were conducted in the Pacific Northwest.

Studies comparing bird use of created or restored wetlands and reference wetlands demonstrated variable results, perhaps indicating that site-specific conditions influence bird use. For example, two studies found no difference in bird abundance between restored and reference wetlands (Brown and Smith 1998, Ratti et al. 2001), while two other studies determined that reference wetlands had greater bird species richness and abundance (Delphey and Dinsmore 1993, Dobkin et al. 1998). Brown and Smith (1998) found no difference in bird abundance or the number of bird species observed. However, they did determine that the bird communities differed by a statistically significant margin and that density was greater at reference wetlands (Brown and Smith 1998). Regardless of the findings for bird populations in general, two studies noted that ducks had similar or greater abundance, species richness, or density at created and restored wetlands (Delphey and Dinsmore 1993, Ratti et al. 2001).

In the literature, the main factors that appeared to affect wetland use by bird populations were:

- The percent cover of emergent vegetation (Belanger and Couture 1988, Hemesath and Dinsmore 1993, VanRees-Siewert and Dinsmore 1996)
- The density and abundance of invertebrates (Belanger and Couture 1988, Cooper and Anderson 1996)

Though the age of the wetland did not directly affect overall bird populations at created and restored wetlands, VanRees-Siewert and Dinsmore (1996) noted that the richness of breeding bird species was significantly greater at older restoration sites. The composition of the bird community changed with age. Both of these effects were associated with an increase in the emergent vegetation in older wetlands.

6.8.2 Plants

6.8.2.1 Comparisons with Reference Wetlands

This section discusses studies that compared the vegetation of created and restored wetlands to that of reference wetlands. The studies examined a variety of parameters in a number of states and found variable results. Only one study determined that there was no difference in vegetation between created/restored and reference wetlands (Brown 1991). Two studies were conducted in the Pacific Northwest.

In the metropolitan area of Portland, Oregon, reference wetlands differed significantly from mitigation wetlands in terms of floristic composition. Mitigation wetlands had higher overall plant species richness, higher average percentage of native species, and significantly higher average occurrence of introduced and invasive/introduced species than reference wetlands (Magee et al. 1999).

Another study was conducted in the northwestern Great Basin on land that had previously been grazed by cattle. The study found that "sedge cover, forb cover, and foliage height diversity of herbs were greater" on reference plots, in which livestock had been excluded for more than 30 years. "[B]are ground, litter cover, shrub cover, and shrub foliage height diversity were greater" on restored plots, in which livestock grazing pressure had been removed prior to commencement of the study (Dobkin et al. 1998). During the four-year study period, restored plots experienced an increase in grass, forb, rush, and cryptogamic cover, but sedge cover did not change. The authors concluded, "the lack of change in sedge and shrub cover on open [restored] plots suggests that restoration to a sedge-dominated meadow will not happen quickly" (Dobkin et al. 1998).

Restored prairie pothole wetlands were found to lack low prairie and wet meadow zones that reference wetlands possessed. Restored wetlands had significantly higher richness of submersed aquatics and greater coverage by mudflat and open water (Delphey and Dinsmore 1993, Galatowitsch and van der Valk 1995, Galatowitsch and van der Valk 1996). The researchers concluded that restored wetlands are not likely to develop the sedge meadow and wet prairie zones present in reference wetlands (Galatowitsch and van der Valk 1995, VanRees-Siewert and Dinsmore 1996).

Other authors determined that reference wetlands exhibited greater percent cover by wetland species. However, created wetlands had species richness that was equal to or greater than reference wetlands (Moore et al. 1999). Restored wetlands had significantly lower wetland index values (indicating that wetland species were providing more of the total vegetative cover) than reference sites (Brown 1999).

One could hypothesize that created and restored wetlands have greater vegetation species richness due to the level of disturbance associated with creation and restoration and the broad range of niches created on a new site. For example, a newly created or restored site is like a *tabula rasa* (a blank slate) upon which species will be planted (installed or seeded), species from the previous habitat on the site will re-emerge, and species adapted to disturbance will colonize.

6.8.2.2 Cowardin Classes Provided by Compensatory Mitigation Wetlands

Cowardin class refers to a method used to categorize wetlands based on the dominant type of vegetation (Cowardin et al. 1979), as well as other factors. The main Cowardin classes used to categorize freshwater wetlands are:

- Emergent
- Scrub-shrub
- Forested
- Aquatic bed
- Open water (though not technically a Cowardin class, open water is often used to map and describe unvegetated areas of inundation)

Several studies evaluated compensatory wetland mitigation sites to determine which Cowardin classes were being established. Nearly all of these studies found that compensatory mitigation resulted in more acreage of open water/aquatic bed/deep marsh than was originally lost or required (Kentula et al. 1992, Shaich and Franklin 1995, Bishel-Machung et al. 1996, Magee et al. 1999, Cole and Brooks 2000, Michigan Department of Environmental Quality 2000, Balzano et al. 2002, Johnson et al. 2002, Robb 2002).

For example, in Washington State over 16 acres (6 ha) of open water/aquatic bed wetlands were gained (Johnson et al. 2002). In the Portland metropolitan area of Oregon, 29 acres (12 ha) of open water were gained (Shaich and Franklin 1995), and Indiana gained over 3 acres (1 ha) of open water/deep marsh/aquatic bed (Robb 2002). Compensatory wetland mitigation projects in New Jersey generated 50 acres (20 ha) more open water than was required (Balzano et al. 2002).

Results for other Cowardin classes were more variable. For example, four studies noted either a loss of forested wetland area (4 to 8 acres [2 to 3 ha]) or an inability to establish this wetland class (Shaich and Franklin 1995, Bishel-Machung et al. 1996, Brown and Veneman 2001, Balzano et al. 2002, Robb 2002). On the other hand, a study from Washington State observed a net gain of over 12 acres (5 ha) in forested/scrub-shrub wetlands (Johnson et al. 2002).

Additional variability occurred in the balance of emergent wetlands. Two studies from the Pacific Northwest noted a loss of 35 to 51 acres (14 to 21 ha) for emergent wetlands due to their conversion to other Cowardin classes (Shaich and Franklin 1995, Johnson et al. 2002). Studies from other states, meanwhile, found that emergent wetlands were established more successfully than other wetland classes (Bishel-Machung et al. 1996, Brown and Veneman 2001, Balzano et al. 2002). Though the studies did not mention whether the emergent wetlands were dominated by native vegetation, Brown and Veneman (2001) noted "plant communities in replicated wetlands differed significantly from those in wetlands they were designed to replace" in terms of the number and percent cover of species in general and the number and percent cover of wetland species.

Compensatory mitigation may often result in a different wetland type compared to what was lost (Shaich and Franklin 1995, Balzano et al. 2002, Johnson et al. 2002, Robb 2002). For example, if an open-water pond was provided as compensation for an authorized impact to a wetland pasture, a change in wetland type occurred. If the compensatory mitigation was enhancement and involved constructing an open water pond in another wetland pasture, a second change in wetland type occurred.

The studies examining changes in Cowardin classes at compensation wetlands found a net increase in open water/aquatic bed habitats (Shaich and Franklin 1995, Balzano et al. 2002, Johnson et al. 2002, Robb 2002). Though the reasons for this change are not clear for all studies, several studies indicated that open water/aquatic bed resulted from an inability to establish the proposed Cowardin class (Balzano et al. 2002, Robb 2002). One could assume that another reason may be that open water is relatively easy to establish given adequate hydrologic conditions. Furthermore, the authors of Volume 1 have

observed situations in which the wetland mitigation design was intended to maximize a limited space by providing a variety of habitat niches, and open water is often considered a key habitat niche for waterfowl. Therefore, it is possible to conclude that regulatory decisions may have been biased toward the construction of more open water/aquatic bed/emergent wetland complexes in order to achieve an enhancement of functions in a limited space.

Studies from Washington and Oregon reported a net loss of emergent wetlands (Shaich and Franklin 1995, Johnson et al. 2002). However, many wetlands in the Puget Lowlands of Washington and the Willamette Valley of Oregon that are classified as emergent are wet pastures dominated by non-native grasses. Johnson et al. (2002) noted that 90% of the emergent acreage lost or converted was pasture dominated by non-native species. It can be assumed that much of the current area of emergent pasture may historically have been forested wetland. Therefore, one can conclude that converting pastures into other wetland types with a greater diversity of hydroperiod and more structural complexity, such as forested wetlands, may represent an opportunity for a net increase in wetland functions over time, compared with leaving the wet pastures unchanged.

6.8.2.3 Factors Affecting Plants

Several major factors influencing wetland vegetation have emerged from the literature:

- Soil and soil disturbance
- Age of the wetland
- Competition and non-native vegetation
- Seed or plant source
- Human manipulation

The studies summarized in this section looked at different parameters in different types of wetlands across the country; therefore, the results are highly variable.

Soil and Soil Disturbance

Five studies indicated that soil conditions at the created or restored wetlands influenced vegetation composition (Brown 1991, Ashworth 1997, Brown and Bedford 1997, Stauffer and Brooks 1997, Brown 1999). Three of these studies discussed the positive effects of adding salvaged or donor hydric soil to created or restored wetlands. Benefits included increased species richness (Brown 1991, Stauffer and Brooks 1997) and significantly higher number and percent cover of wetland species (Brown and Bedford 1997). Stauffer and Brooks (1997) concluded that more organic matter in the hydric soil improved the retention of moisture and nutrients, thereby helping to increase plant cover, density, and species richness. Another study, involving dike removal to restore a site, observed that disturbance of the soil resulted in vegetation dominated by cattails (Brown 1999).

Age of the Wetland

The effect of age on the vegetation of created and restored wetlands was noted in various studies (Reinartz and Warne 1993, Magee et al. 1999, Moore et al. 1999). Created and restored wetlands less than three years old differed, in terms of floristic composition, from sites three years and older (Reinartz and Warne 1993, Magee et al. 1999). Older sites had higher mean total plant cover and mean cover of native wetland species (Reinartz and Warne 1993). Moore et al. (1999) found that age, in addition to sedimentation, resulted in:

- A decrease in open water and water depth
- An increase in emergent and woody cover
- An increase in the number of plant species
- An increase in wetland vegetation species richness

In western Washington, Celedonia (2002) investigated the age at which canopy convergence occurs. The study found that "aerial [woody] cover increases with age until year 8 and remains constant into years 10-11." The author noted, "80% cover is generally achieved by year 8, and perhaps as early as year 7." The study found that the most abundant species in terms of frequency and cover were red alder (*Alnus rubra*), willows (*Salix spp.*), black cottonwood (*Populus balsamifera*) and red osier dogwood (*Cornus sericea*). In addition, Celedonia (2002) found that native woody cover was strongly correlated with the density of stems greater than 6.5 feet (2 m) tall, such that percent cover increased as stem density increased up to about 2,100 stems per acre. Sites with densities higher than 2,100 stems per acre generally had greater than 90% woody cover (Celedonia 2002).

Competition and Non-Native Vegetation

The effect of competition on vegetation has been examined in several studies. The studies focused on specific species or treatments used to manage vegetation, factors that affect competition with non-native species, and the presence and extent of non-native species on compensatory wetland mitigation sites.

A few of the studies were conducted outside of the Pacific Northwest, and may have limited applicability to Washington State. For example, in the southeastern United States McLeod et al. (2001) determined that an existing willow canopy did not detrimentally affect the survival of three under-planted tree species. In the Midwest, Budelsky and Galatowitsch (2000) experimented with hairy sedge (*Carex lacustris*). The authors concluded, "*C. lacustris* can produce dense stands under a primarily annual weed community within two to three growing seasons, but that reed canary grass (*Phalaris arundinacea*) can preclude successful establishment of *C. lacustris*" (Budelsky and Galatowitsch 2000).

In the western Washington, Celedonia (2002) found that reed canary grass (*P. arundinacea*) can exist at relatively high densities (as much as 40% aerial cover) under

abundant canopy cover (>95%). This study was not able to determine: 1) whether reed canary grass was actually spreading through the understory, or whether it was a remnant, and woody species were establishing 'over' it; or 2) the extent to which reed canary grass inhibits establishment of desirable plant species during the re-initiation of the understory (Celedonia 2002).

Research has identified two factors that affect competition with non-native species.

- **Shrub density.** Celedonia (2002) observed, "greater shrub layer densities were associated with less reed canarygrass." The author suggests that an initial planting of a very dense shrub layer (e.g., more than 3,000 stems per acre) may help to preclude domination of reed canarygrass (*Phalaris arundinacea*).

- **Land use.** Magee et al. (1999) found that "the number of introduced and invasive/introduced species per site increases significantly with more intensive land use."

A few studies investigated how many compensation projects experienced problems with invasive species or how many non-native species occurred on sites. In Washington State, Johnson et al. (2002) noted that 61% of compensatory mitigation sites had at least 25% of the site dominated by non-native species. Celedonia (2002) found that nearly half of the sites visited in Washington had greater than 10% cover of reed canarygrass. In a study conducted by the Michigan Department of Environmental Quality (2000), "8% of mitigation sites were found to have a problem with invasive species" (defined as constituting 10% or more of the vegetation community).

In the Portland metropolitan area of Oregon, a study of vegetation at compensatory mitigation wetlands observed that non-natives composed more than half of the species present and "nine of the 14 most common taxa were invasive introduced species" (Magee et al. 1999).

Seed or Plant Source

The seed or plant source has been identified as important for restored wetlands (Reinartz and Warne 1993, Galatowitsch and van der Valk 1995). Restoration wetlands seeded with native wetland species had higher diversity and richness and less cover by cattails than the unseeded wetlands (Reinartz and Warne 1993). Emergent perennial species rapidly recolonized restoration wetlands possessing a viable refugium of wetland plant species (e.g., present in existing ditches) that spread through vegetative rooting (Galatowitsch and van der Valk 1995). The importance of proximity to a seed source was mentioned by Reinartz and Warne (1993) but discounted by Galatowitsch and van der Valk (1995).

Kellogg and Bridgham (2002), however, found that low density planting "offered no clear advantages over hydrologic restoration." Though seeding of a cover crop appeared to limit the establishment of aggressive species such as *Phalaris arundinacea*, it also appeared to limit establishment of wet prairie and sedge meadow species (Kellogg and Bridgham 2002).

Human Manipulation

A study conducted in the Willamette Valley of Oregon examined the response of wetland vegetation to three techniques for the restoration of wet prairie: burning, hand removal, and mowing (Clark and Wilson 2001). Results indicated that:

- **Burning** significantly reduced the survival and percent cover of woody species and non-native forbs (e.g., common St. John's-wort [*Hypericum perforatum*]), increased flowering of slender rush (*Juncus tenuis*), and increased cover of native forbs (e.g., Spanish-clover [*Lotus purshiana*] and marsh speedwell [*Veronica scutellata*]), but decreased flowering of tufted hairgrass (*Deschampsia cespitosa*), the dominant wetland prairie grass.

- **Hand removal** significantly reduced cover by woody species and non-native forbs, increased cover of native forbs, but increased flowering of non-native grasses (e.g., velvet grass [*Holcus lanatus*] and sweet vernal grass [*Anthoxanthum odoratum*]).

- **Mowing** had no effect on cover of woody species, but it increased the flowering of non-native grasses and significantly increased flowering of slender rush.

The authors concluded that though "no treatment was clearly superior in fulfilling the restoration objectives" mowing with removal of cut material was specifically not recommended (Clark and Wilson 2001).

6.8.3 Soil Characteristics

Soils are a critical component of wetlands. Soil characteristics can influence the growth and development of vegetation as well as the ability of wetlands to perform certain water quality functions. Researchers have investigated several factors related to wetland soil characteristics at compensatory wetland mitigation sites, including:

- Organic matter content
- Bulk density (compaction)
- Particle size
- Nitrogen content

Several authors used the approach of comparing soil conditions of created wetlands with reference wetlands. In these studies, the reference wetlands were either of the same wetland types as the mitigation wetlands, or they were adjacent to the mitigation wetlands. Only one study compared treatment plots to control plots at created wetlands. None of the articles on soil characteristics involved non-regulatory projects. Only one was conducted within the Pacific Northwest.

Results consistently indicated that the soil of created wetlands had a lower content of organic matter than reference wetlands (Brown 1991, Bishel-Machung et al. 1996, Streever et al. 1996, Shaffer and Ernst 1999, Whittecar and Daniels 1999, Stolt et al. 2000). Bishel-Machung et al. (1996) found that created wetlands had less organic matter than reference wetlands regardless of the Cowardin class or hydrogeomorphic class.

In the Portland metropolitan area, Shaffer and Ernst (1999) observed that both reference and mitigation wetlands with a high extent and duration of standing water had a lower concentration of soil organic matter. However, the authors also observed a consistent pattern of lower concentrations of organic matter in the soil of mitigation wetlands compared to reference wetlands within the same soil series, texture classes, and associations. Since many of the mitigation wetlands in this study involved construction of a pond in an existing wetland, the authors hypothesized that organic matter in mitigation wetlands is being lost due to the excavation of upper soil layers during project installation (Shafer and Ernst 1999).

In studies examining created wetlands from one to 11 years old and one to eight years old, the age of the created wetlands did not have an effect on organic matter content of the soil (Shaffer and Ernst 1999, Bishel-Machung et al. 1996). Concentrations of organic matter were relatively uniform between surface and subsurface samples. This indicated that accumulation of organic matter was either not occurring or was occurring so slowly it was not detectable (Bishel-Machung et al. 1996, Shaffer and Ernst 1999).

Stauffer and Brooks (1997) examined the effect of adding organic soil amendments to created wetlands. The authors found that plots treated with "salvaged marsh surface" (hydric topsoil) and leaf litter compost contained more organic matter than untreated, control plots. After two growing seasons, soil organic matter remained higher in plots treated with organic soil amendments.

Studies looking at particle size, bulk density, and nitrogen content found that soils in created wetlands had more sand, higher bulk densities (more compacted), and a lower nitrogen content than reference wetlands (Bishel-Machung et al. 1996, Whittecar and Daniels 1999, Stolt et al. 2000). In combination with low organic content, the soil characteristics of created wetlands may hinder plant establishment and growth (Whittecar and Daniels 1999, Stolt et al. 2000), denitrification and pollutant trapping (Stolt et al. 2000), and redox conditions (Bishel-Machung et al. 1996), thereby influencing microbial activity (Whittecar and Daniels 1999).

In contrast, Gilliam et al. (1999) found that redox levels and nitrogen content (in the form of ammonia) at an eight-month-old created wetland were comparable to a reference wetland after the created wetland was inundated. However, pH, phosphorus, manganese, magnesium, and zinc did not change noticeably at the created site. The authors concluded that eight months was "an insufficient period of time for a complete change toward hydromorphic soils."

6.8.4 Water Quality

Most of the water quality studies investigated the ability of created or restored wetlands to retain sediment, phosphorus, nitrogen, or some combination. One study compared water quality attributes at created and reference wetlands (Streever et al. 1996). None of the studies were conducted in the Pacific Northwest.

6.8.4.1 Comparison of Water Quality at Created and Reference Wetlands

Streever et al. (1996) determined that created wetlands had higher pH and conductivity than reference wetlands. The authors hypothesized that the amount of organic matter in the soil is related to pH and conductivity: "because decomposition of organic material releases CO2, lower pH values would be expected in natural systems with well-developed organic soils. A well-developed organic substrate may isolate surface water from underlying sand and rock, leading to decreased dissolution of minerals and lower conductivity." (See the previous discussion of soil characteristics in Section 6.8.3.)

6.8.4.2 Sediment Removal

Findings related to retention of sediment by created wetlands include the following:

- Wetlands created adjacent to roads were effective at retaining sediment, such that inflow culverts were clogged by accumulated sediment at a couple of sites (Moore et al. 1999).

- Mitsch (1992) found that a created wetland retained 90% of sediments, while a reference wetland retained 3%. The actual amount of sediment retained depends upon the loading rate.

- Fennessey et al. (1994) investigated the location within a created wetland where sediment was retained. Rates of sediment deposition, in general, were highest near the inflow and decreased as distance from the inflow increased, "except when outflow ceased, in which case the maximum sedimentation often occurred near the outfall." Open water areas also had higher sediment deposition than vegetated areas, which restricted flow. The authors observed that vegetation seems to present a barrier to water and sediment flow and, therefore, the study "did not illustrate the conventional belief that the presence of vegetation enhances sedimentation." The authors concluded, "deeper open water areas are more conducive to sediment accumulation than are shallower open water areas that are more easily subjected to wind-driven and biological sediment disturbances and subsequent re-suspension."

6.8.4.3 Nutrient Removal

In several studies, phosphorus retention at created or restored wetlands ranged from 16 to 96% (Mitsch 1992, Mitsch et al. 1995, Niswander and Mitsch 1995, White et al. 2000). In all but one of these studies, created/restored wetlands retained at least 53% of phosphorus (Mitsch 1992, Mitsch et al. 1995, White et al. 2000). The percent of retention varied depending on:

- Whether the wetland experienced high or low flows (Mitsch 1992, Mitsch et al. 1995)
- The configuration of the outflow
- The amount of time water was retained in the wetland (Niswander and Mitsch 1995)

White et al. (2000) mentioned that a restored wetland's capacity for phosphorus retention is limited. Sediments near the wetland inflow had a limited ability for additional uptake of phosphorus. However, approximately 66% of the marsh sediments still had a high capacity for uptake. The authors concluded, "future treatment efficacy may decrease if the remaining sediments become saturated. Continued high P [phosphorus] loading to the marsh may lead to eutrophication problems and downstream P export from the wetland."

Romero et al. (1999) found that total nitrogen retention was 30 to 91% at four restored wetlands. The authors attributed this to the high retention of dissolved inorganic nitrogen, while the retention efficiencies for particulate and dissolved organic nitrogen were much lower. The authors observed no significant difference between nitrogen retention and the age of the restored wetland.

Woltemade (2000) examined the factors that affect the ability of a created or restored wetland to retain nutrients. The most critical design elements for wetlands constructed to treat agricultural runoff were determined to be the retention time (amount of time that water is retained in the wetland) and the wetland-to-watershed ratio (size of the wetland compared to the size of its contributing basin):

> *If nutrient and sediment concentrations are to be reduced to acceptable levels on a landscape scale, drainage water must be retained for at least one to two weeks within wetlands before being discharged into streams. Monitoring of restored wetlands indicates that the longer the retention time, the greater the water quality benefits. . . Ultimately, the appropriate size of a restored wetland will depend on the contaminant of greatest local concern that requires the longest retention time for its degradation, and on the percent reduction of this contaminant that is required seasonally, annually, or interannually (van der Valk and Jolly 1992).* (Woltemade 2000).

6.8.5 Water Quantity

No studies were found that discussed the ability of created or restored wetlands to perform water quantity functions, such as decreasing downstream erosion or reducing peak flows, or that mentioned factors influencing a wetland's ability to perform water quantity functions.

Two studies compared the water regime of compensatory mitigation wetlands with reference wetlands. Both found that the compensatory wetlands had more standing water for a longer period (Shaffer et al. 1999, Cole and Brooks 2000).

6.8.5.1 Using Hydrogeomorphic (HGM) Classification to Study Water Regime at Mitigation Sites

Differences in the water regime between existing wetlands and mitigation wetlands have been examined by several researchers in the Pacific Northwest and elsewhere. The researchers used the hydrogeomorphic (HGM) classification to compare the water regimes of existing wetlands with those of mitigation wetlands. As described in Chapter 2, the HGM classification is based on the position of the wetland in the landscape (geomorphic setting), the wetland's water source, and the flow and fluctuation of the water once in the wetland. These are some of the major environmental factors that control wetland functions (National Research Council 1995).

Gwin et al. (1999) focused on HGM classifications of wetlands to determine how compensatory mitigation was affecting the wetland resource in and around Portland, Oregon. Classification of reference wetlands resulted in three regional HGM classes that were typical in the Portland metropolitan area: slope, riverine, and depressional. However, classification of mitigation wetlands

> *required development of new, atypical HGM classes to describe the unique combinations of site morphology and landscape setting found in these wetlands:*
>
> - *depression-in-riverine setting,*
> - *in-stream-depression, and*
> - *depression-in-slope setting* (Gwin et al. 1999).

Atypical refers to created or enhanced wetlands that do not match the geomorphic setting, water source, and/or hydroperiod found within the range of existing wetlands in a region. Gwin et al. (1999) characterized atypical classes by:

- Exaggerated depressional morphology with steep banks
- Large areas of open and/or deep water
- A large berm isolating the wetland from an adjacent stream channel
- Excavation within the stream channel producing an open water area wider and deeper than the original stream

In Washington 35% of compensatory mitigation projects resulted in wetlands of an atypical HGM class (Johnson et al. 2002). In Portland, Gwin et al. (1999) found that almost all of the enhanced wetlands and nearly half of the created wetlands resulted in an atypical HGM class.

What are the hydrologic consequences of creating atypical wetlands in the landscape? Shaffer et al. (1999) examined hydrologic conditions in reference and mitigation wetlands in the Portland metropolitan area. The study compared the regional HGM classes identified by Gwin et al. (1999)—slope, riverine, and depressional—with the atypical classes for mitigation wetlands—depression-in-riverine setting, depression-in-slope setting, and in-stream-depression. The results indicated significant differences. For example, slope wetlands had the lowest extent, depth, and duration of inundation, "while depression-in-slope wetlands had the highest water levels and greatest extent/duration of inundation" (Shaffer et al. 1999).

Similarly, Cole and Brooks (2000) noted that created wetlands were dominated by open water, while "most naturally occurring mainstem floodplain wetlands in central Pennsylvania are vegetated with very little open water." The authors concluded, "in the rush to make sure there is some water in mitigation wetlands we have gone too far in keeping sites inundated. In reality, many wetlands are merely saturated, or much drier" (Cole and Brooks 2000).

Schaffer et al. (1999) state:

> *Unless wetlands are restored or created in a manner that reproduces the hydrogeomorphic characteristics of naturally occurring wetlands in a region, management activities are unlikely to maintain or replace hydrologic and other valued functions of wetlands*.

Similarly, Cole and Brooks (2000) conclude:

> *The ecological consequences of a different hydrologic regime are clear. Standing water will promote anaerobic conditions in the soil, and the resulting soil chemistry will be defined by anaerobic pathways (Mitsch and Gosselink 1993). When combined with other common construction effects (e.g. soil compaction), this leads to difficult conditions for plant community establishment.*

In addition, water regimes exhibiting extensive areas of open water in mitigation wetlands hindered the formation of soil organic matter (Shaffer and Ernst 1999).

6.8.6 Summary of Key Points

- Functions performed and characteristics produced by created, restored and enhanced wetlands differed from those performed and produced by reference wetlands, except water quality functions, which appeared to be performed in a similar capacity.

- Most studies determined that reference wetlands provided habitat for a greater diversity or abundance of wildlife than created or restored wetlands. Birds were an exception since half of the studies found no difference between created/restored sites and reference wetlands, particularly for ducks.
- A variety of factors appeared to influence the abundance and diversity of wildlife at created or restored wetlands: development of vegetation communities, particularly emergent vegetation communities; age of the wetlands, which is often associated with the development of vegetation communities; and availability of a food source, often invertebrates, which is also often associated with the development of vegetation communities.
- Amphibian communities were affected by additional factors, such as the hydroperiod of the wetland, the presence of fish, distance to other wetlands, connectivity between terrestrial and wetland habitats, and surrounding land uses.
- Created and restored wetlands have different vegetation characteristics and plant communities than reference wetlands. A few studies found that certain plant communities, such as sedge meadows, may require many years to develop, if they develop at all.
- Compensatory mitigation is producing more acreage of open water wetlands than was lost. The ability of compensatory mitigation to produce other Cowardin classes varied.
- Several major factors were found to affect vegetation and plant communities, including the age of the wetland (older created/restored sites had a higher percent cover of emergent and woody species than younger sites); soil conditions (positive effects on vegetation resulted from adding hydric topsoil); competition (reed canarygrass can be problematic when attempting to establish emergent vegetation); and a source of native seeds or plants (this may speed up recolonization and increase diversity).
- Created, restored, and enhanced wetlands had less organic matter than reference wetlands. In addition, organic matter at compensation wetlands did not appear to accumulate over time. Plant establishment at compensation sites could be hindered by the low organic content in conjunction with soils that were found to be sandier, more compacted, and lower in nitrogen than soils at reference wetlands.
- Created and restored wetlands were comparable to reference wetlands at retaining sediments, phosphorus, and nitrogen. Factors affecting sediment and nutrient retention included the volume of water flowing into the wetland, the length of time water remains in the wetland, and the size of the wetland compared to the size of the basin.
- Some compensatory mitigation wetlands produced different HGM classes than were present in reference wetlands. This has resulted in wetlands that have more inundation for a longer duration than reference wetlands.

6.9 Reproducibility of Particular Wetland Types

This section discusses findings from the literature regarding the ability to restore, create, or enhance certain wetland types, such as bogs and fens, vernal pools, alkali wetlands, and mature forested wetlands.

6.9.1 Bogs and Fens

Bogs and fens are characterized by their highly organic soils, water regimes, and water chemistries. There were no studies of bog or fen restoration conducted in the Pacific Northwest. However, studies of bog and fen restoration in Northern Europe and Canada concluded that restoration may not be possible due to "irreversible changes of the biotic and abiotic properties" (Schouwenaars 1995, Schrautzer et al. 1996). This includes soil compaction and eutrophication (Grootjans and van Diggelen 1995, Schrautzer et al. 1996, Wind-Mulder and Vitt 2000) and other alterations to bogs resulting from drainage, peat harvesting, pollution, and agricultural practices (National Research Council 2001).

The studies mentioned difficulties in restoring bog vegetation communities (Bolscher 1995, Grosvernier et al. 1995, Schouwenaars 1995, Schrautzer et al. 1996), water regime (Grootjans and van Diggelen 1995, Schouwenaars 1995), and/or water chemistry (Wind-Mulder and Vitt 2000). Major conclusions include the following:

- Restore the water regime and the vegetation community will follow (Grootjans and van Diggelen 1995, Grosvernier et al. 1995).
- Prior to any restoration activity, the chemical state of the bog must be assessed. This influences the vegetation community and will, therefore, dictate the development of a restoration plan (Wind-Mulder and Vitt 2000).
- "Hydrological research may be crucial for a correct assessment of perspectives for rewetting" (Schouwenaars 1995). Prior to restoration it is necessary to determine the reason for a low water table because this affects the activities that will be required to restore a suitable water regime for the desired vegetation communities (Schouwenaars 1995).
- Bogs that were restored by rewetting and tree removal "differed from those of natural raised bogs, particularly in having taller and denser vegetation, a smaller range of moisture gradient and a more uniform vegetation physiognomy. Rewetted bogs did not have an undulating surface relief of hummocks and hollows" (Bolscher 1995).
- The best chance for restoration lies with restoring the least disturbed or damaged bogs or fens (Grootjans and van Diggelen 1995, Schrautzer et al. 1996).
- Restoration of bogs or fens will not yield rapid results (Grootjans and van Diggelen 1995).

- "Research has demonstrated that natural recovery of the moss surface following harvesting takes about 20 years (Elling and Knighton 1984)" (National Research Council 2001).

In terms of creation, research indicates that in reference systems organic soil (peat) accumulates at 0.1 to 3.8 mm per year (National Research Council 2001). At this rate it would take from 7 to 250 years for just 1 inch of peat to accumulate.

No information was available on the success or compliance of bogs or fens that were restored or created as wetland compensation. However, the literature suggests that bogs and fens cannot be reproduced within a regulatory timeframe.

6.9.2 Vernal Pools

Vernal pools are characterized by their short duration of inundation (National Research Council 2001). Thus, in order to reproduce a vernal pool, a site with a suitable substrate must be found and the correct depth and hydroperiod must be created or restored (National Research Council 2001). "In a long-term study of California vernal pools that were created by excavating depressions near natural pools, the hydroperiods did not converge with those of the reference systems until year 10 (Zedler et al. 1993)" (National Research Council 2001). If the hydroperiod is too long, the result will be an emergent marsh or an open water or aquatic bed system. If the site has inadequate substrate or is too shallow, the result may be upland with no inundation.

In terms of compliance, De Weese (1998) examined over 1,500 created vernal pools in California. She found that 83% of projects were in permit compliance, 96% met their hydrologic performance standards for depth of inundation, and 69% met vegetation performance standards. Seventy-two percent of projects were compared with reference vernal pools to determine their biological viability, while 35% of projects required some site remediation.

Guidance on construction has helped to transform the steep-sided "bathtubs" into pools that more closely mimic reference pools with gradual, vegetated slopes (De Weese 1998). De Weese (1998) concluded, "The art and science of constructing vernal pools have greatly improved over the past eight years [1987 to 1994]."

The literature suggests that, in California, vernal pools may be reproduced under the right conditions. However, the right conditions typically occur where vernal pools already exist, so creation of new pools merely increases the density of pools in an area (National Research Council 2001).

No information was found on the reproducibility of vernal pools in Washington.

6.9.3 Alkali Wetlands

No information was found that addressed the reproducibility of alkali wetlands.

6.9.4 Mature Forested Wetlands

Though studies have found that forested wetlands can be reproduced in Washington (Celedonia 2002, Johnson et al. 2002), *mature* forested wetlands have not been successfully reproduced simply because of the time necessary for the trees and the structural characteristics of the forest to mature (National Research Council 2001). Enhanced and created sites that have been planted often have a high density of stems to rapidly provide woody cover and shade out invasive species in the understory (Celedonia 2002, National Research Council 2001). Within a regulatory time-frame, compensatory mitigation wetlands may not begin to reproduce some of the attributes of mature forested reference wetlands unless these sites are thinned (National Research Council 2001).

6.9.5 Summary of Key Points

- The reproducibility of some wetland types is generally dependent upon time. For example, bogs, fens, and mature forested wetlands require several decades at a minimum, and possibly centuries, to develop the structural, chemical, biological, and hydrological attributes that characterize these wetland types.
- Studies suggest that vernal pools, at least in California, may be reproducible under the right conditions.

6.10 Suggestions from the Literature for Improving Compensatory Mitigation

A number of reports and articles suggested or recommended changes that could be made to help improve the effectiveness of compensatory wetland mitigation or alleviate problems that were frequently encountered. The recommendations described below are those of the authors of the literature sources cited, not the agencies or staff who have synthesized the information in this volume.

Data from a variety of sources are summarized throughout this section in a series of tables. To simplify the tables and efficiently use space, each literature source listed in the tables is represented by a reference number listed in Table 6-10. This is not a comprehensive list of all references cited in this section; see the references section at the end of Volume 1 for a complete list of literature sources.

Table 6-10. Literature sources and corresponding reference numbers.

Reference No.	Literature Source	Reference No.	Literature Source
1	Allen and Feddema (1996)	19	Shaich and Franklin (1995)
2	Balzano et al. (2002)	20	Storm and Stellini (1994)
3	Brown (1999)	21	Ossinger (1999)
4	Ashworth (1997)	22	Wilson and Mitsch (1996)
5	Erwin (1991)	23	Barry et al. (1996)
6	Gwin and Kentula (1990)	24	Castelle et al. (1992a)
7	Holland and Kentula (1992)	25	Celedonia (2002)
8	Holland and Bossert (1994)	26	Chovanec (1994)
9	Johnson et al. (2000)	27	Hunt et al. (1999)
10	Johnson et al. (2002)	28	Kentula (2000)
11	Stauffer and Brooks (1997)	29	National Research Council (2001)
12	Kentula et al. (1992)	30	Race and Fonseca (1996)
13	Kunz et al. (1988)	31	Sheldon and Dole (1992)
14	Shaffer and Ernst (1999)	32	Whittecar and Daniels (1999)
15	Michigan Department of Environmental Quality (2000)	33	Zedler and Callaway (2000)
16	Mockler et al. (1998)	34	Mitsch and Wilson (1996)
17	Morgan and Roberts (1999)	35	Breaux and Serefiddin (1999)
18	Robb (2002)	36	Kellogg and Bridgham (2002)

The scientific literature contained recommendations that fall into three main categories:

- Recommendations for regulators of compensatory mitigation, including guidance on mitigation plans and monitoring reports, compliance tracking and enforcement, and alternative mitigation options
- Recommendations for site selection and design, including comprehensive wetland planning, baseline monitoring, hydrologic analysis, and considerations for site design
- Recommendations for implementing compensatory mitigation, including having a wetland biologist on-site to oversee construction activities, performing monitoring and maintenance of the site

The scientific literature provided more extensive information on additional topics:

- Performance standards
- Compensatory mitigation using a watershed approach
- Mitigation banking and in-lieu fees

Each of these is discussed below.

6.10.1 Regulatory Improvements

Of the suggestions provided by the scientific literature, the majority focused on elements that regulatory agencies should address (Table 6-11), such as:

- Improving guidance for every step of the mitigation process, from avoidance and minimization to submitting a monitoring report for a compensation wetland. This should help regulators with decision-making and provide applicants and consultants with more predictability
- Adjusting replacement ratios to reflect the risk of failure
- Requiring financial assurances or performance bonding
- Protecting all compensatory mitigation sites in perpetuity with a legal mechanism, such as a deed restriction or conservation easement
- Increasing regulatory follow-up and enforcement of compensatory mitigation projects, including developing and maintaining a database and filing system, allocating staff to perform compliance and enforcement activities, and implementing reviews of regulatory program performance
- Developing and implementing alternative mitigation options, such as advance mitigation, mitigation banking, and in-lieu fees

Table 6-11. Suggestions from the literature for regulatory improvement.

Suggestion	Reference No. [a]
Improve mitigation sequencing (i.e., avoidance and minimization)	5, 19, 29, 2, 10
Improve guidance for compensation projects, focusing on replacing functions as well as area	22, 29, 10
Improve site selection criteria. Site selection should be based on a watershed scale to maintain diversity, connectivity, and a balance of upland and wetland	5, 12, 15, 29, 2, 10
Improve goals, objectives, and performance standards, so that they are measurable, meaningful, achievable, and enforceable	13, 5, 31, 20, 19, 17, 9, 29, 10, 21
Standardize report format and elements for mitigation plans and monitoring reports, including an implementation schedule	13, 7, 8, 20, 17, 15, 2, 10

Suggestion	Reference No. [a]
Adjust (increase) replacement ratios to reflect the risk of failure. This should be based on the level of success of previous projects	1, 2, 18
Require performance bonding/financial assurances	13, 5, 8, 20, 15, 29, 2, 18
Require that compensation wetlands be protected in perpetuity with some kind of legal mechanism, such as a deed restriction or conservation easement	20, 29
Improve regulatory follow-up and enforcement of compensatory mitigation projects	5, 20, 19, 1, 30, 17, 15, 9, 29, 10, 18
Develop and maintain a permit/compensatory mitigation project tracking database and filing system	5, 7, 20, 19, 1, 17, 9, 15, 29, 2
Allocate staff for compliance and enforcement	5, 19, 17
Implement regular reviews of regulatory program performance	7, 19, 2
Implement studies of cumulative wetland loss (beyond what is recorded for regulatory permitting programs)	19, 1
Develop and implement alternative compensatory mitigation options: in-lieu fees, mitigation banking	20, 19, 1, 15, 29
Perform the compensatory mitigation in advance of the wetland loss	30, 29, 10, 18
[a] See Table 6-10 for a listing of literature sources that correspond to each reference number.	

6.10.2 Improving Site Selection and Design

The scientific literature also suggested site selection and design considerations (Table 6-12), including:

- Using a watershed approach to improve site selection
- Prioritizing wetland restoration
- Performing baseline monitoring of the wetland to be lost, identifying the wetland types and functions so that they can be replaced more effectively
- Performing baseline monitoring of the areas proposed for compensation to document the existing conditions and level of function
- Performing a hydrologic analysis for compensation wetlands to identify where the water will come from, how it will get to the site, and what the extent and duration of inundation or saturation will be
- Designing the compensation site to be self-sustaining and incorporating or simulating natural processes and structures, such as hydroperiods, slopes, shorelines, soils, topography, and vegetation

Table 6-12. Suggestions from the literature for improving site selection and design.

Suggestions	Reference No.[a]
Ensure that compensation wetlands will have a suitable source of water and compatible adjacent land uses	5, 28, 17, 29, 2, 10
Use a watershed approach to select compensation sites and support comprehensive wetland planning	19, 1, 28, 17, 29, 10
Prioritize restoration as the first choice for compensatory mitigation	17, 15, 29
Design compensatory mitigation wetlands to be self-sustaining and incorporate natural processes whenever possible	33, 29
Perform baseline monitoring of wetlands to be lost and areas proposed for compensatory wetland mitigation. Monitoring should characterize hydroperiod, soils, water quality, macroinvertebrates, and wetland functions	13, 5, 31, 20, 29, 10
Perform hydrologic analysis: identify hydrologic source, how water will get to the site, the intended depth and duration of inundation, and demonstrate that water source will be reliable and adequate Determine appropriate hydroperiod/hydrologic inputs early in the design stage, so that the water levels of the compensation wetland dictate how to design the building sites and roads, rather than letting the upland development create poor wetland conditions (too wet or too dry)	5, 31, 16, 28, 2
Grade slopes to be as gentle as possible; they should match the slopes of adjacent natural wetlands	6
Provide heterogeneous topography. For example, simulate microtopographic "mound and pool" features (e.g., wind-thrown or toppled trees)	23, 29
Incorporate native upland ecosystems into compensatory mitigation sites	5, 29
Deconsolidate (i.e., break-up) soils to reduce compaction and amend to insure adequate soil organic matter (e.g., 2 inches of coarse sand and 4 inches organic compost, natural hydric muck, or topsoil)	6, 16, 28, 32, 14
Take advantage of native seedbanks, natural recruitment, and salvaged topsoil and plants when available and feasible	29, 3, 4, 11
Minimize human encroachment by planting dense vegetation around the site or installing fences	26, 20, 16
Establish rapid canopy convergence and limit invasive species infestations by planting trees and shrubs at specific densities	25
Indicate the boundaries of the site with signs and markers	20, 16

[a] See Table 6-10 for a listing of literature sources that correspond to each reference number.

6.10.3 Improving Implementation

Compensatory wetland mitigation projects would be greatly improved if they were implemented as designed (Johnson et al. 2000, Balzano et al. 2002). The scientific literature provides numerous suggestions for improving implementation (Table 6-13), such as:

- Having a wetland biologist on-site during construction
- Monitoring the compensation wetland
- Develop an adaptive management plan that allows potential problems to be detected early and identifies how problems will be addressed
- Maintaining the compensation wetland to avoid problems and manage them early in the development of the site

Table 6-13. Suggestions from the literature for improving implementation.

Suggestion	Reference No.[a]
Wetland biologist on-site to oversee construction or train/educate contractors and to authorize and document any necessary changes	5, 31, 9, 2
Monitoring of mitigation sites should characterize baseline, construction, as-built, and post-construction conditions. Monitoring reports should include a section on lessons learned	13, 6, 5, 24, 7, 31, 8, 20, 19, 15, 9, 2, 10
Monitoring parameters and methods should be specific to a project's goals, objectives, and should include: project size, shape, topography, hydroperiod, water quality, flora, and fauna	5, 17, 33
Monitor compensatory mitigation wetlands. Duration of monitoring may range from 3 to more than 20 years, depending on the size of compensation wetland, the proposed wetland type (e.g., Cowardin class), and the likelihood of success	5, 34, 35, 17, 15, 10, 29, 36
Monitor hydrology during the first growing season to characterize the site's hydroperiod. Develop and implement a planting plan after the hydroperiod has been characterized	27
Perform long-term monitoring after a project has been deemed successful to keep track of it over time, study how it matures, use it as model for other sites	5, 28, 36
Develop an adaptive management program, which includes early monitoring of wetland structure, processes, and functions to detect potential problems and allow for corrective actions	29
Maintain compensatory mitigation sites, including a contingency plan for how to address problems. Maintenance should focus on controlling invasive species, providing irrigation, replacing dead plants, correcting slopes and topography	13, 24, 31, 8, 2, 10, 29
[a] See Table 6-10 for a listing of literature sources that correspond to each reference number.	

6.10.4 Performance Standards

Performance standards, performance criteria, success criteria, success measures, standards of success, and other terms all refer to regulatory conditions used to determine how effective a mitigation project is at meeting regulatory requirements, which may or may not include compensating for wetland loss. Ideally performance standards should serve as "measurable benchmarks used to evaluate the development of ecological characteristics associated with specific wetland functions" (Azous et al. 1998). Performance standards allow regulators to determine if a compensatory mitigation project has fulfilled its goals, and also provide a mechanism for regulators to implement enforcement actions against unsuccessful projects (Streever 1999).

As explained in Chapter 2, wetlands differ in how they function, by geomorphology and water regime and other characteristics. Compensatory wetland mitigation projects, likewise, exhibit considerable variability with different types of wetland compensation (creation, restoration, etc.). The variability makes it difficult to develop and require universal performance standards, yet in the absence of some kind of uniformity, performance standards that are approved can lack meaning.

6.10.4.1 Shortcomings of Existing Performance Standards

Sheldon and Dole (1992) performed a study of eight compensatory mitigation projects in King and Snohomish Counties in Washington. The authors observed that "none of the goal statements provided a quantifiable method of determining success, thus they provided no means for an agency to assess success/failure or to require remediation." The Michigan Department of Environmental Quality (2000) similarly found, "The practice of including no specific performance standards, or only very general performance standards (regarding the size and possibly the type of wetland to be constructed), resulted in many unenforceable permits and contributed to the poor quality mitigation wetlands."

Johnson et al. (2000), in their study of 45 compensatory mitigation wetlands, noted some problems with performance standards, such as:

- Standards that are too general or "easy to attain" and, therefore, are not indicative of ecological development at a site
- Standards that are not measurable and, therefore, cannot be used to evaluate the success or compliance of projects
- Standards that contain confusing or ambiguous language and, therefore, result in inaccurate assessment or preclude assessment

In addition, Johnson et al. (2002) in their evaluation of 24 compensation projects excluded performance standards that were unrealistic, not feasible, or so rigorous that the standard may never be attained. Such standards were ". . .setting sites up for failure" and therefore ". . .did not reflect how the site was functioning or progressing ecologically"

(Johnson et al. 2002). Ossinger (1999), in a guidance document for the Washington State Department of Transportation, suggests that performance standards should strike a balance between accountability and flexibility. The author recommends that crafting performance standards requires a technical knowledge of the quantitative values that are achievable, or to be expected, for the wetland attributes targeted by the standard.

Approved mitigation projects can also lack performance standards for important wetland functions or conditions. Breaux and Serefiddin (1999) discovered in their review of 110 projects in San Francisco, California, that only 22% had quantitative standards focusing on hydrological parameters. Johnson et al. (2000) reviewed 179 performance standards from 36 projects and observed that 8% of the performance standards related to hydrological conditions. The Michigan Department of Environmental Quality (2000) found that "none of the permits examined contained any specific criteria regarding vegetation or hydrology by which the mitigation wetland could be judged for success or failure." Johnson et al. (2002) noted that most of the projects evaluated in their study of 24 compensation wetlands lacked basic standards for wetland area, water regime, area of Cowardin classes, percent cover of native wetland vegetation, and maximum percent cover of invasive vegetation.

Breaux and Serefiddin (1999) argue, "In seasonal wetlands, hydrology clearly ought to be the reigning criterion given that the successive presence and absence of water is the defining characteristic of a seasonal wetland." However, the authors go on to admit, "there is no agreement as to what the specific hydrological criterion should be."

6.10.4.2 Use of Reference Wetlands in Developing Performance Standards

Brinson and Rheinhardt (1996) state that "the proper use of reference wetlands removes potential bias and provides the foundation for more objective functional-assessment procedures…reference wetlands should be central to the development of standards against which impacts to wetlands and restoration efforts are evaluated."

Azous et al. (1998) also support the use of reference wetlands:

> *By collecting data on the ecological characteristics associated with reference wetlands, and created or restored wetlands, standards of comparison can be established by which to judge the development of wetland characteristics in compensatory mitigation projects. The use of regional reference wetland characteristics provide greater assurance that project performance standards will be reasonable (i.e., attainable) and useful gauges of the development of wetland functions.*

For example, a compensation wetland might have a goal to provide amphibian habitat by the end of the monitoring period. Based on an evaluation of 24 depressional, flow-through, reference wetlands in the Puget Lowlands of western Washington, Azous et al. (1998) proposed performance standards to determine if amphibian habitat had successfully been established. "The standards include specific guidelines for planning

and designing mitigation projects to provide preference for the establishment of amphibian breeding, feeding, and refuge habitats." The authors suggested the following standard, "Wetlands created for amphibian habitat should have thin-stemmed emergent plants that comprise at least 30% or more of the total wetland area (Azous et al. 1998)."

However, Whittecar and Daniels (1999) mention a problem with using reference wetlands to develop benchmarks or performance standards for compensatory mitigation:

> *[U]nlike the mitigation site, reference wetlands coexist with landforms that may have required thousands of years to form (Brinson et al. 1995). Each wetland has a history that influences modern functions. Many of these functions will not redevelop in the new wetland within a time span acceptable to regulatory constraints without thoughtful planning and careful attention to construction.*

Ehrenfeld (2000) recommends that reference sites be identified in urban areas and used to develop attainable performance standards for compensatory wetland mitigation projects that are also located in urban areas. The author states: "Measures of restoration success and functional performance must start with an appreciation and assessment of the particular conditions imposed by the urban environment."

6.10.4.3 Longer Period Needed to Evaluate Projects

Part of the problem with developing achievable performance standards is that monitoring periods or regulatory timeframes for the majority of compensatory mitigation projects are relatively short (five to 10 years). The "success" or compliance of compensatory mitigation projects is, therefore, determined or evaluated when the site is still relatively young and immature (Kentula 1995, Mitsch and Wilson 1996). Longer monitoring periods are necessary to allow for secondary succession and natural events (e.g., drought or floods) that may affect or restructure vegetation communities (Kellogg and Bridgham 2002). Long term monitoring would also result in larger data sets upon which realistic performance standards and project goals could be based (Kellogg and Bridgham 2002).

If projects are to be evaluated within five to 20 years, then they should be compared to other compensatory mitigation projects. Kentula (1995) suggests comparing "wetland creation and restoration projects to each other and to similar, naturally occurring wetlands to define standards for project performance over time." She describes an approach for developing performance standards based on monitoring information from previous projects. "In this way, we can be assured that new projects are doing at least as well as past projects."

Celedonia (2002) implemented Kentula's approach by conducting a study of 29 compensatory mitigation projects from six to 11 years old in the lowland wetlands of western Washington. Time series curves were created from the data to determine at what point in time projects could be expected to meet certain vegetative standards, such as percent areal cover of woody vegetation. Based on the data, the author proposed that by year eight a mitigation site could attain 80% cover of native woody vegetation.

6.10.5 Compensatory Mitigation Using a Watershed/Landscape Approach

In the context of compensatory mitigation, a watershed approach means:

> *to recognize that management of wetland types, functions, and locations requires structured consideration of watershed needs and how wetland types and location serve these needs. A watershed approach means that mitigation decisions are made with a regional perspective, involve multiple agencies, citizens, scientists, and nonprofit organizations, and draw upon multiple funding sources (e.g., permittee-responsible, mitigation banks, and in-lieu fees). A watershed approach means that permitting decisions are integrated with other regulatory programs (e.g., storm water management or habitat conservation) and nonregulatory programs (e.g., conservation easement programs)* (National Research Council 2001).

Bedford (1996) explained the need for a watershed/landscape approach as follows:

> *From a policy perspective, the central issue in wetland mitigation is not the effects on a single site but the cumulative effect of numerous mitigation decisions on landscapes. Mitigation must be recognized as a policy that has the potential to re-configure the kinds and spatial distribution of wetland ecosystems over large geographic areas. … The net effect is the loss of wetland diversity in terms of both hydrologic functions and biological communities, and a consequent homogenization of wetland landscapes. One way to avoid such cumulative effects is to make decisions about individual projects within a framework focused at larger scales (Lee and Gosselink 1988).*

This section describes recommendations from the literature for methods to implement a landscape or watershed-scale approach in order to improve the success of mitigation projects. Further discussion of restoration using a landscape approach is included in Chapter 7 in the context of addressing cumulative impacts to wetlands.

6.10.5.1 Methods for Implementing a Landscape Approach

Three types of watershed planning are described in a report by the National Research Council (2001):

- **Management-oriented** wetland planning, which would replace case-by-case permitting. Decisions about permitting, mitigation sequencing, and the acreage, type, and location of compensation would be made in advance using a watershed approach. This type of watershed plan would require regulatory and non-regulatory programs to be coordinated.

- **Protection-oriented** wetland planning, which is focused on avoiding wetland loss and alteration by identifying wetlands and their ecological value. This type of watershed plan would be used during the mitigation sequencing process.

- **Compensation** wetland planning, which "identifies watershed needs for types, functions, and general locations of wetlands in the landscape in order to establish restoration priorities for both regulatory and nonregulatory programs. …This type of planning might link projects undertaken through both regulatory and nonregulatory programs to secure some desired mosaic of wetlands in the landscape."

Hashisaki (1996) discusses the utility of a landscape-level analysis to examine conditions not just at an impact, compensation, or reference site, but also in the surrounding landscape. A landscape-level analysis "considers the effect of historic, current, and proposed land management practices on the individual functional indicators. . . . In addition to identifying constraints on land management practices, it can be useful in identifying critical preservation and restoration opportunities. Understanding the control that human activities exert on the disturbance regimes of an ecosystem allows projections about expected future conditions."

Bedford (1996) recommends developing wetland profiles/templates based on the diversity of wetland types that exist in a region as a result of the unique interaction of hydrogeology and climate. By understanding the current and historic wetland types and their relative abundances in a region, decisions regarding compensatory mitigation can be made to help maintain the diversity and hydrologic equivalence.

In some cases, using a watershed approach may result in a watershed plan that identifies all the wetlands in an area and assesses the functions that they perform. Hruby and Scuderi (1995) used this approach for a watershed near Seattle, Washington, that was experiencing development pressure. The goal of the plan was "to ensure that the performance of wetland functions and their societal values continue to be equal to or greater than those currently existing…" (Hruby and Scuderi 1995). Wetland areas targeted for restoration or enhancement were assessed to quantify how much wetland function could be gained. The proposed/potential gain in function through restoration/enhancement could then be used to determine how much wetland function could be lost to development activities in the watershed.

A report by the National Research Council (2001) proposed that "Functional tradeoffs might be considered in the context of the needs of the watershed." A watershed plan would be developed for an area, such that the functions of wetlands proposed for loss or alteration are understood, as well as the needs of the watershed for wetland functions. Functions that are abundant or a low priority in a watershed could be lost and replaced by other functions that are limited or a higher priority in the watershed.

Race and Fonseca (1996) point out that on a national level, a landscape approach to land use and compensation would require the cooperation/participation of thousands or millions of private landowners:

> *Taking a large-scale, ecosystem approach to wetlands management is a significant change in natural resource management policies, one representing a major paradigm shift that will require radical revision in values, management practices, and institutional structures in order to succeed (Cortner and Moote 1994). …Thus, integrating ecologically relevant concepts such as landscape-scale decision criteria need more than good science; it will also require conscious redesign of the entire permitting infrastructure to avoid legal challenges.*

6.10.6 Mitigation Banking

Compensatory mitigation banking and other third-party compensation approaches (in-lieu fee, market-based mitigation) are believed by some to provide part of a solution and have offered new hope for successful compensation of wetland impacts (Kukoy and Canter 1995).

Currently, even when wetlands have been avoided or established as compensation they often "have diminished ecological functions from polluted runoff, from changes in hydrologic regimes, and from the fragmentation of the landscape which isolates the wetlands from the surrounding uplands, water, and biological resources of the watershed" (Shabman et al. 1993).

In addition, some federal, state, and local permits for wetland loss do not require compensatory mitigation because the individual impact is so small that compensation is considered impractical, despite the fact that cumulative losses are occurring (Shabman et al. 1993, Kukoy and Canter 1995, Weems and Canter 1995). Finally, even when compensatory mitigation is required there is no guarantee that it will be implemented or successful.

Shabman et al. (1993) outlined a market solution to improve compensatory wetland mitigation. Market-based mitigation approaches start with an entrepreneurial restoration firm seeking to make a profit from selling a product—a wetland ecosystem. If the product is not of a particular quality then it will not sell. For example, if the wetland bank is not in compliance, not meeting its performance standards, or not providing the proposed functions then the regulatory agencies will not accept credits from the bank as compensation for wetland losses. The permit applicant, therefore, will not purchase the "product" of the wetland bank. This is the incentive for the restoration firm to establish a functioning wetland ecosystem.

In addition, a restoration firm can take the time to find a suitable location for the wetland that will minimize problems with fragmentation (Kukoy and Canter 1995). Wetland banks can also secure large sites for restoration that would not be feasible on a small project scale (Weems and Canter 1995).

Once the wetland is established, credits or tradable portions of the wetland can be made available for purchase to compensate for wetland losses (Weems and Canter 1995), even wetland losses that were previously too small to require compensation (Kukoy and Canter 1995). It is assumed that the availability of bank credits for compensation can also provide efficient permitting since the applicant would not have to worry about getting a mitigation plan approved, and regulators could more readily assess the effectiveness of the compensation.

Mitigation banking in Washington State has been more thoroughly discussed in the *Draft Programmatic Environmental Impact Statement: Washington State's Draft Rule on Wetland Mitigation Banking* (Driscoll and Granger 2001, available at: http://www.ecy.wa.gov/biblio/0106022.html). For additional information on mitigation banking and in-lieu fee programs refer to *Banks and Fees: The Status of Off-Site Wetland Mitigation in the United States* (Environmental Law Institute 2002).

6.10.7 Summary of Key Points

- The scientific literature provided suggestions for improving virtually every aspect of the mitigation process from regulatory guidance and policies to specifications for controlling invasive vegetation.
- Suggestions included measurable, meaningful, achievable, and enforceable performance standards; better sites that provide increased benefits due to their location within a watershed; better monitoring of compensatory mitigation wetlands; and measures to increase regulatory follow-up of compensation projects.

6.11 Chapter Summary and Conclusions

Wetland compensatory mitigation has been studied in Washington and elsewhere in the United States for the past 15 years. Considerable data are available to evaluate the effectiveness of compensatory mitigation.

The majority of compensatory wetland mitigation projects described in the literature was neither fully successful nor completely unsuccessful. Most projects were found to have an intermediate level of success. While most compensatory mitigation projects were installed, compliance of the projects with permit requirements was generally low. The authors of Volume 1 hypothesized that this was due to shortfalls of wetland acreage, failure to achieve performance standards, and a lack of monitoring and maintenance. The few studies that examined the effect of regulatory follow-up suggested that it had a positive influence on the level of compliance and success for compensatory wetland mitigation projects.

There is a general lack of information about the relative effectiveness of the various types of compensation (e.g., restoration, creation, enhancement, etc.). Creation is generally the most frequently used type of compensation, but studies of its effectiveness produced

mixed results. Enhancement of wetlands was also frequently used, but few studies examined its effectiveness. Limited studies from Washington indicated a low level of success among enhanced wetlands, primarily due to a minimal gain in functions. Restoring wetlands was noted as a high priority, but as a type of compensation it is not frequently used.

Preservation and a mixture of compensation types appear to be used occasionally. Studies provided limited information on the effectiveness of these types. Two studies from Washington indicated that mixed compensation projects had a higher level of compliance than creation or enhancement, and all mixed projects were moderately successful. The lack of data regarding the effectiveness of preservation is problematic since one of the only studies to look at its effectiveness determined that one large site was predominantly upland habitat. On the other hand, if a site can be confirmed as wetland, or if a mosaic of wetland and upland is determined to be acceptable, preservation of existing wetlands offers no risk of failure and no temporal loss of wetland functions, which are inherent in the other types of compensation. Preservation does, however, result in a net loss of wetland area and possibly functions.

Replacement ratios attempt to equalize the trade-off between the wetland being lost and the wetland being provided as compensation by accounting for the risk of failure and temporal loss of functions. Required replacement ratios vary from one state to another, based on the type of compensation proposed, and based on project-specific circumstances. Replacement ratios actually achieved through compensation were less than what was required, which is to be expected since the ratios are meant to encompass a certain level of failure. However, in some cases this resulted in less than 1:1 acreage replacement.

Studies relying solely on permit files and databases indicated that permitting programs have improved over time in terms of wetland acreage required for compensation. However, studies which relied on site visits and field analyses indicated that compensatory wetland mitigation has resulted in a loss of wetland acreage.

Functions performed and characteristics produced by created and restored wetlands differed from those performed and produced by reference wetlands, except water quality functions, which appeared to be performed in a similar capacity. None of the studies compared the functions provided by compensation wetlands with the functions provided by the wetlands that were lost.

For the most part, reference wetlands provided habitat for a greater diversity or abundance of wildlife than created or restored wetlands. Birds were an exception since half of the studies found no difference between created/restored sites and reference wetlands, particularly for ducks. Created and restored wetlands have different vegetative characteristics and plant communities than reference wetlands. Certain plant communities, such as sedge meadows, may require many years to develop if at all.

The authors of Volume 1 conclude that the common finding that wetland compensation sites have greater vegetation species richness is linked to the broad range of niches created on a new site. A newly created or restored site is a “blank slate” upon which

species will be planted, species from the previous habitat on the site will re-emerge, and species adapted to disturbance will colonize. Over time the site will stabilize and mature and only the species adapted to the resulting conditions will remain. However, research on restored, created, or enhanced sites that have stabilized is currently lacking. One could infer, therefore, that sites are not studied for a long enough time, due either to the relatively short regulatory timeframe or the decades or lifetimes necessary to achieve stabilization and maturity.

Researchers observed that created, restored, and enhanced wetlands had less organic matter than reference wetlands. This could be due to the excavation of surface soil layers during project construction. Studies also indicated that organic matter at compensation wetlands did not appear to accumulate over time. Therefore, plant establishment at compensation wetlands could be hindered by low organic content in conjunction with soils that were found to be sandier, more compacted, and lower in nitrogen.

Compensatory mitigation is producing more acreage of open water wetlands than was lost. The ability of compensatory mitigation projects to produce other Cowardin classes varied. Some compensatory mitigation wetlands have produced different HGM classes than were present in the reference wetlands. This has resulted in wetlands that have more inundation for a longer period than reference systems.

Some unique types of wetlands, such as bogs, fens, and mature forested wetlands, may not be reproducible, especially not within current regulatory timeframes. Other wetland types, such as vernal pools, may be reproducible given the right conditions.

The literature provided numerous suggestions on virtually every aspect of the mitigation process. Key suggestions include:

- Improving regulatory guidance on a variety of topics, such as measurable, meaningful, achievable, and enforceable performance standards for compensatory mitigation
- Finding better sites that provide increased benefits due to their location within a watershed
- Monitoring compensatory mitigation wetlands more effectively
- Implementing measures to increase regulatory follow-up of compensation projects

The literature suggests that some improvements have been made in compensatory mitigation over the past two decades, particularly in terms of what is required. However, overall success and permit compliance have not noticeably improved. Most studies indicate that created and restored wetlands do not provide the same characteristics or level of functions as reference wetlands (water quality functions may be the exception).

Since the effectiveness of compensatory mitigation remains highly variable and somewhat questionable, it is increasingly important to understand the cumulative effects of the continuing loss of wetland acreage and functions. This will be addressed in the next chapter.

Chapter 7

Cumulative Impacts to Wetlands and the Need for a New Approach

"Evidence in increasing that the most devastating environmental effects may result, not from the direct effects of a particular action, but from the combination of individually minor effects of multiple actions over time." (Council of Environmental Quality 1997)

7.1 Reader's Guide to This Chapter

This chapter introduces the concept of "cumulative impacts" to represent the incremental losses and degradation of wetlands that continue in spite of all the existing regulatory and non-regulatory actions we are taking to protect them. The chapter discusses different types of cumulative impacts and the loss of wetland area as the most easily assessed measure of cumulative impacts. It goes on to present some of the causes of cumulative impacts in Washington.

The synthesis of the scientific literature in Chapters 2, 3, and 4 has clearly established that wetlands do not function in isolation from the landscape that surrounds them. A wetland's ability to provide certain functions is influenced by the conditions and land uses within their contributing basins, especially by the patterns of water flow and movement that can be changed by different land uses. Existing wetland regulations usually are structured so decisions are made on an application by application basis. There are no provisions for assessing or considering the implications of individual decisions on the resource in general. The information presented in previous chapters demonstrates that project-by-project decisions cannot adequately address the complexities of wetland systems, and new approaches are needed to reduce the continued impacts to wetlands.

7.1.1 Chapter Contents

Major sections of this chapter and the topics they cover include:

Section 7.2, Loss of Wetlands as an Indicator of Cumulative Impacts describes the total wetland losses in Washington and three studies in the Pacific Northwest that illustrate more recent loss.

Section 7.3, Types of Cumulative Impacts describes how cumulative impacts result from disturbances related to geography and time that are not adequately managed. It lists types of cumulative impacts such as fragmentation and time lags.

Sections 7.4, Causes of Cumulative Impacts in Washington describes how the current approach to wetland management and protection results in cumulative impacts. The causes discussed include case-by-case permitting, lack of consistency between jurisdictions, and implementation of local programs for protecting wetlands through regulations. Different types of cumulative impacts are listed along with examples of possible causes from inadequate protection at the local level.

Section 7.5, Chapter Summary and Conclusions ties together the major concepts presented in the chapter.

7.1.2 Where to Find Summary Information and Conclusions

One summary is provided at the end of the chapter, along with the authors' conclusions. The reader is encouraged to remember that a review of the entire section preceding the summary is necessary for an in-depth understanding of the topic.

7.1.3 Sources and Gaps in Information

Much of the literature published on the topic of cumulative impacts is not specific to wetlands. Most of the research has been focused on environmental processes that affect biodiversity (i.e., habitat loss, fragmentation, metapopulations). The available information is weighted toward the impacts of some types of land use (urbanization and forest practices), with less information available on the impacts from other types of land use (agricultural practices, mining).

The 1997 Council of Environmental Quality report (Executive Office of the President) is a key document on cumulative impacts in general, and it provides a good summary of how land uses can cause cumulative impacts. This document is available on the internet at: http://ceq.eh.doe.gov/nepa/ccenepa/ccenepa.htm . This information can be applied to the protection and management of wetlands in the state.

The information available that specifically addresses wetlands is very general in nature and addresses cumulative impacts to wetlands only in terms of direct loss of wetland area, not the changes in functions that might result from changes in environmental processes at the landscape scale.

There is a significant gap in information regarding the cumulative impacts to wetlands and their functions resulting from the current approaches to managing wetlands at any level of government. The gap regarding the cumulative impacts and local protection programs is especially significant. The legal framework within Washington State (see Chapter 2 in Volume 2), delegates the decisions about land use, including comprehensive planning, designation of zoning, and regulation of critical areas, to local governments. As the information synthesized in Chapters 2-4 of this document has shown, decisions that change land uses can cause impacts to wetlands. However, little research has been conducted on the effectiveness of local efforts in effectively planning for and protecting wetlands, thereby preventing cumulative impacts. Only two studies were found that

review the effectiveness of local protection programs for wetlands, and they dealt with specific topics relating to regulations: standards for compensatory mitigation in King County and buffer requirements in the critical area ordinances of local jurisdictions in Washington in 1999 (See section 7.4.3).

Some hypotheses about the effectiveness of local programs, however, can be made by correlating the findings of the relevant literature with different aspects of the regulatory framework for wetlands used by local governments. The scientific information provides ample guidance on what is needed to protect wetland functions (e.g., planning to address and protect landscape processes, providing adequate buffers, modifying current practices of compensatory mitigation). A comparison of this information to the usual standards found in current programs can provide insights about the effectiveness of these programs. If they do not provide the range of measures for protection that are suggested by the scientific literature, it can be hypothesized that those programs may not be providing adequate protection to prevent cumulative impacts and assure long-term sustainability of wetlands.

What are Cumulative Impacts?

Cumulative impact, as defined by the Council on Environmental Quality, "is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." http://ceq.eh.doe.gov/nepa/regs/ceq/1508.htm#1508.1

Cumulative impacts also have been described by Hemond and Benoit (1988) as follows: "Wetlands are frequently subject to multiple impacts over time and/or space; the effects of such multiple impacts may be simply additive, or the total effect may be more severe than the sum of the effects of the individual impacts alone. Cumulative impact as used here refers to multiple impacts whose effects on the wetland cannot be predicted by simply adding the effects of all the individual impacts."

7.2 Loss of Wetlands as an Indicator of Cumulative Impacts

The loss of wetland area that continues to occur as a result of human activities is a general indicator that cumulative impacts are occurring. A net loss of wetland area and the functions it supports is a measure of the incremental impacts of human activities that are not adequately addressed. At the national level, wetlands continue to be lost, according to a report released by the National Research Council (1995). The U.S. Environmental Protection Agency states that although wetland loss rates are slowing, the United States continues to lose approximately 70,000 to 90,000 acres (28,300 to 36,400 ha) of wetlands on non-federal, rural lands each year (U.S. Environmental Protection Agency 2002).

Here in Washington, the state has lost an estimated 31% of its 1.35 million acres (55 million ha) of wetlands up to the 1980s (Dahl 1990). Recent data on total wetland losses in the state are not available, but three studies in the Pacific Northwest illustrate that the loss of wetlands continues:

- Bell (2002) studied sphagnum-dominated peatlands that were originally mapped by Rigg in the early 1950s in King County. Bell found a 69% loss of these wetlands since 1958. Of 26 sites, six remained relatively undisturbed. Eight showed a decline in acreage and quality of plant communities. Five wetlands are now highly disturbed with no sphagnum moss present. The remaining seven wetlands were either drained or filled. Of the 406 acres (162 ha) present in 1958, only 125 acres (50 ha) remain today. The losses were due to agricultural conversion, development, and peat mining.
- A study of recent losses of wetlands within the Willamette Valley, Oregon, found that from 1981/1982 to 1994 there was a loss of approximately 9,500 acres (3,800 ha) of wetlands, representing approximately a 2.1% loss of wetlands within the Willamette Valley study area. They found that 70% of the loss was attributable to agriculture, 6% was associated with the impacts of urbanization, and 24% was attributable to other unidentified causes (Bernert et al. 1999).
- A study conducted by Holland et al. (1995) in the greater Portland, Oregon, area found that 40% of the wetlands identified in the National Wetland Inventory of 1981/1982 were missing in 1992. They attributed most of the loss to the impacts of urbanization, yet they still attributed 31% of the losses to agricultural conversion. One conclusion of their study was that small, often isolated wetlands were lost due to decisions regarding single-project permits that did not take into account the overall pattern of wetland loss.

In addition to the direct loss of wetlands, alterations have occurred from human activities such as diking, draining, and agricultural practices (Washington State Department of Natural Resources 1998). These changes, even if apparently small on an individual basis, can have a cumulative impact on the functions of wetlands.

7.3 Types of Cumulative Impacts

Cumulative impacts result from the spatial (geographic) and temporal (time) crowding of disturbances that are not adequately managed. The impacts of a disturbance can be compounded when a second disturbance occurs at a site before the ecosystem can fully recover from the effect of the first disturbance (Council of Environmental Quality 1997). The scientific community has not yet agreed on a standard definition or method for assessing cumulative impacts because of the diversity of disturbances, the complexity of environmental processes, and the diversity of impacts possible (Council of Environmental Quality 1997). Nonetheless, the Council was able to identify eight scenarios (types of cumulative impacts) by which cumulative impacts occur (Table 7-1). These types are discussed further in Section 7.4.4 (Table 2) in relation to various causes of cumulative impacts in Washington.

Table 7-1. Types of cumulative impacts (modified from Council of Environmental Quality 1997)

Type of Cumulative Impact	Main Characteristics	Examples of Cumulative Impacts
Time crowding	Frequent and repetitive disturbances before the ecosystem has recovered from previous disturbance	Changes in the water regime that increase the depths of water and duration of flooding that, in turn, drowns vegetation not tolerant to prolonged inundation
Time lags	Impacts of disturbance are delayed from the time the disturbance occurs	Changes in water regime that causes a slow shift in the vegetation to species not suitable as sites for laying amphibian eggs
Space crowding	Impacts are occurring in close physical proximity to each other	Construction of new roads and commercial land uses on opposite sides of a wetland, resulting in increased human disturbances, such as noise, lighting, and less upland habitat
Cross-boundary	Impacts occur away from the source	Eutrophication in wetlands and lakes that results from discharges of nutrients in upper watershed
Fragmentation	Changes in the pattern of ecosystems across the landscape	Construction of a subdivision with roads interrupts the natural pathways used by animals for movement between patches of habitat
Compounding effects	Impacts arising from multiple sources or pathways	A small buffer reduces the upland habitat needed for wildlife that is closely associated with wetlands and that allows intrusion by humans and domestic pets
Indirect effects	Additional disturbances that result from changes in human activities that themselves are a result of the initial disturbance	The additional impacts that result from development after roads or other infrastructure are built. The building of a road has direct impacts but also changes human activities that cause additional ones.
Thresholds and triggers	The accumulation of disturbances causes a fundamental change in the behavior of the ecosystem	Changes in land use result in increased surface runoff that causes streams to become incised. As a result, wetlands become disconnected from the floodplain.

7.4 Causes of Cumulative Impacts in Washington

Some of the causes of cumulative impacts on wetlands stem from how wetlands are regulated in Washington State, and how local governments plan for future land use and development. Local city or county governments generally have the authority to plan for, manage, and otherwise regulate land uses within their jurisdictional boundaries, including those within and adjacent to wetlands. They may regulate what occurs directly in a wetland and, in many cases, they regulate land uses adjacent to a wetland and its buffer (see Volume 2). Federal and state agencies may regulate many direct impacts to wetlands. However, state and federal agencies do not regulate all activities that take place in wetlands and do not regulate land uses in the uplands around a wetland. They also don't provide the comprehensive planning and inter-jurisdictional coordination that affects cumulative impacts. Thus, federal and state agencies that regulate wetlands do not manage, and cannot protect, all wetlands nor many of the landscape processes that influence the functions that wetlands provide.

7.4.1 Case-by-case Permitting as a Cause of Cumulative Impacts

Wetlands in Washington are primarily managed by local jurisdictions through regulations that are implemented on a case-by-case or permit-by-permit basis. Proposed actions are often reviewed and approved without a legal authority or mechanism to assess how previous, relevant decisions may have impacted wetlands and caused cumulative impacts. Each action also is not typically reviewed in the context of impacts to associated landscape processes that may result in cumulative impacts.

On a national level, there is information on the relation between case-by-case decision-making and cumulative impacts. One of the reasons often cited for the failure of site-specific management to adequately protect aquatic resources is the inability of such an approach to address cumulative impacts (Johnston et al. 1990, U.S. Environmental Protection Agency 1999, Dale et al. 2000).

The literature has clearly identified that environmental regulations that are implemented on a permit-by-permit basis have a substantial cumulative impact. This occurs because the permit-by-permit approach fails to identify and account for the landscape processes that create and maintain wetlands (Wissmar and Beschta 1998). In the late 1980s, Bedford and Preston (1988) observed, "The incongruity between the regional scales at which wetland losses are occurring and the project-specific scale at which wetlands are regulated, and also studied, has become obvious." Failure to address the landscape processes results in two types of cumulative impacts (see Table 7-1) that are based on larger, geographic scales - cross-boundary impacts and fragmentation.

Bedford and Preston (1988) note that making decisions on a project-by-project basis fails to evaluate the potential impacts within the spatial and temporal scale within which ecosystems function. They state that, although project-by-project decision-making

> *. . . allows evaluation of the local impacts on resources, it does not allow evaluation of impacts of the project on these resources as a whole, of the total impact on these resources from all anthropogenic disturbances, or of secondary impacts resulting from the interaction of impacts from the project with other anthropogenic disturbances. This is true because the spatial and temporal boundaries of the analysis have not fully enclosed spatial and temporal dynamics of the environmental resources of concern and the anthropogenic activities influencing them.*

These authors recognize that impacts can be generated not only from project-specific actions, but they can also result from actions that occur out of time and outside the vicinity of the activity that may be under scrutiny for a particular project. This results in two types of cumulative impacts described on Table 7-1, time-lags and indirect effects.

Others, such as Everard (1999), are concerned that regulating wetlands and other aquatic resources without considering landscape processes creates the illusion that the resources are being protected by case-by-case management decisions. The ramifications of this misconception include:

- Assumptions by the public that current land-use regulations and management decisions are adequate to protect aquatic systems
- The public perception that protection of aquatic resources is an ongoing financial burden
- The assumption that current regulations are adequate eliminates any incentive or perceived need to assess or modify existing policies and/or regulatory programs

Cumulative effects of decisions made project-by-project: An analogy

Understanding the implication of cumulative impacts from a project-by-project perspective rather than one at a landscape scale may seem abstract given the complexity of how the environment functions in the landscape. The following analogy is offered to provide an alternative description of cumulative effects and the need to manage natural resources using a landscape approach. Credit for the following analogy was given to Gosselink and Lee by Preston and Bedford (1988):

Imagine a Renaissance mosaic of a mother and child, composed of beautiful tiles of various shapes and colors. As it has aged the mosaic has begun to lose tiles. As managers responsible for the mosaic, we have to determine which of the tiles to preserve and reinforce, which to attempt to restore, and which we will allow to be further damaged or even destroyed. Our objective is to attempt to preserve the highest value for the mosaic. Using a tile-by-tile decision method (the project-by-project impacts assessment), each tile would be assessed separately and individually for its intrinsic value. Each decision for a tile would not consider the other nearby tiles, nor even how the tiles fit into the whole image. This strategy would very likely not preserve the image of the mother and child. Yet, it is the image that gives the mosaic its inherent value, not the sum of the individual tiles. If one is to preserve the value of the image, then one needs to be able to determine the relative significance of each individual tile relative to each other tile and to the image as a whole.

7.4.2 Lack of Consistent Plans and Regulations between Jurisdictions as a Possible Cause of Cumulative Impacts

The approach of managing wetlands on a permit-by-permit basis described in the previous section is the best documented cause of cumulative impacts. There are other aspects, however, of the regulatory framework in Washington that can be hypothesized to cause cumulative impacts. A possible source of cumulative impacts is the lack of consistent regulations between jurisdictions to protect and manage landscape processes that occur across jurisdictional boundaries. One jurisdiction may manage water flows from impervious surface, but another one that is further upstream may not manage such flows. Or, one jurisdiction may provide a 200-foot buffer on a reach of riparian wetlands while the adjacent jurisdiction may only provide a 50-foot buffer on the same reach.

In Washington State, most local jurisdictions have development codes that establish the regulatory framework for land use in all areas including wetlands. These codes are based on the objectives developed for each jurisdiction. Adjacent jurisdictions may have quite different objectives for managing the resources and therefore adopt distinctly different codes and regulatory protection. A common inconsistency in regulatory protection is the use of different wetland rating systems that result in variable levels of protection. For example, the city of Tukwila in King County has adopted a rating of wetlands into three categories (Critical Areas Ordinance #2074, December 13, 2004) while King County has adopted a four category rating system (Final Critical Areas Ordinance 15051, Adopted

October 29, 2004). The levels of protection assigned each of the wetland categories is also different. Disparities between rating systems may result in different levels of protection to different portions of the same wetland if it crosses jurisdictional boundaries. It is also quite possible that different buffer widths and different ratios for compensatory mitigation could be required for different parts of the same wetland in adjacent jurisdictions. Such discrepancies therefore can result in cumulative impacts across boundaries.

The failure to address the landscape processes consistently can result in two types of cumulative impacts (see Table 7-1) that are based on larger geographic scales - cross-boundary impacts and fragmentation. The differences in rating systems can result in "cross-boundary" impacts while the example of the different buffers for riparian wetlands would cause impacts from fragmentation.

7.4.3 Implementation of Regulatory Programs at the Local Level as a Possible Cause of Cumulative Impacts

Currently, there is little published information on the possible cumulative impacts that may result from the implementation of regulatory programs by local jurisdictions. For example, there is no documentation on the impacts of:

- Exempting wetlands from protection based on size (e.g., wetlands smaller than ¼ acre are not being regulated at all). Such exemptions can be hypothesized to cause cumulative impacts such as fragmentation and exceeding thresholds of ecosystem viability if there are many small wetlands within a jurisdiction.
- Exempting wetlands based on isolation (e.g., isolated wetlands are those that do not have a surface water connection to other water bodies). Such exemptions can be hypothesized to cause cumulative impacts such as fragmentation and exceeding thresholds of ecosystem viability if there are many isolated wetlands within a jurisdiction.
- Inadequate provisions for protection (e.g., inadequate buffer widths). This can be hypothesized to cause cumulative impacts such as "compounding effect" where an inadequate buffer reduces the habitat for species that need the buffer, as well as by introducing additional disturbances from adjacent development.
- Using standards for compensatory mitigation that are inadequate to ensure replacement of wetland area and/or function. This will result in all types of cumulative impacts because there is a continued loss of wetlands and their functions.

Scientific information synthesized in this document provides guidance on what should be used to effectively protect wetland functions (e.g., landscape approaches, buffers, mitigation standards). See Volume 2 in this two-part series for details regarding specific recommendations. To assess the effectiveness of local programs, we can, therefore, compare the requirements developed by local jurisdictions against what natural resource experts say is needed. The information available suggests that local programs do not

provide the level of planning and protection needed to maintain existing functions and address cumulative impacts.

Two studies in Washington provide more direct information regarding this issue. A King County study (Mockler et al. 1998) concluded that standards for compensatory mitigation implemented by the county were significantly less than what was necessary to meet the goal of no net loss of function or area. In addition, data from the Washington State Department of Community, Trade and Economic Development (CTED) addresses the adequacy of buffer requirements by local governments in Washington. The department collects data on the buffer requirements in critical area ordinances of cities and counties in Washington. In the last such survey in 1999 (Chris Parsons, CTED, personal communications 1999, data are available on request from CTED), the buffers for wetlands were considerably narrower than what the scientific information indicates is necessary to protect many functions. Of the 128 jurisdictions in Washington that specify a numeric buffer width, 99 had buffers of 100 ft or less on wetlands that rate high for their habitat functions. The summary of the scientific information provided in Chapter 5 indicates, however, that most habitat functions are not adequately protected by this buffer width.

Additionally, no city or county in Washington has developed and implemented a landscape-based approach to assessing and protecting wetlands. The scientific information summarized by the Ecological Society of America (Dale et al. 2000) and by the Council of Environmental Quality (1997) indicates that a landscape-based approach is necessary to minimize cumulative impacts.

Thus, it is reasonable to hypothesize that existing wetland protection programs, as implemented in Washington, are not adequately protecting wetland functions and values, and cumulative impacts are resulting.

7.4.4 Relating the Types of Cumulative Impacts to Measures Taken by Local Governments

The list of types of cumulative impacts listed in Table 7-1 can be related to inadequacies of the measures taken to protect wetlands at the local level that have been documented or that can be hypothesized. Examples of the different types of cumulative impacts and examples illustrating these inadequacies are provided in Table 7-2. The inadequacies span the realms of planning, coordination, and regulation.

Table 7-2. Types of cumulative impacts and examples of factors at the local level that might cause the impacts.

Type of Cumulative Impact	Main Characteristics	Examples of Cumulative Impacts	Examples at the Local Level That Might Cause This Impact
Time crowding	Frequent and repetitive disturbances before recovery has occurred from previous disturbance	Reoccurring flooding that drowns vegetation that is not adapted to prolonged inundation	Inadequate storm-water regulations that do not address impacts on wetlands of changes in water regime
Time lags	Impacts of disturbance are delayed	Exposure to toxics	No provision for regulating the use of chemicals on residential lawns draining to wetlands
Space crowding	Impacts are occurring in close proximity to each other	Construction of new highways and high-density commercial zones on both sides of a wetland, resulting in increased noise, lighting, and human presence	No provision for planning at the landscape scale that allows the identification and adequate protection of critical landscape linkages between habitats
Cross-boundary	Impacts occur away from the source	Eutrophication in wetlands and lakes that results from nutrient discharges in upper watershed	Lack of coordination among jurisdictions in controlling nutrient inputs to a watershed
Fragmentation	Changes in the pattern of ecosystems across the landscape	Distribution and size of wetlands across the landscape is reduced	No planning at a landscape scale that identifies key landscape processes and incorporates appropriate management options. Permits are issued on a case-by-case basis
Compounding effects	Impacts arising from multiple sources or pathways	Construction of roads, stormwater facilities, and high density commercial development after an approved rezone	The lack of authority to adequately assess potential long-term effects to landscape processes when changing the potential land use of a parcel or area
Thresholds and triggers	The accumulation of disturbances causes a fundamental change in the behavior of the ecosystem	Increased surface runoff causes streams to be incised and wetlands become disconnected from the floodplain	Permit-by-permit decision making precludes the ability to regulate known or anticipated cumulative effects, unless the regulatory framework is in place

7.5 Chapter Summary and Conclusions

Loss of wetland area and alteration of wetland functions due to human activities are indicators that cumulative impacts are occurring. Wetland losses continue to occur on a national level. The few studies done in the Pacific Northwest suggest that losses continue to occur in the region as well.

The Council on Environmental Quality has identified seven types of cumulative impacts: time crowding, time lags, space crowding, cross-boundary, fragmentation, compounding effects, thresholds and triggers.

Some of the causes of cumulative impacts include the following:

- Permit decisions made on a case-by-case basis. The scientific information available has clearly identified that environmental regulations that are implemented on a permit-by-permit basis have substantial cumulative impacts.
- Lack of consistent regulations between jurisdictions. Local governments vary in the protection they provide to wetlands or to different parts of the same wetland if it crosses political boundaries. Therefore, the same wetland may be subject to a variety of policies and regulatory standards. Differing standards can result in cumulative effects and loss of wetland functions across the landscape.
- Insufficient protection at the local level. Most cities and counties in Washington have historically required buffers that are considerably less than what the research indicates are necessary to protect functions.
- The lack of planning at a larger geographic scale. The scientific information shows that a landscape-based approach is needed to effectively manage wetlands. However, no local government in Washington has developed and implemented a landscape-based approach to assessing and protecting wetlands.

Based on the synthesis of the scientific literature, combined with the knowledge of the standards for protection and how land-use decisions are currently made, it can be hypothesized that current protection programs result in cumulative impacts to wetlands.

Improvements in the way wetlands are protected and managed, and therefore how cumulative impacts can be avoided, is the subject of the second volume in this two-part series. It provides guidance in regard to:

- Implementing a four-part framework for protecting and managing wetlands
- Analyzing the landscape and its wetlands
- Using landscape information in developing plans and policies, and incorporating these into comprehensive planning
- Developing and improving tools typically used in local regulations (rating, buffers, compensatory mitigation, etc)

- Developing and improving non-regulatory tools such as preservation, conservation, and restoration
- Identifying the risks from proposed or existing programs
- Implementing programs
- Monitoring wetland protection and management measures that have been implemented, and adapting programs to address the inadequacies identified

The reader is referred to Volume 2 for suggestions regarding solutions to the problem of cumulative impacts.

References

The following list of references includes those literature sources obtained, reviewed, and synthesized by the Core Team (See Appendix 1-A) that prepared this document. The list also includes references cited in those portions of "Indicators for Monitoring Biological Integrity of Inland, Freshwater Wetlands" (Adamus et al. 2001) that were adapted for use in this synthesis. The references from the adapted portions of the Adamus et al. (2001) document have not all been obtained and reviewed by the Core Team, but they are included here for the convenience of the reader who wishes to consult the original literature for further information. Not all references listed here are cited in the synthesis. Citations listed as "personal communications" in the text are not listed here since the citation contains the information. The references cited in the appendices are listed here and at the end of each appendix. The authors recognize that the format of the references is not always consistent but that this should not prevent interested persons from locating any of the listed references.

Abbruzzese, B. and S.G. Leibowitz. 1997. A synoptic approach for assessing cumulative impacts to wetlands. Environmental Management 21(3): 457-475.

Abbruzzese, B., S.G. Leibowitz, and R. Sumner. 1990. Application of the Synoptic Approach to Wetland Designation: A Case Study in Washington. Final Report. EPA/600/3-90/072. U.S. Environmental Protection Agency Environmental Research Laboratory. Corvallis, OR.

Adair, S.E., J.L. Moore, and W.H. Kiel, Jr. 1996. Wintering diving duck use of coastal ponds: An analysis of alternative hypotheses. Journal of Wildlife Management 60(1):83-93.

(Adams 1999a) Adams, M.J. 1999. Correlated factors in amphibian decline: Exotic species and habitat change in western Washington. Journal of Wildlife Management 63(4): 1162-1171.

(Adams 1999b) Adams, M.J. 1999. Pond permanence and the effects of exotic vertebrates on anurans. Ecological Applications 10:559-568.

Adams, M.J., C.A. Pearl, and R.B. Bury. 2003. Indirect facilitation of an anuran invasion by non-native fishes. Ecology Letters 6:343-351.

Adams, M.J., R.B. Bury and S.A. Swarts. 1998. Amphibians of the Fort Lewis Military Reservation, Washington: sampling techniques and community patterns. Northwestern Naturalist 79:12-18.

Adamus, P.R, T.J. Danielson, and A. Gonyaw. 2001. Indicators for Monitoring Biological Integrity of Inland, Freshwater Wetlands: A Survey of North American Technical Literature (1990-2000). EPA 843-R-01. Fall 2001. Available: http://www.epa.gov/owow/wetlands/bawwg/monindicators.pdf. U.S. Environmental Protection Agency, Office of Water.

Adamus, P.R. 1993. Irrigated Wetlands of the Colorado Plateau: Information Synthesis and Habitat Evaluation Method. EPA/600/R-93/071. U.S. Environmental Protection Agency.

Adamus, P.R. and A. Gonyaw. 2000. National Database of Wetland Plant Tolerances. Prepared for the USEPA. Available: http://www.epa.gov/owow/wetlands/bawwg/publicat.html

Adamus, P.R. and A. Gonyaw. 2001. National Database of Wetland Invertebrate Tolerances. Prepared for the U.S. Environmental Protection Agency. Available: http://www.epa.gov/owow/wetlands/bawwg/publicat.html.

Adamus, P.R. and D. Field. 2001. Guidebook for Hydrogeomorphic (HGM)-Based Assessment of Oregon Wetland and Riparian Sites: I. Willamette Valley Ecoregion, Riverine Impounding and Slope/Flats Subclasses. Volume IA: Assessment Methods. Salem, OR: Oregon Division of State Lands.

Adamus, P.R. and K. Brandt. 1990. Impacts on Quality of Inland Wetlands of the United States: A Survey of Indicators, Techniques, and Applications of Community Level Biomonitoring Data. EPA/600/3-90/073. Available: http://www.epa.gov/owow/wetlands/wqual/introweb.html. U.S. Environmental Protection Agency.

Adamus, P.R., E.J. Clairain, Jr., M.E. Morrow, L.P. Rozas, and R.D. Smith. 1991. Wetland Evaluation Technique (WET), Volume I: Literature Review and Evaluation. WRP-DE-2. Vicksburg MS: U.S. Army Corps of Engineers Waterways Experiment Station.

Adamus, P.R., E.J. Clairain, Jr., R.D. Smith, and R.E. Young. 1987. Wetland Evaluation Technique (WET) Volume II: Methodology. NTIS No. ADA 189968. Vicksburg, MS: U.S. Army Corps of Engineers Waterways Experiment Station.

Aker, L.M. 1998. The Effect of Native and Non-Native Fish on Amphibian Populations in Northeast Washington. M.S. Thesis. Cheney, WA: Eastern Washington University.

Albers, P.H., and M.B. Camardese. 1993. Effects of acidification on metal accumulation by aquatic plants and invertebrates: 2. Wetlands, ponds and small lakes. Environmental Toxicology and Chemistry 12(6):969-976.

Allen, A.J. and J.J. Feddema. 1996. Environmental auditing, wetland loss and substitution by the Section 404 permit program in southern California, USA. Environmental Management 20(2): 263-274.

Allen, A.W. 1982. Habitat Suitability Index Models: Mink. FWS/OSB-82/10.61. U.S. Fish and Wildlife Service.

Allen, A.W. 1983. Habitat Suitability Index Models: Beaver. FWS/OBS-82/10.46. U.S. Fish and Wildlife Service.

Allen, A.W. and R.D. Hoffman. 1984. Habitat Suitability Index Models: Muskrat. FWS/OBS-82/10.46. U.S. Fish and Wildlife Service.

Almendinger, J.E. 1999. A method to prioritize and monitor wetland restoration for water-quality improvement. Wetlands Ecology and Management 6(4): 241-251.

Amman, A.P., R.W. Franzen, and J.L. Johnson. 1986. Method for the Evaluation of Inland Wetlands in Connecticut. DEP Bulletin No. 9. Connecticut Department of Environmental Protection.

Ammon, E.M. and P.B. Stacey. 1999. Avian nest success in relation to past grazing regimes in a montane riparian system. The Condor 99:49-51.

Anderson, J.D. 1967. A comparison of the life histories of coastal and montane populations of Ambystoma macrodactylum in California. The American Midland Naturalist 77:323-355.

Andrews, J.D. and A.D. Hasler. 1943. Fluctuations in the animal populations of the littoral zone in Lake Mendota. Transactions, Wisconsin Academy of Sciences, Arts, and Letters 35:175-185.

Armour, C.L., D.A. Duff, and W. Elmore. 1991. The effects of livestock grazing on riparian and stream ecosystems. Fisheries 16(7-11).

Arner, D.H., H.R. Robinette, J.E. Frasier, and M.H. Grey. 1976. Effects of Channelization of the Luxapalila River on Fish, Aquatic Invertebrates, Water Quality and Furbearers. FWS/OBS-76-08. Washington, DC: U.S. Fish and Wildlife Service.

Arts, G.H.P., G. van der Velde, J.G.M. Roelofs, and C.A.M. van Swaay. 1990. Successional changes in the softwater macrophyte vegetation of (sub)Atlantic, sandy, lowland regimes during this century. Freshwater Biology 24:287-294.

Ashworth, S.M. 1997. Comparison between restored and reference sedge meadow wetlands in south-central Wisconsin. Wetlands 17(4): 518-527.

Atlas, R.M., A. Horowitz, M. Krichevsky, and A.K. Bej. 1991. Response of microbial populations to environmental disturbance. Microbial Ecology 22:249-256.

Aurambout, J.P. 2003. A Spatial Model to Estimate Habitat Fragmentation and its Consequences of Long-Term Survival of Animal Populations. Available: http://65.61.22.59/summer03/studentpapers/jpaurambout.pdf. Accessed July 8, 2003. Champaign, IL: Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana Champaign.

Averill, R.D., L Larson, J. Saveland, P. Wargo, and J. Williams. 2003. Disturbance processes and ecosystem management. U.S. Forest Service, RMRS Online Publication, Rocky Mountain Research Station

Azaizah, H.A., S. Gowthaman, and N. Terry. 1997. Microbial selenium volatilization in rhizosphere and bulksoils from a constructed wetland. Journal of Environmental Quality 26: 666-672.

Azous, A.L. 1991. An Analysis of Urbanization Effects on Wetland Biological Communities. M.S. Thesis. Seattle, WA: University of Washington.

Azous, A.L. and K.O. Richter. 1995. Amphibian and plant community responses to changing hydrology in urban wetlands. Pages 156-162 in E. Robichaud (ed.), Puget Sound Research 1995 Proceedings, Volume 1. Olympia, WA: Puget Sound Water Quality Authority.

Azous, A.L. and R.R. Horner (eds). 2001. Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Azous, A.L., and S.S. Cooke. 2001. Wetland plant communities in relation to watershed development. Chapter 10, pages 255-263 in A.L. Azous and R.R. Horner (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Azous, A.L., L.E. Reinelt, and J. Burkey. 2001. Managing wetland hydroperiod: Issues and concerns. Chapter 13, pages 287-298 in A.L. Azous and R.R. Horner (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Azous, A.L., M.B. Bowles, and K.O. Richter. 1998. Reference Standards and Project Performance Standards for the Establishment of Depressional Flow-Through Wetlands in the Puget Lowlands of Western Washington. Renton, WA: King County Department of Development and Environmental Services.

Babbitt, K.J. and G.W. Tanner. 2000. Use of temporary wetlands by anurans in a hydrologically modified landscape. Wetlands 20(2): 313-322.

Bailey, R.G. 1976. Ecoregions of the United States (map 1:7,500,000). Ogden, UT: U.S. Forest Service, Intermountain Region.

Bailey, R.G. 1995. Description of the Ecoregions of the United States. Miscellaneous Publication 1391. Washington, DC: U.S. Forest Service.

Bain, M.B. 1993. Assessing impacts of introduced aquatic species: Grass carp in large systems. Environmental Management 17:211-224.

Baker, J.M.R. and T.R. Halliday. 1999. Amphibian colonization of new ponds in an agricultural landscape. Herpetological Journal 9: 55-63.

Baker, J.P. and S.W. Christensen. 1990. Effects of acidification in biological communities in aquatic ecosystems. Pages 83-106 in D.F. Charles (ed.), Acid Deposition and Aquatic Ecosystems: Regional Case Studies. New York: Springer-Verlag.

Baker, L.A. 1992. Introduction to nonpoint source pollution in the United States and prospects for wetlands use. Ecological Engineering 1:1-26.

Balding, T. 1992. Distribution, abundance, and diversity of mollusks (*Bivalvia: Unionidae*) from the Lower Chippewa River, Wisconsin. Transactions of the Wisconsin Academy of Sciences, Arts, and Letters 80:163-268.

Baldwin, A.H. and I.A. Mendelssohn. 1998. Response of two oligohaline marsh communities to lethal and nonlethal disturbance. Oecologia 116(4): 543-555.

Balla, S.A. and J.A. Davis. 1995. Seasonal variation in the macroinvertebrate fauna of wetlands of differing water regime and nutrient status on the Swan Coastal Plain, Western Australia. Hydrobiologia 299:147-161.

Baltz, D.M., and P.B. Moyle. 1993. Invasion resistance to introduced species by a native assemblage of California stream fishes. Ecological Applications 3:246-255.

Balzano, S., A. Ertman, L. Brancheau, and W. Smejkal. 2002. Creating Indicators of Wetland Status (Quantity and Quality): Freshwater Wetland Mitigation in New Jersey. New Jersey Department of Environmental Protection; Division of Science, Research, and Technology.

Bancroft, G.T., A.M Strong, R.J. Sawicki, W. Hoffman, and S.D. Jewell. 1994. Relationships among wading bird foraging patterns, colony locations, and hydrology in the Everglades. Pages 615-657 in S.M. Davis and J.C. Ogden (eds.), Everglades: The Ecosystem and its Restoration. FL: St. Lucie Press.

Barass, A.N. 1985. The Effects of Highway Traffic Noise on the Phonotactic and Associated Reproductive Behavior of Selected Anurans. Ph.D. Dissertation. Vanderbilt University.

Bardecki, M.J. 1988. Impacts of agricultural land drainage on wetlands: A geographical appraisal. In: National Symposium on Protection of Wetlands from Agricultural Impacts. U.S. Fish and Wildlife Service.

Barratt, D.G. 1997. Predation by house cats, *Felis catus* (L.) in Canberra, Australia: I. Prey composition and preference. Wildlife Research 24(3): 263-277.

Barry, W.J., A.S. Garlo, and C.A. Wood. 1996. Duplicating the mound-and-pool microtopography of forested wetlands. Restoration and Management Notes 14(1): 15-21.

Bartoldus, C.C. 1999. A Comprehensive Review of Wetland Assessment Procedures: A Guide for Wetland Practitioners. Environmental Concern, Inc. St. Michaels, MD.

Batzer, D.P. and V.H. Resh. 1992. Macroinvertebrates of a California seasonal wetland and responses to experimental habitat manipulation. Wetlands 12(1):1-7.

Beamer, E., A. McBride, R. Henderson, and K. Wolf. 2003 (unpublished report). The importance of non-natal pocket estuaries in Skagit Bay to wild Chinook salmon: an emerging priority for restoration. Skagit System Cooperative Research Department. La Conner, WA.

Beanlands, G.E., and P.N. Duinker. 1983. An ecological framework for environmental impact assessment in Canada. Institute for Resources and Environmental Studies, Dalhousie University. 132pp.

Bedford, B. 1996. The need to define hydrologic equivalence at the landscape scale for freshwater wetland mitigation. Ecological Applications 6:57-68.

Bedford, B.L. 1999. Cumulative effects on wetland landscapes: Links to wetland restoration in the United States and southern Canada. Wetlands 19(4): 775-788.

Bedford, B.L., and E.M. Preston. 1988. Developing the scientific basis for assessing cumulative effects of wetland loss and degradation on landscape functions: Status, perspectives, and prospects. Environmental Management 12(5): 751-771.

Beebee, T.C.J. 1996. Ecology and Conservation of Amphibians. London: Chapman & Hall.

Beeby, A. 1985. The role of *Helix aspersa* as a major herbivore in the transfer of lead through a polluted ecosystem. Journal of Applied Ecology 22:267-275.

Beecher, W.J. 1942. Nesting Birds and Vegetative Substrate. Chicago Ornithological Society. Report. Chicago, Illinois. 69 pp.

Beechie, T. and S. Bolton. 1999. An approach to restoring salmonid habitat-forming processes in Pacific Northwest watersheds. Fisheries Habitat 24:6-15.

Behan, M.J., T.B. Kinraide, W.I. Seller. 1979. Lead accumulation in aquatic plants from metallic sources including shot. Journal of Wildlife Management 43:240-244.

Belanger, L. and R. Couture. 1988. Use of man-made ponds by dabbling duck broods. Journal of Wildlife Management 52:718-723.

Bell, J.M. 2002. An Assessment of Selected Sphagnum-Dominated Peatlands of King County, WA, and Their Decline. August. Master's of Environmental Science Thesis. Olympia, WA: Evergreen State College.

Belsky, A.J. 1987. The effects of grazing: Confounding of ecosystem, community, and organism scales. The American Naturalist.

Belt, G.H. and J. O'Laughlin. 1994. Buffer strip design for protecting water quality and fish habitat. Western Journal of Applied Forestry 9: 41-45.

Benda, L. et al. 1998. Dynamic landscape systems. Pages 261-288 in R. Naiman and R. Bilby (eds.), River Ecology and Management, Lessons from the Pacific Coastal Ecoregion. Springer-Velag. New York, NY.

Bendell-Young, L.I., K.E. Bennett, A. Crowe, C.J. Kennedy, A.R. Kermode, M.M Moore, A.L. Plant, and A. Wood. 2000. Ecological characteristics of wetlands receiving an industrial effluent. Ecological Applications 10: 310-322

Beneski, J.T. Jr., E.J. Zalisko, and J.H. Larsen, Jr. 1986. Demography and migratory patterns of the eastern long-toed salamander, *Ambystoma macrodactylum columbianum*. Copeia 1986:398-408.

Bermingham, S., L. Maltby, and R.C. Cooke. 1996. Effects of a coal mine effluent on aquatic hyphomycetes: I. Field study. Journal of Applied Ecology 33: 1311-1321

Bernert, J.A., J.M. Eilers, B.J. Eilers, E. Blok, S.G.Daggett, and K.F. Bierly. 1999. Recent wetland trends (1981/82-1994) in the Willamette Valley, Oregon, USA. Wetlands 19(3): 545-559.

Berrill, M., D. Coulson, L. McGillivray, and B. Pauli. 1998. Toxicity of endosulfan to aquatic stages of anuran amphibians. Environmental Toxicology and Chemistry 17(9): 1738-1744.

Berrill, M., S. Bertram, A. Wilson, S. Louis, and D. Brigham. 1993. Lethal and sublethal impacts of pyrethroid insecticides on amphibian embryos and tadpoles. Environmental Toxicology and Chemistry 12(3):525-539.

Berrill, M., S. Bertram, and B. Pauli. 1997. Effects of pesticides on amphibian embryos and larvae. Pages 233-245 in D.M. Green (ed.), Amphibians in Decline: Canadian Studies of a Global Problem. St. Louis, MO: Society for the Study of Amphibians and Reptiles.

Berrill, M., S. Bertram, L. McGillivary, M. Kolohon, and B. Pauli. 1991. Effects of low concentrations of forest use pesticides on frog embryos and tadpoles. Environmental Toxicology and Chemistry 13(4):657-658.

Berven, K.A., and T.A. Grudzien. 1990. Dispersal of the wood frog (*Rana sylvatica*): Implications for genetic population structure. Evolution 44(8):2047-2056.

Bethke, R.W. and T.D. Nudds. 1993. Variation in the diversity of ducks along a gradient of environmental variability. Oecologia 93:242-250.

Bettoli, P.W., J.E. Morris, and R.L. Noble. 1991. Changes in the abundance of two atherinid species after aquatic vegetation removal. Transactions of the American Fisheries Society 120: 90-97.

Beyerlein, D. 1999. Why standard stormwater mitigation doesn't work. Pages 477-479 in Proceedings for American Water Resources Association Conference: Watershed Management to Protect Declining Species. Seattle, WA.

Bider, J.R. 1968. Animal activity in uncontrolled terrestrial communities as determined by a sand transect technique. Ecological Monographs 38:269-308.

Bishel-Machung, L., R.P. Brooks, S.S. Yates, and K.L. Hoover. 1996. Soil properties of reference wetlands and wetland creation projects in Pennsylvania. Wetlands 16(4): 532-541.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Doloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: Past, present and future. Pages 143-190 in Streamside Management Forestry and Fishery Interactions. Seattle, WA: University of Washington, Institute of Forest Resources.

Bissonette, J.A., and I. Storch. 2002. Fragmentation: Is the message clear? Conservation Ecology 6: #14 (online http://www.consecol.org/vol6/iss2/art14)

Blackshaw, R.E. 1992. Soil temperature, soil moisture, and seed burial depths on redstem filarie (*Erodium cicutarium*) emergence. Weed Science 40: 204-207.

Blair, R.B. 1996. Land use and avian species diversity along an urban gradient. Ecological Applications 6(2): 506-519.

Blancher, P.J. 1991. Acidification: Implications for Wildlife. Pages 195-204 in Transactions of the North American Wildlife and Natural Resources Conference NAWTA6.

Blancher, P.J., and D.K. McNicol. 1991. Tree swallow diet in relation to wetland acidity. Canadian Journal of Zoology 69(10):2629-2637.

Bluemle, J.P. 1999. North Dakota's Badlands. North Dakota Notes #12. North Dakota Geological Survey.

Bodeller, P.L.E., P. Roslev, T. Henckel, and P. Frenzel. 2000. Stimulation by ammonium-based fertilizers of methane oxidation in soil around rice roots. Nature 403: 421-424.

Boening, D.W. and G.J. Vasconcelos. 1997. Persistence and antibiotic immunity of bacteria from a wetland used as a medical waste landfill. Journal of Environmental Health 59(6): 6-12.

Bohor B F, Hatch J R & Hill D J 1976. Altered volcanic ash partings as stratigraphic marker beds in coals of the Rocky Mountain region. American Association of Petroleum Geologists Bulletin 60 651. Available on the web at: http://www.pnl.gov/cms/docs/Volcanically_Derived_Clays.pdf

Bohor B.F, Philips R E & Pollastro R M 1979. Altered volcanic ash partings in Wasatch Formation coal beds of the northern Powder River basin. U S Geological Survey Open-File Report 79-1203 21pp. Available on the web at: http://www.pnl.gov/cms/docs/Volcanically_Derived_Clays.pdf

Bolscher, B. 1995. Niche requirements of birds in raised bogs: Habitat attributes in relation to bog restoration. In B.D. Wheeler, S.C. Shaw, W.J. Fojt and R.A. Robertson (eds), Restoration of Temperate Wetlands. John Wiley & Sons Ltd.

Booth, D.B. and L.E. Reinelt. 1993. Consequences of urbanization on aquatic systems: Measured effects, degradation thresholds, and corrective strategies. In Proceedings, Watershed '93, A National Conference on Watershed Management. March 21-24, 1993, Alexandria, VA.

Booth, D.E. 1991. Urbanization and the natural drainage system impacts, solutions, and prognoses. The Northwest Environmental Journal 7(1):93-118.

Booth, DB, D. Hartley and R. Jackson. 2002. Forest Cover, Impervious-surface area and the mitigation of stormwater impacts. Journal of American Water Resources Association, 38:835-845.

Bortleson, G.C. and D.A. Davis. 1997. Pesticides in Selected Small Streams in the Puget Sound Basin, 1987-1995. U.S. Geological Survey Fact Sheet 067-97.

Bortelson, G.C., M.J. Chrzastowski, and A.K. Helegerson. 1980. Historical Changes of Shoreline and Wetland at Eleven Major Deltas in the Puget Sound Region, Washington. Hydrologic Investigations Atlas HA-617. U.S. Geological Survey.

Bouffard, S.H. and M.A. Hanson. 1997. Fish in waterfowl marshes: Waterfowl managers' perspective. Wildlife Society Bulletin 25:146-57.

Boulton, A.J., C.G. Peterson, N.B. Grimm, and S.G. Fisher. 1992. Stability of an aquatic macroinvertebrate community in a multiyear hydrologic disturbance regime. Ecology 73(6): 2192-2207.

Bowles, A.E. 1995. Responses of wildlife to noise. Pages 109-156 in R.L. Knight and K.J. Gutzwiller (eds.), Wildlife and Recreationists: Coexistence Through Management and Research. Covelo, CA: Island Press.

Box, J.B. and J. Mossa. 1999. Sediment, land use, and freshwater mussels: prospects and problems. Journal of the North American Benthological Society 18(1): 99-117.

Brabec, E. and C. Smith. 2002. Agricultural land fragmentation: The spatial effects of three land protection strategies in the eastern United States. Landscape and Urban Planning 58: 255-268.

Braccia, A. and D.P. Batzer. 2001. Invertebrates associated with woody debris in a southeastern U.S. forested floodplain wetland. Wetlands 21(1): 18-31.

Bradford, D.F. 1991. Mass mortality and extinction in a high-elevation population of Rana muscosa. Journal of Herpetology 25:174-177.

Bradford, D.F., C. Swanson, and M.S. Gordon. 1991. Acid deposition in the Sierra Nevada, California: Effects of low pH and inorganic aluminum on two declining species of amphibians. American Zoologist 31(5):114A.

Breaux, A. and F. Serefiddin. 1999. Validity of performance criteria and a tentative model for regulatory use in compensatory wetland mitigation permitting. Environmental Management 24(3): 327-336.

Brenner, F.J. 1962. Food consumed by beavers in Crawford County, Pennsylvania. Journal of Wildlife Management 26:104-107.

Brenner, J. 1995. Impact of changing land use on water quality in an agricultural watershed. Pages 189-193 in Proceedings of Conservation '96. Denver, CO: American Water Works Association.

Brett, M.T. 1989. The distribution of free-swimming macroinvertebrates in acidic lakes of Maine: The role of fish predation. Aqua Finn. 19:113-118.

Brinson, M.M. 1988. Strategies for assessing the cumulative effects of wetland alteration on water-quality. Environmental Management 12:655-662.

(Brinson 1993a) Brinson, M.M. 1993. Changes in the functioning of wetlands along environmental gradients. Wetlands 13(2): 65-74.

(Brinson 1993b) Brinson, M.M. 1993. Hydrogeomorphic Classification for Wetlands. Technical Report WRP-DE-4. U.S. Army Corps of Engineers Waterways Experiment Station.

Brinson, M.M. 1995. The HGM approach explained. National Wetland Newsletter Nov-Dec. 1995: 7-13.

Brinson, M.M. and R. Rheinhardt. 1996. The role of reference wetlands in functional assessment and mitigation. Ecological Applications 6:69-76.

Brinson, M.M., F.R. Hauer, L.C. Lee, W.L. Nutter, R.D. Rheinhardt, R.D. Smith, and D. Whigham. 1995. Guidebook for Application of Hydrogeomorphic Assessments to Riverine Wetlands. Operational draft. Technical Report WRP-DE-11. Vicksburg MS: U.S. Army Corps of Engineers Waterways Experiment Station.

Brock, M.A., K. Theodore, and L. O'Donnnell. 1994. Seed-bank methods for Australian wetlands. Australian Journal of Marine and Freshwater Research 45:483-493.

Broderson, J.M. 1973. Sizing Buffer Strips to Maintain Water Quality. Master's thesis. Seattle, WA: University of Washington.

Brown, K.S. 1998. Vanishing pools taking species with them. Science 281:626.

Brown, M. and J.J. Dinsmore. 1986. Implications of marsh size and isolation for marsh bird management. Journal of Wildlife Management 50: 392-397.

Brown, M.T. 1991. Evaluating Created Wetlands through Comparisons with Natural Wetlands. EPA/600/3-91/058. Corvallis, OR: U.S. Environmental Protection Agency, Environmental Research Laboratory.

Brown, P.H. and C.L. Lant. 1999. The effect of wetland mitigation banking on the achievement of no-net-loss. Environmental Management 23: 333-345.

Brown, R. 1988. Effects of wetland channelization on runoff and loading. Wetlands 8:123-133.

Brown, R.E. 1985. Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington. Parts 1 and 2. U.S. Forest Service, Pacific Northwest Region.

Brown, S.C. 1998. Remnant seed banks and vegetation as predictors of restored marsh vegetation. Canadian Journal of Botany 76:620-629.

Brown, S.C. 1999. Vegetation similarity and avifaunal food value of restored and natural marshes in northern New York. Restoration Ecology 7: 56-68.

Brown, S.C. and B.L. Bedford. 1997. Restoration of wetland vegetation with transplanted wetland soil: An experimental study. Wetlands 17: 424-437.

Brown, S.C. and C.R. Smith. 1998. Breeding season bird use of recently restored versus natural wetlands in New York. Journal of Wildlife Management 62: 1480-1491.

Brown, S.C. and P.L.M. Veneman. 2001. Effectiveness of compensatory wetland mitigation in Massachuetts, USA. Wetlands 21:508-518.

Brown, S.C., K. Smith, and D. Batzer. 1997. Macroinvertebrate responses to wetland restoration in northern New York. Environmental Entomology 26: 1016-1024.

Brumback, B. and R. Brumback. 1988. Protecting resources through land acquisition. Forum for Applied Research and Public Policy Fall: 92-99.

Bruner, K.A., S.W. Fisher, and P.F. Landrum. 1994. The role of the zebra mussel, Dreissena polymorpha, in contaminant cycling: II. Zebra mussel contaminant accumulation from algae and suspended particles, and transfer to the benthic invertebrate, *Gammarus fasciatis*. Journal of Great Lake Research 20(4):735-750.

Buchanan, J.B. 2004. Shorebirds: Plovers, Oystercatchers, Avocets and Stilts, Sandpipers, Snipes, and Phalaropes. In: Larsen, E.M., J.M. Azzerad, and N. Nordstrom (eds). Management Recommendations for Washington's priority species, Volume IV: Birds. Washington Department of Fish and Wildlife, Olympia Washington USA.

Budd, W., P.L. Cohen, P.R. Saunders, and F.R. Steiner. 1987. Stream corridor management in the Pacific Northwest: Determination of stream corridor widths. Environmental Management 11(5): 587-597.

Budeau, D.A. and P. Snow. 1992. Wildlife Use of Agriculturally Disturbed Wetland Sites in the Willamette Valley, Oregon. Salem, OR: Oregon Fish and Wildlife Department.

Budelsky, R.A. and S.M. Galatowitsch. 2000. Effects of water regime and competition on the establishment of a native sedge in restored wetlands. Journal of Applied Ecology 37: 971-985.

Bull, E.L. and M.P. Hayes. 2000. Livestock effects on reproduction of the Columbia spotted frog. Journal of Range Management 53: 291-294.

Bullock, A. and M. Acreman. 2003. The role of wetlands in the hydrologic cycle. Hydrology and Earth System Sciences 7:358-389.

Bunn, S.E. and A. H. Arthington. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management 30:492-507.

Burgess, S.A. 1978. Aspects of Mink (*Mustela vison*) Ecology in the Southern Laurentians of Quebec. M.S. Thesis. Montreal, Quebec: MacDonald College of McGill University.

Burgess, S.A. and J.R. Bider. 1980. Effects of stream habitat improvements on invertebrates, trout populations, and mink activity. Journal of Wildlife Management 44:871-880.

Burke, V.J. and J.W. Gibbons. 1995. Terrestrial buffer zones and wetland conservation: A case study of freshwater turtles in a Carolina Bay. Conservation Biology 9(6): 1365-1369.

Bursey, C.R. 1998. The suitability of constructed wetlands as amphibian habitat. Pages 281-286 in S.K. Majumdar, E.W. Miller, and F.J. Brenner (eds.), Ecology of Wetlands and Associated Systems. Pennsylvania Academy of Science.

Bury, R.B. 1988. Habitat relationships and ecological importance of amphibians and reptiles. In K.J. Raedeke, Streamside Management: Riparian Wildlife and Forestry Interaction. Contribution No. 59: 61. Seattle, WA: University of Washington, Institute of Forest Resources.

Busby, F.E. 1979. Riparian and stream ecosystems, livestock grazing, and multiple-use management. Pages 6-12 in O.B. Cope (ed.), Forum on Grazing and Riparian/Stream Ecosystems. November 3-4, 1978. Denver, CO: Trout Unlimited, Inc.

Caltech. 2003. Salinization. Available: http://www.gps.caltech.edu/~arid/salt/salt.html

Camargo, J.A. and J.V. Ward. 1992. Differential sensitivity of Dugesia dorotocephala and Cheumatopsyche pettiti to water acidification: Ecological implication for predator-prey interactions. Archives of Environmental Contamination and Toxicology 23:59-63.

Campeau, S., H.R. Murkin, and R.D. Titman. 1994. Relative importance of algae and emergent plant litter to freshwater marsh invertebrates. Canadian Journal of Fisheries and Aquatic Sciences 51:681-692.

Carlisle, B.K., J.P. Smith, A.L. Hicks, B.G. Largay, and S.R. Garcia. 1998. Wetland Ecological Integrity: An Assessment Approach. Boston, MA: Massachusetts Coastal Zone Management.

Casanova, M.T. and M.A. Brock. 2000. How do depth, duration and frequency of flooding influence the establishment of wetland plant communities? Plant Ecology 147:237-250.

Castelle, A. and A.W. Johnson. 2000. Riparian Vegetation Effectiveness. National Council for Air and Stream Improvement. Technical Bulletin #799.

Castelle, A.J., A.W. Johnson, and C. Conolly. 1994. Wetland and stream buffer size requirements: A review. Journal of Environmental Quality 23(5): 878-882.

(Castelle et al. 1992a) Castelle, A.J., C. Conolly, M. Emers, E.D. Metz, S. Meyer, M. Witter, S. Mauermann, M. Bentley, D. Sheldon, and D. Dole. 1992. Wetland Mitigation Replacement Ratios: Defining Equivalency. Washington Department of Ecology Publication No. 92-08. Olympia, WA.

(Castelle et al. 1992b) Castelle, A.J., C. Conolly, M. Emers, E.D. Metz, S. Meyer, M. Witter, S. Mauermann, T. Erickson, and S.S. Cooke. 1992. Wetland Buffers: Use and Effectiveness. Washington. Department of Ecology, Publication No. 92-10. Olympia, WA.

Celedonia, M.T. 2002. Benchmarks for Stand Development of Forested and Scrub-Shrub Plant Communities at Wetland Mitigation Sites in the Lowlands of Western Washington. Olympia, WA: Washington State Department of Transportation.

Chappell, C.B., R.C. Crawford, C. Barrett, J. Kagan, M. Johnson, M. O'Mealy, G. A. Green, H. L. Ferguson, W. D. Edge, E.L. Greda, and T.A. O'Neil. 2001. Wildlife habitats: Descriptions, status, trends, and system dynamics. In D.H. Johnson and T.A. O'Neil (eds.), Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press.

Chase, V., L. Deming, and F. Latawiec. 1995. Buffers for Wetlands and Surface Waters: A Guidebook for New Hampshire Municipalities. Concord, NH: Audubon Society of New Hampshire.

Chavez, J.E., A.I. Mazeroll, and D.B. Parker. 1999. Response of *Rana pipiens* (Leopard Frog) Egg and Larval Developmental Stages to Varied Concentrations of Feedlot Wastewater Runoff. ASAE Paper No. 99-4080. Annual International Meeting, Toronto, Ontario, Canada, July 18-21, 1999.

Chin, N. 1996. Watershed Urbanization Effects on Palustrine Wetlands: A Study of the Hydrologic, Vegetative and Amphibian Community Response over Eight Years. M.S. Thesis. Seattle, WA: University of Washington.

Chovanec, A. 1994. Man-made wetlands in urban recreational areas: A habitat for endangered species? Landscape and Urban Planning 29(1): 43-54.

Chovanec, A. and R. Raab. 1997. Dragonflies (*Insecta, Odanata*) and the ecological status of newly created wetlands: Examples for long-term bioindication programmes. Limnolgica 27(3-4): 381-392.

Christensen, D.L., B.R. Herwig, D.E. Schindler, and S.R. Carpenter. 1996. Impacts of lakeshore residential development on coarse woody debris in north temperate lakes. Ecological Applications 6:1143-1149.

Christiansen, N.L., J.K. Agee, P.F. Brussard, J. Hughes, D.H. Knight, G.W. Minshall, J.M. Peek, S.J. Pyne, and F. Swanson. 1989. Interpreting the Yellowstone fires of 1988. BioScience 39: 678-685.

Chung, K.H.. K.S. Ro, and D. Roy. 1996. Fate and enhancement of atrazine biotransformation in anaerobic wetland sediment. Water Research 30: 341-346.

Churcher, P.B. 1989. Beware of well-fed felines. Natural History 98(7):40.

Cieminski, K.L. and L.D. Flake. 1995. Invertebrate fauna of wastewater ponds in southeastern Idaho. Great Basin Naturalist 55(2): 105-116.

Clairain, Jr. E.J. 2002. Hydrogeomorphic Approach to Assessing Wetland Functions: Guidelines for Developing Regional Guidebooks. Chapter 1. Introduction and Overview of the Hydrogeomorphic Approach. ERDC/EL TR-02-3. March 2002. U.S. Army Corps of Engineers, Wetlands Research Program.

Clark, D.L. and M.V. Wilson. 2001. Fire, mowing, and hand-removal of woody species in restoring a native wetland prairie in the Willamette Valley of Oregon. Wetlands 21(1): 135-144.

Clark, R.G. and T.D. Nudds. 1991. Habitat patch size and duck nesting success: The crucial experiments have not been performed. Wildlife Society Bulletin 19:534-543.

Clary, W.P. 1995. Vegetation and soil responses to grazing simulation on riparian meadows. Journal of Range Management 48: 18-25.

Clary, W.P., N.L. Shaw, J.G. Dudley, V.A. Saab, J.W. Kinney, and L.C. Smithman. 1996. Response of a Depleted Sagebrush Steppe Riparian System to Grazing Control and Woody Plantings. U.S. Forest Service, Intermountain Research Station.

Clements, W.H. 1994. Benthic invertebrate community responses to heavy metals in the Upper Arkansas River, Colorado. Journal of the North American Benthological Society 13:30-44.

Cole, C.A. and D. Shafer. 2002. Section 404 wetland mitigation and permit success criteria in Pennsylvania, USA, 1986-1999. Environmental Management 30(4): 508-515.

Cole, C.A. and R.P. Brooks. 2000. A comparison of the hydrologic characteristics of natural and created mainstem floodplain wetlands in Pennsylvania. Ecological Engineering 14(3): 221-231.

Collins, S.J. and D.J. Gibson. 1990. Effects of fire on community structure in tallgrass and mixed grass prairie. In S. Collins and L.L. Wallace (eds.), Fire in North American Tallgrass Prairie. Norman, OK: University of Oklahoma Press.

Compton, J.E., M.R. Church, S.T. Larned, and W.E. Hogsett. 2003. Nitrogen Export from Forested Watersheds in the Oregon Coast Range: The Role of N_2-fixing Red Alder. Ecosystems Vol. 6., Number 8. Pages 773-785.

Confer, S.R. and W.A. Niering. 1992. Comparison of created and natural freshwater emergent wetlands in Connecticut (USA). Wetlands Ecology and Management 2(3): 143-156.

Conway, V.M. 1949. The bogs of central Minnesota. Ecological Monographs 19:173-206.

Cooke, S.S. In press. Pacific Northwest Forested Wetland Literature Survey: Synthesis Paper. Washington State Department of Natural Resources.

Cooke, S.S. and A.L. Azous. 2001. Characteristics of central Puget Sound basin palustrine wetland vegetation. Chapter 3, pages 69-95 in A.L. Azous and R.R. Horner (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Cooke, Sarah Spear. 1992. Wetland Buffers - A Field Evaluation of Buffer Effectiveness in Puget Sound. Appendix A. *In:* Castelle, A. J. et al. Wetland Buffers: Use and Effectiveness. Shorelands and Coastal Zone Management Program, Washington Dept. of Ecology, Olympia, Pub. No. 92-10.

Cooper, C.B. and S.H. Anderson. 1996. Significance of invertebrate abundance to dabbling duck brood use of created wetlands. Wetlands 16: 557-563.

Cooper, C.G. 1996. Hydrologic Effects of Urbanization on Puget Sound Lowland Streams. M.S. Thesis. University of Washington

Cooper, C.M. 1993. Biological effects of agriculturally derived surface water pollutants on aquatic systems: A review. Journal of Environmental Quality 22:402-408

Corn, P.S. and F.A. Vertucci. 1992. Descriptive risk assessment of the effects of acidic deposition on Rocky Mountain amphibians. Journal of Herpetology 26(4):361-369.

COST-Transport. 2003. COST 341: Habitat Fragmentation due to Transportation Infrastructure. Available: http://www.cordis.lu/cost-transport/src/cost-341.htm. Accessed July 8, 2003.

Coulton, K.G., P. Goodwin, C. Perala, and M.G. Scott. 1996. An Evaluation of Flood Management Benefits Through Floodplain Restoration on the Willamette River, Oregon, USA. River Network, Portland, OR. Philip Williams & Associates, Ltd.

Council of Environmental Quality. 1997. Considering cumulative effects under the National Environmental Policy Act. Executive Office of the President. Washington D.C.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Washington, DC: U.S. Fish and Wildlife Service.

Craft, C.B. and C.J. Richardson. 1993. Peat accretion and N, P, and organic accumulation in nutrient-enriched and unenriched Everglades peatlands. Ecological Applications 3:446-458.

Creighton, J.H., R.D. Sayler, J.E. Tabor, and M.J. Monda. 1997. Effects of wetland excavation on avian communities in eastern Washington. Wetlands 17(2): 216-227.

Crosbie, B. and F.P. Chow. 1999. Percentage land use in the watershed determines the water and sediment quality of 22 marshes in the Great Lakes basin. Canadian Journal of Fisheries and Aquatic Sciences 56(10): 1781-1791.

Cross, S.P. 1985. Responses of small mammals to forest riparian perturbations. In Riparian Ecosystems and their Management: Reconciling Conflicting Uses. Proceedings of First North American Riparian Conference, University of Arizona, Tucson, AZ, April 16-18, 1985. U.S. Forest Service General Technical Report RM-120.

Cross, S.P. 1988. Riparian systems and small mammals and bats. In K.J. Raedeke, Streamside Management: Riparian Wildlife and Forestry Interactions. Contribution No. 59. Seattle, WA: University of Washington, Institute of Forest Resources.

Crossle, K. and M.A. Brock. 2002. How do water regime and clipping influence wetland plant establishment from seed banks and subsequent reproduction? Aquatic Botany 74:43-56.

Crowder, A. and D.S. Painter. 1991. Submersed macrophytes in Lake Ontario: Current knowledge, importance, threats to stability, and needed studies. Canadian Journal of Fisheries and Wildlife 48: 1539-1545.

Crowley, J.M. 1967. Biogeography. Canadian Geographer 11:312-326.

Crunkilton, R.L. and R.M. Duchrow. 1990. Impact of a massive crude oil spill on the invertebrate fauna of a Missouri Ozark stream. Environmental Pollution 63(1):13-31.

Cyr, H. and J.A. Downing. 1988. The abundance of phytophilous invertebrates on different species of submerged macrophytes. Freshwater Biology 20:365-374.

d'Itri, Frank M. (ed.). 1997. Zebra Mussels and Aquatic Nuisance Species. Chelsea, MI: Ann Arbor Press, Inc.

Dahl, T.E. 1990. Wetland Losses in the United States 1780's to 1980's. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Dale, V.H., S. Brown, R.A. Haeuber, N.T. Hobbs, N. Huntly, R.J. Naiman, W.E. Riebsame, M.G. Turner, and T.J. Valone. 2000. Ecological principles and guidelines for managing the use of land. Ecological Applications 10: 639-670.

Dallinger, R. and W. Wieser. 1984. Patterns of accumulation, distribution and liberation, Zn, Cu, Cd, and Pb in different organs of the land snail *Helix pomatia* L. Comparative Biochemistry and Physiology 79:117-124.

Daniels, R.B. and J.W. Gilliam. 1996. Sediment and chemical load reduction by grass and riparian filters. Soil Science Society of America Journal 60: 246-251.

David, P.G. 1994. The effects of regulating Lake Okeechobee water levels on flora and fauna. Lake and Reservoir Management 9(2): 67.

David, P.G. 1996. Changes in plant communities relative to hydrologic conditions in the Florida Everglades. Wetlands 16(1): 15-23.

David, P.G. 1999. Response of exotics to restored hydroperiod at Dupuis Reserve, Florida. Restoration Ecology 7(4): 407-410.

Davis, J.W., G.A. Goodwin, and R.A. Ockenfels. 1983. Snag Habitat Management: Proceedings of the Symposium. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station.

de Szalay, F.A. and V.H. Resh. 1997. Responses of wetland invertebrates and plants important in waterfowl diets to burning and mowing of emergent vegetation. Wetlands 17:149-156.

de Szalay, F.A., D.P. Batzer, and F.H. Resh. 1996. Mesocosm and macrocosm experiments to examine effects of mowing emergent vegetation on wetland invertebrates. Environmental Entomology 25:203-209.

De Weese, J.M. 1998. Vernal pool construction monitoring methods and habitat replacement evaluation: Ecology, conservation, and management of vernal pool ecosystems. In C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (eds.), Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference. Sacramento, CA: California Native Plant Society.

DeAngelis, D.L., W.F. Loftus, J.C. Trexler, and R.E. Ulanowicz. 1997. Modeling fish dynamics and effects of stress in a hydrologically pulsed ecosystem. Journal of Aquatic Ecosystem Stress and Recovery 6(1): 1-13.

Debose, A. and M.W. Klugland. 1983. Soil Survey of Snohomish County Area, Washington. U.S. Department of Agriculture, Soil Conservation Service.

Delaplane, K.S. and D.F. Mayer. 2000. Crop Pollination by Bees. CABI Publishing. New York.

Delis, P.R., H.R. Mushinsky, and E.D. McCoy. 1996. Decline of some west-central Florida anuran populations in response to habitat degradation. Biodiversity and Conservation 5(12): 1579-1595.

Delphey, P.J. and J.J. Dinsmore. 1993. Breeding bird communities of recently restored and natural prairie potholes. Wetlands 13: 200-206.

Demayo et al. 1982. Toxic effects of lead and lead compounds on human health, aquatic life, wildlife, plants, and livestock. CRC Critical Reviews in Enviornmental Control 12:257-305.

Dennis, D.G., G.B. McCullough, N.R. North, and B. Collins. 1989. Surveys of Breeding Waterfowl in Southern Ontario, 1971-1987. Canadian Wildlife Report Series. 29.

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated Buffers in the Coastal Zone: A Summary Review and Bibliography. Coastal Resources Center Technical Report No. 2064. University of Rhode Island 72pp.

Detenbeck, N.E., S.M. Galatowitsch, J. Atkinson, and H. Ball. 1999. Evaluating perturbations and developing restoration strategies for inland wetlands in the Great Lakes basin. Wetlands 19(4): 789-820.

Dewey, M.R. and C.A. Jennings. 1992. Habitat use by larval fishes in a backwater lake of the upper Mississippi River. Journal of Freshwater Ecology 7:363-372.

Diamond, J.M., E.L. Winchester, D.G. Mackler, and D. Gruber. 1992. Use of the mayfly *Stenonema modestum* (Heptageniidae) in subacute toxicity assessments. Environmental Toxicology and Chemistry 11:415-425.

Dicke, S.G. and J.R. Toliver. 1990. Growth and development of bald-cypress and water tupelo stands under continuous versus seasonal flooding. Forest Ecology and Management 33/34:523-530.

Dieter, C.D., W.G. Duffy, and L.D. Flake. 1996. The effect of phorate on wetland macroinvertebrates. Environmenetal Toxicology and Chemistry 15:308-312.

Dillaha, T.A.I. and S.P. Inamdar. 1997. Buffer zones as sediment traps or sources. Pages 33-42 in N.E. Haycock, T.P. Burt, K.W.T. Goulding, and G. Pinay (eds.), Buffer Zones: Their Processes and Potential in Water Protection. Harpenden, Hertfordshire, UK: Quest Environmental.

Dillaha, T. 1993. Development of a Buffer Zone Evaluation Model/Procedure. Report to the Virginia Council on the Environment. Coastal Resources Management Program, Virginia Polytechnic Institute and University, Blacksburg, Virginia.

Dittmar, L.A. and R.K. Neely. 1999. Wetland seed bank response to sedimentation varying in loading rate and texture. Wetlands 19(2): 341-351.

DNR. See Washington State Department of Natural Resources.

Dobkin, D.S., A.C. Rich, and W.H. Pyle. 1998. Habitat and avifaunal recovery from livestock grazing in a riparian meadow system of the northwestern great basin. Conservation Biology 12(1): 209-221.

Dodd, C.K. and B.S. Cade. 1998. Movement patterns and the conservation of amphibians breeding in small, temporary wetlands. Conservation Biology 12(2): 331-339.

Dodd, K.C., Jr. 1995. The ecology of a sandhills population of the eastern narrow-mouthed toad, *Gastrophryne carolinensis*, during a drought. Bulletin of the Florida Museum of Natural History 38: 11-41.

Dodson, S.I. and R.A. Lillie. 2001. Zooplankton communities of restored depressional wetlands in Wisconsin, USA. Wetlands 21: 292-300.

Donald, D.B., J. Syrgiannis, F. Hunter, and G. Weiss. 1999. Agricultural pesticides threaten the ecological integrity of northern prairie wetlands. Science of the Total Environment 231(2-3): 173-181.

Dorge, J. 1994. Modelling nitrogen transformations in freshwater wetlands. Estimating nitrogen retention and removal in natural wetlands in relation to their hydrology and nutrient loadings. Ecological Modelling 75:409-420.

Dortch, M.S. 1996. Removal of solids, nitrogen, and phosphorus in the Cache River wetland. Wetlands 16:358-365.

Dosskey, M.G. 2000. How much can USDA riparian buffers reduce agricultural nonpoint source pollution? In P.J. Wigington and R.L. Beschta (eds), Riparian Ecology and Management in Multi-Land Use Watersheds. American Water Resources Association. Middleburg VA.

Dosskey, M.G. 2001. Toward quantifying water pollution abatement in response to installing buffers on crop land. Environmental Management 28(5): 577-598.

Dougherty, J.E. and M.D. Morgan. 1991. Benthic community response (primarily Chironomidae) to nutrient enrichment and alkalinization in shallow, soft water humic lakes. Hydrobiologia 215:73-82.

Doyle, R. C., G. C. Stanton, and D. C. Wolf. 1977. Effectiveness of forest and grass buffer strips in improving the water quality of manure polluted runoff. American Society of Agricultural Engineers, Paper No. 77-2051.

Dozier, H.L. 1953. Muskrat Production and Management. Circular No. 18. U.S. Fish and Wildlife Service.

Driscoll, L. and T. Granger. 2001. Draft Programmatic Environmental Impact Statement: Washington State's Draft Rule on Wetland Mitigation Banking. Washington State Department of Ecology. Publication #01-06-022. Olympia WA.

Dunne, T. and L.B. Leopold. 1978. Water in Environmental Planning. New York: W.H. Freeman and Company.

Dunstone, N. 1978. The fishing strategy of the mink (*Mustela vison*): Time-budgeting of hunting effort? Behaviour 67:157-177.

Durno, S.E. 1961. Evidence regarding the rate of peat growth. Journal of Ecology 49:347-351.

Dvorak, J. and E.P.H. Best. 1982. Macro-invertebrate communities associated with the macrophytes of Lake Vechten: Structural functional relationships. Hydrobiologia 95:115-126.

Dwyer, N.C. and G.W. Tanner. 1992. Nesting success in Florida sandhill cranes. Wilson Bulletin 104:22-31.

Dyste, R. 1995. Wetland Buffers in the Monterey Bay Region: A Field Study of Function and Effectiveness. M.S. thesis. San Jose, CA: San Jose State University.

Earnst, W.H.O. 1990. Ecophysiology of plants in waterlogged and flooded environments. Aquatic Botany 38: 73-90.

Easter-Pilcher, A. 1987. Forage Utilization, Habitat Selection, and Population Indices of Beaver in Northwestern Montana. M.S. Thesis, University of Montana.

Ecology. See Washington State Department of Ecology.

Edge, WD. 2001. Wildlife of Agriculture, Pastures, and Mixed Environs. pp. 342-360. in: Johnson, DH and TA O'Neil (eds). Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis.

Edwards, W.M., L.B. Owens, and R.K. White. 1983. Managing runoff from a small, paved, beef feedlot. *Journal of Environmental Quality*. **12:**281-286.

Ehrenfeld, J.G. 2000. Evaluating wetlands within an urban context. Ecological Engineering 15(3-4): 253-265.

Ehrenfeld, J.G. and J.P. Schneider. 1991. *Chamaecyparis thyoides* wetlands and suburbanization: Effects on hydrology, water quality and plant community composition. Journal of Applied Ecology 28: 467-490.

Ehrenfeld, J.G. and J.P.Schneider. 1993. Responses of forested wetland vegetation to perturbations of water chemistry and hydrology. Wetlands 13 Special Issue 22-129.

Eisler, R. 1988. Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish and Wildlife Service Biological Report No. 85(1.14).

Eisler, R. 1992. Fenvalerate Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Biological Report 92(2). U.S. Fish and Wildlife Service.

Ellison, A.M. and B.L. Bedford. 1995. Response of a wetland vascular plant community to disturbance: A simulation study. Ecological Applications 5(1):109-123.

Emerson, D. 1999. Iron-oxidizing bacteria are associated with ferric hydroxide precipitates (Fe-plaque) on the roots of wetland plants. Applied and Environmental Microbiology 65(6): 2758-2761.

Emmett, B.A., J.A. Hudson, P.A. Coward, and B. Reynolds. 1994. The impact of a riparian wetland on streamwater quality in a recently afforested upland catchment. Journal of Hydrology 162: 337-353.

Entry, J.A. and W.H. Emmingham. 1996. Influence of vegetation on microbial degradation of atrazine and 2, 4-dichlorophenoxyacetic acid in riparian soils. Canadian Journal of Soil Science 76: 101-106

Environmental Law Institute. 2002. Banks and Fees: The Status of Off-Site Wetland Mitigation in the United States. Washington, DC.

EPA. See U.S. Environmental Protection Agency.

Errington, P.L. 1937. Habitat requirements of stream-dwelling muskrats. Transactions of the North American Wildlife Confederation 2:411-416.

Errington, P.L. 1963. Muskrat Populations. Ames, IA: Iowa State University Press.

Erwin, K.L. 1991. An Evaluation of Wetland Mitigation in the South Florida Water Management District, Volume 1. West Palm Beach, FL: South Florida Water Management District. Available: http://www.aswm.org/science/mitigation/erwin91.pdf.

Ettema, C.H., D.C. Coleman, G. Vellidis, R. Lowrance, and S.L. Rathbun. 1998. Spatiotemporal distributions of bacterivorous nematodes and soil resources in a restored riparian wetland. Ecology 79 (8): 2721-2734

Eugene, City of. 2002. West Eugene Wetlands Plan Appendices. http://www.ci.eugene.or.us/wewetlands/WEWP2000/WEWP2000_Appendices.htm#appendix%20b. Accessed August 2003.

Euliss, N.H., D.M. Mushet, D.A. Wrubleski. 1999. Wetlands of the Prairie Pothole Region: Invertebrate species composition. Pages 471-514 in D. Batzer, R. Rader, and S. Wissinger (eds.), Invertebrates in Freshwater Wetlands of North America: Ecology and Management. Chapter 21. New York: John Wiley & Sons.

Euliss, N.H., Jr. and D.M. Mushet. 1996. Water-level fluctuation in wetlands as a function of landscape condition in the prairie pothole region. Wetlands 16(4): 587-593. 1996.

Euliss, N.H., Jr. and D.M. Mushet. 1999. Influence of agriculture on aquatic invertebrate communities of temporary wetlands in the prairie pothole region of North Dakota, USA. Wetlands 19(3): 578-583.

Everard, M. 1999. Towards sustainable development of still water resources. Hydrobiologia 395/396, 29-38.

Everett, City of. 1997. Snohomish Estuary Wetlands Integration Plan. Everett, WA.

Ewing, K. 1996. Tolerance of four wetland plant species to flooding and sediment deposition. Environmental and Experimental Botany 36: 131-146.

Eyre, M.D. 1992. The effects of varying site-water duration on the distribution of water beetle assemblages, adults and larvae (Coleoptera: Haliplidae, Dytiscidae, Hydrophilidae). Archiv fur Hydrobiologie 124: 281-291.

Facemire, C.F. 1992. Impact of Agricultural Chemicals on Wetland Habitats and Associated Biota with Special Reference to Migratory Birds: A Selected and Annotated Bibliography. SD: Agricultural Experiment Station, South Dakota State University.

Fahrig, L. 1997. Relative effects of habitat loss and fragmentation on population extinction. Journal of Wildlife Management 61(3): 603-610.

Fahrig, L. 2003. Effects of habitat fragmentation on biodiversity. Annual Revue of Ecology and Systematics 34:487-515.

Fahrig, L., J.H. Pedlar, S.E. Pope, P.D. Taylor, and J.F. Wegner. 1995. Effect of road traffic on amphibian density. Biological Conservation 73: 177-182.

Fairbairn, S.E. and J.J. Dinsmore. 2001. Local and landscape-level influences on wetland bird communities of the prairie pothole region of Iowa, USA. Wetlands 21(1): 41-47.

Fairchild, G.W., A.M. Faulds, and J.F. Matta. 2000. Beetle assemblages in ponds: Effects of habitat and site age. Freshwater Biology 44(3): 523-534.

Fairchild, G.W., J.M. Campbell, and R.L. Lowe. 1989. Numerical response of chydorids (Cladocera) and chironomids (Diptera) to nutrient-enhanced periphyton growth. Archiv fur Hydrobiologie 114(3): 369-382.

Fairchild, W.L. and D.C. Eidt. 1993. Perturbation of the aquatic invertebrate community of acidic bog ponds by the insecticide fenitrothion. Archives of Environmental Contamination & Toxicology 25(2): 170-183.

Farago, M.E. and A. Mehra. 1993. Partial identification and copper tolerance of soil bacteria from copperimpregnated bog and from a salt marsh. Chemical Speciation & Bioavailability 5(2): 51-60.

Farber, S. and R. Costanza. 1987. The economic value of wetland systems. Journal of Environmental Management 24:41-51.

Farmer, A.M. 1990. The effect of lake acidification on aquatic macrophytes: A review. Environmental Pollution 65:219- 240.

Fausch, K.D. and T.G. Northcote. 1992. Large woody debris and salmonid habitat in a small coastal British Columbia stream. Canadian Journal of Fisheries and Aquatic Sciences 49: 682-693.

Feldman, R.S. and E.F. Connor. 1992. The relationship between pH and community structure of invertebrates in streams in the Shanandoah National Park, Virginia, USA. Freshwater Biology 27:261-276.

Feltz, H.R., M.A. Sylvester, and R.A. Engberg. 1991. Reconnaissance investigations of the effects of irrigation drainage on water quality, bottom sediment, and biota in the western United States. Pages 319-323 in Water-Resources Investigations Report 91-4034. U.S. Geological Survey Toxic Substances Hydrology Program.

FEMAT(Forest Ecosystem Management Assessment Team). 1993. Forest Ecosystem Management: An Ecological, Economic, and Social Assessment. Report available on line http://pnwin.nbii.gov/nwfp/FEMAT/

Fennessy, M.S., C.C. Brueske, and J.W. Mitsch. 1994. Sediment deposition patterns in restored freshwater wetlands using sediment traps. Ecological Engineering 3:409-428.

Figiel, C.R., Jr., B. Collins, and G. Wein. 1995. Variation in the survival of two wetland grasses at differing nutrient and water levels over a six week period. Bulletin of the Torrey Botany Club 122(1):24-29.

Findlay, C.S. and J. Bourdages. 2000. Response time of wetland biodiversity to road construction on adjacent lands. Conservation Biology 14(1): 86-94.

Findlay, C.S. and J. Houlahan. 1997. Anthropogenic correlates of species richness in southeastern Ontario wetlands. Conservation Biology 11(4): 1000-1009.

Fischer, R.A., C.O. Martin, and J.C. Fischenich. 2000. Improving riparian buffer strips and corridors for water quality and wildlife. In P.J. Wigington and R.L. Beschta, Riparian Ecology and Management in Multi-Land Use Watersheds. American Water Resources Association. Middleburg VA

Fisher, P.J., O. Petrini, and J. Webster. 1991. Aquatic hyphomycetes and other fungi in living aquatic and terrestrial roots of Alnus glutinosa. Mycological Research 95(5): 543-547

Fitch, L. and B.W. Adams. 1998. Can cows and fish co-exist? Canadian Journal of Plant Science 78:191-198

Fitter, A.H. and R.K.M. Hay. 1987. Environmental Physiology of Plants. New York: Academic Press.

Fjellheim, A. and G.G. Raddum. 1996. Weir building in regulated west Norwegian rivers: long-term dynamics of invertebrates and fish. Regulated Rivers: Research and Management 12:501-508.

Flickinger, E.L., G. Juenger, T.J. Roffe, M.R. Smith, and R.J. Irwin. 1991. Poisoning of Canada geese in Texas by parathion sprayed for control of Russian wheat aphid. Journal of Wildlife Diseases 27:265-268

Ford, M.R. 1993. The Effect of Riparian Corridor Width on the Relative Abundance and Relative Diversity of Avian Communities. M.S. Thesis. Washington State University.

Fore, L.S., J.R. Karr, and R.W. Wisseman. 1996. Assessing invertebrate responses to human activities: Evaluating alternative approaches. Journal of the North American Benthological Society 15(2): 212-231.

Forman, A.T. and L.E. Alexander. 1998. Roads and their ecological effects. Annual Review of Ecology and Systematics 29:207-231.

Forman, R.T.T. 1998. The ecological road-effect zone for transportation planning and Massachusetts highway example. In G.L. Evink, P.A. Garrett, D. Zeigler, and J. Berry (eds.), Proceedings of the International Conference on Wildlife Ecology and Transportation. February 10-12. Fort Myers, FL.

Forman, R.T.T. and R.D. Deblinger. 2000. The ecological road-effect zone of a Massachusetts (USA) suburban highway. Conservation Biology 14(1): 36-46.

Foster, J.H., W.E. Tillett, W.L. Meyers, and J.C. Hoag. 1984. Columbia Basin Wildlife/Irrigation Development Study. REC-ERC-83-6. U.S. Department of the Interior, Bureau of Reclamation.

Fox, A.D., T.A. Jones, R. Singleton, and A.D.Q. Agnew. 1994. Food supply and the effects of recreational disturbance on the abundance and distribution of wintering Pochard on a gravel pit complex in southern Britain. Hydrobiologia 279/280: 253-261.

Franklin, J.F. and C.T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. Corvallis, OR: Oregon State University Press.

Freda, J. 1991. The effects of aluminum and other metals on amphibians. Environmental Pollution 71:305-328.

Freda, J. and D.G. McDonald. 1993. Toxicity of amphibian breeding ponds in the Sudbury Region. Canadian Journal of Fisheries and Aquatic Sciences 50(7):1497-1503.

Freda, J., V. Cavdek, and D.G. McDonald. 1990. Role of organic complexation in the toxicity of aluminum to Rana pipiens embryos and Bufo americanus tadpoles. Canadian Journal of Fisheries and Aquatic Sciences 47(1):217-224.

Freda, J., W.J. Sadinski, and W.A. Dunson. 1991. Long term monitoring of amphibian populations with respect to the effects of acidic deposition. Water Air Soil Pollution 55:445-463.

Freda, J. and D.G. McDonald. 1990. Effects of aluminum on the leopard frog, *Rana pipiens*: Life stage comparisons and aluminum uptake. Canadian Journal of Fisheries and Aquatic Sciences 47:210-216.

Fredrickson, L.H. 1982. Managed wetland habitats for wildlife: Why are they important? Proceedings of Water Impoundments for Wildlife: A Habitat Management Workshop. Aug. 31-Sept. 2, 1982. Bemidji, MN.

Freeman, C., G. Liska, N.J. Ostle, M.A. Lock, B. Reynolds, and J. Hudson. 1996. Microbial activity and enzymic decomposition processes following peatland water table drawdown. Plant and Soil 180: 121- 127.

Fushiwaki, Y. and K. Urano. 2001. Adsorption of pesticides and their biodegraded products on clay minerals and soils. Journal of Health Science 47:429-432.

Gainey, K.W. and J.P. Roise. 1998. Determination of possible wetland mitigation sites using NC-CREWS and an integer linear programming formulation. Connections 98 Conference. Available: http://itre.ncsu.edu/cte/S9-kgainey.html. North Carolina State University.

Galat, D.L., L.H. Fredrickson, D.D. Humburg, K.J. Bataille, J.R. Bodie, J. Dohrenwend, G.T. Gelwicks, J.E. Havel, D.L. Helmers, J.B. Hooker, J.R. Jones, M.F. Knowlton, J. Kubisiak, J. Mazourek, A.C. McColpin, R.B. Renken, and R.D. Semlitsch. 1998. Flooding to restore connectivity of regulated, large-river wetlands. BioScience 48:721-733.

Galatowitsch, S.M. and A.G. van der Valk. 1995. Natural revegetation during restoration of wetlands in the sourthern prairie pothole region of North America. In B.D. Wheeler, S.C. Shaw, W.J. Fojt, and R.A. Robertson (eds.), Restoration of Temperate Wetlands. John Wiley & Sons Ltd.

Galatowitsch, S.M. and A.G. van der Valk. 1996. The vegetation of restored and natural prairie wetlands. Ecological Application 6: 102-112.

Galatowitsch, S.M., N.O. Anderson, and P.D. Ascher. 1999. Invasiveness in wetland plants in temperate North America. Wetlands 19(4): 733-755.

Gambrell, R. and P. Trace. 1994. Toxic metals in wetlands: A review. Journal of Environmental Quality 23:883-892.

Gardner, S.C. and C.E. Grue. 1996. Effects of Rodeo and Garlon 3A on nontarget wetland species in central Washington. Environmental Toxicology and Chemistry 15:441-451.

Gelbard, J.L. and J. Belnap. 2003. Roads as conduits for exotic plant invasions in a semiarid landscape. Conservation Biology 17:420-432.

Gerguson, H.L. and S.K. Robinette. 2001. Wildlife of urban habitats. Pages 317-341 in D.H. Johnson and T.A. O'Neil (eds.), Wildlife-Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press.

Gernes, M.C. and J.C. Helgen. 1999. Indexes of Biotic Integrity (IBI) for Wetlands: Vegetation and Invertebrate IBI's. Minnesota Pollution Control Agency. St. Paul, MN.

Gersib, R. 1997. Restoring Wetlands at a River Basin Scale, A Guide for Washington's Puget Sound. Operational Draft. Olympia, WA: Washington State Department of Ecology.

Gersib, R. 2001. The need for process-driven, watershed-based wetland restoration in Washington State. Proceedings of the Puget Sound Research Conference 2001.

Gese, E.M., O.J. Rongstad, W.R. and Mytton. 1989. Changes in coyote movements due to military activity. Journal of Wildlife Management 53:334-339.

Ghaffarzadeh, M., C.A. Robinson, and R.M. Cruse. 1992. Vegetative filter strip effects on sediment deposition from overland flow. Agronomy Abstracts. Madison, WI: ASA.

Gibbons, J.W. 2003. Terrestrial habitat: a vital component for herpetofauna of isolated wetlands. Wetlands 23:630-635.

Gibbons, W.N., and G.L. Mackie. 1991. Relationship between environmental variables and demographic patterns of *Hyalella azteca* (Crustacea: Amphipoda). Journal of the North American Benthological Society 10(4):444-454.

Gibbs, J.P. 1991. Spatial relationships between nesting colonies and foraging areas of great blue herons. Auk 108:764-770

Gibbs, J.P. 1993. Importance of small wetlands for the persistence of local populations of wetland-associated animals. Wetlands 13(1): 25-31.

Gibbs, J.P. 2000. Wetland loss and biodiversity conservation. Conservation Biology 14: 314-317.

Gibbs, J.P., J.R. Longcore, D.G. McAuley, and J.K. Ringelman. 1991. Use of Wetland Habitats by Selected Nongame Water Birds in Maine. Fish and Wildlife Research 9. U.S. Fish and Wildlife Service.

Giberson, D.J. and R.J. MacKay. 1991. Life history and distribution of mayflies (Ephemeroptera) in some acid streams in South Central Ontario, Canada. Canadian Journal of Zoology 69(4):899-910.

Giberson, D.J., D.M. Rosenberg, and A.P. Wiens. 1992. Long-term abundance patterns of Hexagenia (Ephemeroptera: Ephemeridae) in Southern Indian Lake, Manitoba: Responses to weather and hydroelectric development. Canadian Technical Report, Fisheries and Aquatic Science No. 1837.

Giger, R.D. 1973. Streamflow Requirements of Salmonids. Final Report Project AFS-62-1. Portland, OR: Oregon Wildlife Commission.

(Gill 1978a) Gill, D.E. 1978. Effective population size and interdemic migration rates in a metapopulation of the red-spotted newt, *Notopthalmus viridescens* (Rafinesque). Evolution 32:839-849.

(Gill 1978b) Gill, D.E. 1978. The metapopulation ecology of the red-spotted newt, *Notopthalmus viridescens* (Rafinesque). Ecological Monographs 48:145-166.

Gilliam, F.S., J.D. May, M.A. Fisher, and D.K. Evans. 1999. Short-term changes in soil nutrients during wetland creation. Wetlands Ecology and Management 6(4): 203-208.

Gilliam, J.W. 1994. Riparian wetlands and water quality. Journal of Environmental Quality 23(5): 896-900.

Gladwin, D.N. and J.E. Roelle. 1998. Survival of cottonwood (*Populus deltoides* subsp. monilifera) and saltcedar (*Tamarix ramosissima*) seedlings in response to flooding. Wetlands 18(4): 669-674.

Gleason, R.A. and N.H. Euliss, Jr. 1998. Sedimentation of prairie wetlands. Great Plains Research 8(1): 97-112.

Glooschenko, V., W.F. Weller, P.G.R. Smith, R. Alvo, and J.H.G. Archbold. 1992. Amphibian distribution with respect to pond water chemistry near Sudbury. Canadian Journal of Fisheries and Aquatic Sciences 49(Supp 1):114- 121.

Golet, F.C. and J.S. Larson. 1974. Classification of Freshwater Wetlands in the Glaciated Northeast. Resource Publication 116. Washington, DC: U.S. Fish and Wildlife Service.

Goodwin, C.N., C.P. Hawkins, and J.L. Kershner. 1997. Riparian restoration in the western United States: Overview and perspective. Restoration Ecology 5(4s): 4-14.

Gopal, B. and Chamanlal. 1991. Distribution of aquatic macrophytes in polluted water bodies and their bioindicator value. Verh. Internat. Limnol. 24: 2125-2129.

Gordon, S.C. 1995. West Eugene wetlands program: A case study in multiple objective water resources management planning. In J.A. Kusler, D.E. Willard, and H.C. Hull, Jr. (eds.), Wetlands and Watershed Management: Science Applications and Public Policy. April 23-26, 1995.

Gore, A.J.P. (ed.). 1983. Ecosystems of the World 4A. Mires: Swamp, Bog, Fen and Moor. New York: Elsevier Scientific Publishing Co.

Gorman, O.T. and J.R. Karr. 1978. Habitat structure and stream fish communities. Ecology 59:507-515.

Goudreau, S.E., R.J. Neves, and R.J. Sheehan. 1993. Effects of wastewater treatment plant effluents on freshwater mollusks in the Upper Clinch River, Virginia, USA. Hydrobiologia 252(3):211-230.

Grapentine, L.C. and D.M. Rosenberg. 1992. Responses of the freshwater amphipod Hyalella azteca to environmental acidification. Canadian Journal of Fisheries and Aquatic Sciences 49(1):52-64.

Graves, G.A., D.G. Strom, and B.E. Robson. 1998. Stormwater impact to the freshwater Savannas Preserve marsh, Florida. Hydrobiologia 379:111-122.

Gray, J.J., R.M. Kaminski, G. Weerakkody, B.D. Leopold, and K.C. Jensen. 1999. Aquatic invertebrate and plant responses following mechanical manipulations of moist-soil habitat. Wildlife Society Bulletin 27:770-779.

Greenwood, R.J., A.B. Sargeant, D.H. Johnson, L.M. Cowardin, and T.L. Shaffer. 1995. Factors associated with Duck Nest Success in the Prairie Pothole Region of Canada. Wildlife Monographs No. 128.

Griffith, M.B., S.A. Perry, and W.B. Perry. 1995. Macroinvertebrate communities in headwater streams affected by acidic precipitation in the Central Appalachians. Journal of Environmental Quality 24(2):233-238.

Griffiths, R.W. and W. Keller. 1992. Benthic macroinvertebrate changes in lakes near Sudbury, Ontario, following a reduction in acid emissions. Canadian Journal of Fisheries and Aquatic Sciences 49(supp 1):63:75.

Grismer, M. E. 1981. Evaluating Dairy Waste Management Systems Influence on Fecal Coliform Concentration in Runoff. M.S. thesis, Oregon State Univ., Corvallis, OR.

Groffman, P.M., A.J. Gold, T.P. Husband, R.C. Simmons, and W.R. Eddleman. 1991a. An Investigation into Multiple Uses of Vegetated Buffer Strips. Narrangansett Bay Project No. NBP-91-63. Providence, RI.

Groffman, P.M., E.A. Axelrod, J.L. Lemunyon, and W.M. Sullivan. 1991b. Denitrification in grass and forest vegetated buffer strips. Journal of Environmental Quality 21:671-674.

Groot, C. and L. Margolis. 1991. Pacific Salmon Life Histories. Vancouver, BC: University of British Columbia Press.

Grootjans, A. and R. van Diggelen. 1995. Assessing the restoration prospects of degraded fens. In B.D. Wheeler, S.C. Shaw, W.J. Fojt and R.A. Robertson, Restoration of Temperate Wetlands. John Wiley & Sons Ltd.

Grosvernier, P.H., Y. Matthey, and A. Buttler. 1995. Microclimate and physical properties of peat: New clues to the understanding of bog restortation processes. In B.D. Wheeler, S.C. Shaw, W.J. Fojt and R.A. Robertson, Restoration of Temperate Wetlands. John Wiley & Sons Ltd.

Guenzi, W.D., W.E. Beard, and F.G. Viets. 1971. Influence of soil treatment on persistence of six chlorinated hydrocarbon insecticides in the field. Proceedings of the Soil Science Society of America 35:910-913.

Gulve, P.S. 1991. Extinction and isolation gradients in metapopulations: The case of the pool frog (*Rana lessonae*). Biological Journal of the Linnean Society (London) 42:135-147.

Gulve, P.S. 1994. Distribution and extinction patterns within a northern metapopulation of the pool frog Rana lessonae. Ecology 75:1357-1367.

Gwin, S.E. and M.E. Kentula. 1990. Evaluating Design and Verifying Compliance of Wetlands Created under Section 404 of the Clean Water Act in Oregon. EPA/600/3-90/061. Corvallis, OR: Environmental Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency.

Gwin, S.E., M.E. Kentula, and P.W. Shaffer. 1999. Evaluating the effects of wetland regulation through hydrogeomorphic classification and landscape profiles. Wetlands 19(3): 477-489.

Haag, W.R., D.J. Berg, D.W. Garton, and J.L. Farris. 1993. Reduced survival and fitness in native bivalves in response to fouling by the introduced zebra mussel (*Dreissena polymorpha*) in Western Lake Erie. Canadian Journal of Fisheries and Aquatic Sciences 50(1):13-19.

Hachmoller, B., R.A. Matthews, and D.F. Brakke. 1991. Effects of riparian community structure, sediment size, and water quality on the macroinvertebrate communities in a small, suburban stream. Northwest Science 65(3):125-132.

Haddad, N.M., D.R. Bowne, A. Cunningham, B.J. Danielson, D.J. Levey, S. Sargent, and T. Spira. 2003. Corridor use by diverse taxa. Ecology 84:609-615.

Haig, S.M., D.W. Mehlman, and L.W. Oring. 1997. Avian movements and wetland connectivity in landscape conservation. Conservation Biology 12:749-758.

Haila, Y. 2002. A conceptual genealogy of fragmentation research: from island biogeography to landscape ecology. Ecological Applications 12:321-334.

Hall, R.J. 1994. Herptofaunal Richness of the Four Holes Swamp, South Carolina. Resource Publication 198. Reston, VA: National Biological Survey, U.S. Geological Survey.

Hallock, R.J. and L.L. Hallock (eds.). 1993. Detailed Study of Irrigation Drainage in and near Wildlife Management Areas, West-Central Nevada, 1987-1990: Part B. Effect on Biota in Stillwater and Fernley Wildlife Management Areas and Other Nearby Wetlands. USGS Water-Resources Investigation Report 92-4024B. Denver, CO.

Hammer, D.A. 1989. Constructed Wetlands for Wastewater Treatment: Municipal, Industrial and Agricultural. Lewis Publishers, Inc. Chelsea MI. 856pp.

Hammer, U.T. and J.M. Heseltine. 1988. Aquatic macrophytes in saline lakes of the Canadian provinces. Hydrobiologia 158: 101-116.

Hanowski, J.M., G.J. Niemi, A.R. Lima, and R.R. Regal. 1997. Response of breeding birds to mosquito control treatments of wetlands. Wetlands 17: 485-492

Harmata, A.R., J.E. Durr, and H. Geduldig. 1978. Home Range Activity Patterns and Habitat Use of Prairie Falcons Nesting in the Mojave Desert. Contribution YA-512-CT8-43. Riverside, CA: U.S. Bureau of Land Management, California Desert Program.

Harper, D. 1992. Eutrophication of Freshwaters: Principles, Problems, and Restoration. New York: Chapman & Hall.

Harper, K.A. and S.E. MacDonald. 2001. Structure and composition of riparian boreal forest: New methods for analyzing edge influence. Ecology 82(3): 649-659.

Harris, L.D. 1988. The nature of cumulative impacts on biotic diversity of wetland vertebrates. Environmental Management 12(5): 675-693.

Harris, R. and C. Olson. 1997. Two-stage system for prioritizing riparian restoration at stream reach and community scales. Restoration Ecology 5(4s): 34-42.

Hart, L.E., K.M. Cheng, P.E. Whitehead, R.M. Shah, and R.J. Lewis. 1991. Dioxin contamination and growth and development of great blue heron embryos. Journal of Toxicology and Environmental Health 32(3):331-344.

Hashisaki, S. 1996. Functional wetland restoration: An ecosystem approach. Northwest Science 70(4): 348-351.

Havens, K.E. 1993. Lake acidification: Effects on crustacean zooplankton populations. Environmental Science and Technology 27:1621-1624.

(Havens 1994a) Havens, K.E. 1994. Acid and aluminum effects on the survival of littoral macroinvertebrates during acute bioassays. Environmental Pollution 80(1):95-100.

(Havens 1994b) Havens, K.E. 1994. Experimental peturbation of a freshwater plankton community: A test of hypothesis regarding the effects of stress. Oikos 69(1):147-153.

Havera, S.P., R.M. Whitton, and R.T. Shealy. 1992. Blood lead and ingested shot in diving ducks during spring. Journal of Wildlife Management 56:539-545.

Hawkins, C.P., K.L Bartz, and C.M.U. Neale. 1997. Vulnerability of riparian vegetation to catastrophic flooding: Implications for riparian restoration. Restoration Ecology 5(4s): 75-88.

Haworth-Brockman, M. J. and H.R. Murkin. 1993. Effects of shallow flooding on newly established purple loosestrife seedlings. Wetlands 13(3): 224-227.

Hayes, M.P. and M.R. Jennings. 1986. Decline of ranid frog species in Western North America: Are bullfrogs (*Rana catesbeiana*) responsible? Journal of Herpetology 20(4): 490-509.

Hayes, R.J. 1995. Soil Structural Breakdown and Compaction in New Zealand Soils. A report prepared for MAF Policy. ISBN: 0-478-07404-2; ISSN: 1171-4662.

Heathewaite, A.L. and KH. Gottlich (eds). 1993. Mires: Process, Exploitation, and Conservation. New York: John Wiley and Sons.

Hebert, P.D.N., C.C. Wilson, M.H. Murdoch, and R. Lazar. 1991. Demography and ecological impacts of the invading mollusc *Dreissena polymorpha*. Canadian Journal of Zoology 69(2):405-409.

Hecnar, S.J. and R.T. M'Closkey. 1996. Changes in the composition of a ranid frog community following bullfrog extinction. American Midland Naturalist 137: 145-150.

Heinz Center for Science. 2002. The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States. Washington, DC: John Heinz Center for Science, Economics, and the Environment.

Heitschmidt, R.K. 1990. The role of livestock and other herbivores in improving rangeland vegetation. Rangelands 12:

Heitschmidt, R.K. and J.W. Stuth. 1991. Grazing Management: An Ecological Perspective. 297 p. Timber Press. Portland, OR. Accessed on http://cnrit.tamu.edu/rlem/textbook/textbook-fr.html

Hemesath, L.M. and J.J. Dinsmore. 1993. Factors affecting bird colonization of restored wetlands. Prairie-Naturalist 25(1): 1-11.

Hemond, H.F. and J. Benoit. 1988. Cumulative impacts on water quality functions of wetlands. Environmental Management 12(5): 639-653.

Henry, C.J., K.F. Higgins, and K.J. Buhl. 1994. Acute toxicity and hazard assessment of Rodeo, X-77 Spreader, and Chem- Trol to aquatic invertebrates. Archive of Environmental Contamination and Toxicology 27: 392-399.

Herbold, H., F. Suchentrunk, S. Wagner, and R. Willing. 1992. The influence of anthropogenic disturbances on the heart frequency of red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*). Zeitshrift Fur Jagdwissenshaft 38:145-159.

Hershey, A.E., L. Shannon, G.J. Niemi, A.R. Lima, and R.R. Regal. 1999. Prairie wetlands of south-central Minnesota: Effects of drought on invertebrate communities. In D.P. Batzer, R.B. Rader, and S.A. Wissinger (eds), Invertebrates in Freshwater Wetlands of North America: Ecology and Management. John Wiley and Sons, Inc.

Herson-Jones, L.M., M. Heraty, and B. Jordan. 1995. Riparian Buffer Strategies for Urban Watersheds. Pub. 95703. Washington, DC: Metropolitan Washington Council of Governments.

Heusser, H. 1968. Die Lebensweise der Erdkrote, Bufo bufo L.: Wanderungen und Sommerquartiere. Revue Suisse Zoologique 76:444-517.

Hickman, S. 1994. Improvement of habitat quality for nesting and migrating birds at the Des Plaines River Wetlands Demonstration Project. Ecological Engineering 3(4): 485-494.

Hicks, A.L. 1995. Impervious Surface Area and Benthic Macroinvertebrate Response as an Index of Impact from Urbanization on Freshwater Wetlands. M.S. Thesis. University of Massachusetts.

Hicks, A.L. 1996. Aquatic Invertebrates and Wetlands: Ecology, Biomonitoring, and Assessment of Impact from Urbanization. Literature Review. Amherst, MA: The Environmental Institute, Blaisdell House, University of Massachusetts.

Higgins, K.F., L.M. Kirsch, A.T. Klett, and H.W. Miller. 1992. Waterfowl Production on the Woodworth Station in South-Central North Dakota, 1965–1981. Resource Publication 180. Jamestown, ND: U.S. Department of the Interior, Fish and Wildlife Service.

Hirschi, R., T. Doty, A. Keller, and T. Lebbe. 2003. Unpublished report. Juvenile salmonid use of tidal creek and independent marsh environments in North Hood Canal: Summary of first year findings. Port Gamble S'Klallam Tribe Natural Resources.

Hoffman, W., G. Bancroft, and R.J. Sawicki. 1994. Foraging habitat of wading birds in the water conservation areas of the Everglades. Pages 585-614 in S.M. Davis and J.C. Ogden (eds.), Everglades: The Ecosystem and its Restoration. FL: St. Lucie Press.

Hogg, I.D. and R.H. Norris. 1991. Effects of runoff from land clearing and urban development on the distribution and abundance of macroinvertebrates in pool areas of a river. Australian Journal of Marine and Freshwater Research 42:507-518.

Hohman, W.L., R.D. Pritchert, J.L. Moore, and D.O. Schaeffer. 1993. Survival of female canvasbacks wintering in coastal Louisiana. Journal of Wildlife Management 54:211-215.

Hoiland, W.K. and F.W. Rabe. 1992. Effects of increasing zinc levels and habitat degradation on macroinvertebrate communities in three north Idaho streams. Journal of Freshwater Ecology 7:373-380.

Hoiland, W.K., F.W. Rabe, and R.C. Biggam. 1994. Recovery of macroinvertebrate communities from metal pollution in the South Fork and mainstream of the Coeur d' Alene River, Idaho. Water Environmental Research 66(1)84-88.

Holland, C.C. and M.E. Kentula. 1992. Impacts of Section 404 permits requiring compensatory mitigation on wetlands in California (USA). Wetlands Ecology and Management 2: 157-169.

Holland, C.C., J. Honea, S.E. Gwin, and M.E. Kentula. 1995. Wetland degradation and loss in the rapidly urbanizing area of Portland, Oregon. Wetlands 15(4): 336-345.

Holland, D.C. 1991. Status and reproductive dynamics of a population of western pond turtles (*Clemmys marmorata*) in Klickitat County, Washington in 1990. Unpublished Report. Washington Dept. Wildlife, Olympia.

Holland, P.V. and D.C. Bossert. 1994. Mitigation Follow-Up Study of Selected Department of the Army Permits in Southern Louisiana. Lafayette, LA: U.S. Fish and Wildlife Service, Ecological Services.

Hollis, G.E. and J.R. Thompson. 1998. Hydrological data for wetland management. Journal of the Chartered Institution of Water and Environmental Management 12, 9-17.

Hollis, L., L. Muench, and R.C. Playle. 1997. Influence of dissolved organic matter on copper binding, and calcium on cadmium binding, by gills of rainbow trout. Journal of Fish Biology 50(4): 703-720.

Holmes, W.N. and K.P. Cavanaugh. 1990. Some evidence for an effect of ingested petroleum on the fertility of the mallard drake (*Anas platyrhynchos*). Archives of Environmental Contamination and Toxicology 19(6):898-901.

(Horne and Dunson 1994a). Horne, M.T. and W.A. Dunson. 1994. Behavioral and physiological responses of the terrestrial life stages of the Jefferson salamander, *Ambystoma jeffersonianum*, to low soil pH. Archives of Environmental Contamination and Toxicology 27(2):232-238.

(Horne and Dunson 1994b). Horne, M.T. and W.A. Dunson. 1994. Exclusion of the Jefferson salamander, *Ambystoma jeffersonianum*, from some potential breeding ponds in Pennsylvania: Effects of pH, temperature, and metals on embryonic development. Archives of Environmental Contamination and Toxicology 27(3):323-330.

Horne, M.T. and W.A. Dunson. 1995. Effects of pH, metals, and water hardness on larval amphibians. Archives of Environmental Contamination and Toxicology 29(4):500-505.

Horner, R.R. 1986. Water quality and carbon and nutrient cycling. Chapter 4 in R. Strickland (ed.), Wetland Functions, Rehabilitation and Creation in the Pacific Northwest: The State of Our Understanding. Olympia WA: Washington State Department of Ecology.

Horner, R.R., D.B. Booth, A. Azous, and C.W. May. 1996. Watershed determinants of ecosystem functioning. In L.A. Roesner (ed.), Effects of Watershed Development and Management on Aquatic Ecosystems: Proceedings of an Engineering Foundation Conference. Snowbird, UT: American Society of Civil Engineers.

Horner, R.R. and B.W. Mar. 1982. Guide for water quality impact assessment of highway operations and maintenance. Rep. WA-RD-39.14. Washington Department of Transportation, Olympia, WA.

Houck, C.A. 1996. The distribution and abundance of invasive plant species in freshwater wetlands of the Puget Sound lowlands, King County, Washington. M.S. Thesis University of Washington College of Forest Resources.

Hough, R.A., MD. Fornwall, B.J. Negele, R.L. Thompson, and D.A. Putt. 1989. Plant community dynamics in a chain of lakes: principal factors in the decline of rooted macrophytes with eutrophication. Hydrobiologia 173: 199-217.

Houlahan, J.E. and C.S. Findlay. 2003. The effects of adjacent land use on wetland amphibian species richness and community composition. Canadian Journal of Fisheries and Aquatic Sciences 60:1078-1094.

Howard, R. J. and J. A. Allen. 1989. Streamside habitats in southern forested wetlands: Their role and implications for management. *In*: Hook, D. D., and R. Lea (eds.) The Forested Wetlands of the Southern United States. United States Department of Agriculture, Forest Service General Technical Report SE-50. Atlanta, GA. 97-106.

Howard, R.W., G. Billen, D. Swaney, A. Townsend, N. Jaworksi, K. Lajtha, J.A. Downing, P. Elmgren, N. Caraco, T. Jordan, F. Berendse, J. Freney, V. Kudeyarov, P. Murdoch, and Z. Zhao-liang. 1966. Regional nitrogen budgets and riverine N & P fluxes for the drainages to the North Atlantic Ocean: natural and human influences. Biogeochemistry 35:75-139.

Hoyer, M.V. and D.E. Canfield, Jr. 1994. Handbook of Common Freshwater Fish in Florida Lakes. Gainesville, FL: University of Florida, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences.

Hruby, T. 1999. Assessments of wetland functions: What they are and what they are not. Environmental Management 23:75-85.

(Hruby 2004a). Hruby, T. 2004. Washington State Wetland Rating System for Eastern Washington – Revised. Ecology Publication # 04-06-015. Olympia, WA.

(Hruby 2004b). Hruby, T. 2004. Washington State Wetland Rating System for Western Washington – Revised. Ecology Publication # 04-06-025. Olympia, WA.

Hruby, T. and M. Scuderi. 1995. Integrated planning for wetland restoration and mitigation. Restoration Management Notes 13: 45-46.

Hruby, T., C. Brower, D. Knaub, J. Stellini, L. Storm, and R. Zeigler. 1994. Guidelines for Developing Freshwater Wetlands Mitigation Plans and Proposals. Publication #94-29. Olympia, WA: Washington State Department of Ecology.

Hruby, T., S. Stanley, T. Granger, T. Duebendorfer, R. Friesz, B. Lang, B. Leonard, K. March, and A. Wald. 2000. Methods for Assessing Wetland Functions, Volume II: Depressional Wetlands in the Columbia Basin of Eastern Washington. 2 Parts, Publication #00-06-47 and #00-06-48. Washington State Department of Ecology, Olympia, WA.

Hruby, T., T. Granger, K. Brunner, S. Cooke, K. Dublanica, R. Gersib, L. Reinelt, K. Richter, D. Sheldon, E. Teachout, A. Wald, and F. Weinmann. 1999. Methods for Assessing Wetland Functions, Volume I: Riverine and Depressional Wetlands in the Lowlands of Western Washington. 2 Parts, Publication #99-115 and #99-116. Washington State Department of Ecology, Olympia, WA.

Hruby, T., W. Cesanek, and K. Miller. 1995. Estimating relative wetland value for regional planning. Wetlands 15(2): 93-107.

Hudon, C. 1997. Impact of water level fluctuations on St. Lawrence River aquatic vegetation. Canadian Journal of Fisheries and Aquatic Sciences 54:2853-2865.

Huener, J.D. and J.A. Kadlec. 1992. Macroinvertebrate response to marsh management strategies in Utah. Wetlands 12(2):72-78.

Hunt, R.J., D.P. Krabbenhoft, and M.P. Anderson. 1996. Groundwater inflow measurements in wetland systems. Water Resources Research 3:495-507.

Hunt, R.J., J.F. Walker, and D.P. Krabbenhoft. 1999. Characterizing hydrology and the importance of ground-water discharge in natural and constructed wetlands. Wetlands 19: 458-472.

Hunter, M.L., Jr. 1996. Fundamentals of Conservation Biology. Cambridge, MA: Blackwell Science.

Hutchinson, I. 1991. Salinity Tolerances of Plants of Estuarine Wetlands and Associated Uplands. Washington State Department of Ecology.

Hutchinson, T.C., S.A. Watmough, E.P.S. Sager, and J.D. Karagatzides. 1999. The impact of simulated acid rain and fertilizer application on a mature sugar maple (Acer saccharum Marsh.) forest in central Ontario Canada. Water Air Soil Pollution 109:17-39.

Ibanez, C., J.W. Day, Jr., and D. Pont. 1999. Primary production and decomposition of wetlands of the Rhone Delta, France: Interactive impacts of human modifications and relative sea level rise. Journal of Coastal Research 15(3): 717-731.

Ildos, A.S. and N. Ancona. 1994. Analysis of amphibian habitat preferences in a farmland area - Po Plain, northern Italy. Amphibia-Reptilia 15:307-316.

Interagency Committee for Outdoor Recreation. 2001. The 1999 Public and Tribal Land Inventory. Final Report. Olympia, WA.

Ireland, P.H. 1991. Separate effects of acid-derived anions and cations on growth of larval salamanders of *Ambystoma maculatum*. Copeia 1991:132-137.

ITRC (Interstate Technology & Regulatory Council). 2003. Technical and regulatory guidance document for constructed treatment wetlands. Prepared by the ITRC Wetlands Team with funding from the Department of Energy. Available at (http://www.itrcweb.org/WTLND-1.pdf) accessed November 1, 2004.

Jackson, J.K., B.W. Sweeney, T.L. Bott, J.D. Newbold, and L.A. Kaplan. 1994. Transport of *Bacillus thuringiensis* var. israelensis and its effect on drift and benthic densities of nontarget macroinvertebrates in the Susquehanna River, northern Pennsylvania. Canadian Journal of Fisheries and Aquatic Sciences 51:294-314.

Jadhav, R.S. and S.G. Buchberger. 1995. Effects of vegetation on flow through free water surface wetlands. Ecological Engineering 5:481-496.

James, R.T. 1991. Microbiology and chemistry of acid lakes in Florida: I. Effects of drought and postdrought conditions. Hydrobiologia 213: 205-225.

Jansen, A. and A.I. Robertson. 2001. Relationships between livestock management and the ecological condition of riparian habitats along an Australian floodplain river. Journal of Applied Ecology 38(1): 63-75.

Jansen, A. and M. Healy. 2003. Frog communities and wetland condition: relationships with grazing by domestic livestock along an Australian floodplain river. Biological Conservation 109:207-219.

Jansson, M., R. Andersson, H. Berggren, and L. Leonardson. 1994. Wetlands and lakes as nitrogen traps. Ambio 23:320-325.

Jehl, J.R., Jr. 1994. Changes in saline and alkaline lake avifaunas in western North America in the past 150 years. Studies in Avian Biology 15:258-272.

Jobin, B., and J. Picman. 1997. Factors affecting predation on artificial nests in marshes. Journal of Wildlife Management 61:792-800.

Johnson, A.M. and D.J. Leopold. 1994. Vascular plant species richness and rarity across a minerotrophic gradient in wetlands of St. Lawrence County, New York, USA. Biodiversity and Conservation 3:606-627.

Johnson, A.W. and J.M. Stypula. 1993. Guidelines for Bank Stabilization Projects in the Riverine Environments of King County. Seattle, WA: King County Department of Public Works.

Johnson, C.D. and D. Juengst. 1997. Polluted Urban Runoff – A Source of Concern. I-02-97-5M-20-S. University of Wisconsin Extension.

Johnson, D.H, and T.A. O'Neil (eds.) 2001. Wildlife-Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press. 736pp.

Johnson, D.M., T.H. Martin, M. Mahato, L.B. Crowder, and P.H. Crowley. 1995. Predation, density dependence, and life histories of dragonflies: A field experiment in a freshwater community. Journal of the North American Benthological Society 14(4):547-562.

Johnson, G.D., D.P. Young, W.P. Erickson, M.D. Strickland, and L.L. McDonald. 1996. Assessing river habitat by waterfowl wintering in the South Platte River, Colorado. Wetlands 16:542-547.

Johnson, P., D.L. Mock, A. McMillan, L. Driscoll, and T. Hruby. 2002. Washington State Wetland Mitigation Evaluation Study Phase 2: Evaluating Success. Publication No. 02-06-009. Olympia, WA: Washington State Department of Ecology.

Johnson, P., D.L. Mock, E.J. Teachout, and A. McMillan. 2000. Washington State Wetland Mitigation Evaluation Study Phase 1: Compliance. Publication No. 00-06-016. Olympia, WA: Washington State Department of Ecology.

Johnson, R.K., T. Wiederholm, and D.M. Rosenberg. 1993. Freshwater biomonitoring using individual organisms, populations, and species assemblages of benthic macroinvertebrates. Pages 40-125 in D.M. Rosenberg and V.H. Resh (eds.), Freshwater Biomonitoring and Benthic Macroinvertebrates. New York: Chapman and Hall.

Johnson, R.R. and D.A. Jones. 1977. Importance, Preservation and Management of Riparian Habitat: A Symposium. General Technical Report RM-43. U.S. Forest Service, Rocky Mountain Range and Experiment Station.

Johnson, S.R. and A.K. Knapp. 1995. The influence of fire on *Spartina pectinata* wetland communities in a northeastern Kansas tallgrass prairie. Canadian Journal of Botany 73: 94-90.

Johnston, C., A. Schubauer, J.P. Berigan, and S.D. Bridgham. 1997. The potential role of riverine wetlands as buffer zones. Pages 155-170 in N.E. Haycock, T.P Burt, K.W.T. Goulding, and G. Pinay (eds.), Buffer Zones: Their Processes and Potential in Water Protection. Harpenden, England: Quest Enviromental.

Johnston, C.A. 1991. Sediment and nutrient retention by freshwater wetlands: Effects on surface water quality. Critical Reviews in Environmental Control 21:491-565.

Johnston, C.A. 1994. Cumulative impacts to wetlands. Wetlands 14(1): 49-55.

Johnston, C.A., N.E. Detenbeck, and G.J. Niemi. 1990. The cumulative effect of wetlands on stream water quality and quantity: A landscape approach. Biogeochemistry-Dordrecht 10:105-142.

Jones, R.H. and M. Boyd. 2000. Evaluation of the effectiveness of within watershed compensation in response to permitted activities through the Norfolk District's Section 404 regulatory program. Wetland Journal 12(3): 17-22.

Joosten, J.H.J. 1995. Time to regenerate: long-term perspectives of raised bog regeneration with special emphasis on palaeoecological studies. Pp.379-404 In B.D. Wheeler, S.C. Shaw, W.J. Fojt and R.A. Robertson (eds.) Restoration of Temperate Wetlands, John Wiley & Sons: Chichester, UK.

Jordan, F., H.L. Jelks, and W.M. Kitchens. 1994. Habitat use by the fishing spider Dolomedes triton in a northern Everglades wetland. Wetlands 14(3):239-242.

Josselyn, M. N., M. Martindale, and J. Duffield. 1989. Public Access and Wetlands: Impacts of Recreational Use. California Coastal Conservancy. Report.

Jude, D.J. and J. Pappas. 1992. Fish utilization of great lake coastal wetlands. Journal of Great Lakes Research 18:651-672.

Jurik, T.W., S. Wang, and A.G. van der Valk. 1994. Effects of sediment load on seedling emergence from wetland seed banks. Wetlands 14(3):159-165.

Kadlec, R.H. and R.L. Knight. 1996. Treatment Wetlands. Lewis Publishers New York, NY. 881pages.

Kantrud, H.A., J.B. Millar, and A.G. van der Valk. 1989. Vegetation of the wetlands of the northern prairie pothole region. Pages 132-187 in A. van der Valk (ed.), Northern Prairie Wetlands. Ames, IA: Iowa State University.

Kao, C.M. and M.J. Wu. 2001. Control of non-point source pollution by a natural wetland. Water Science and Technology 43(5): 169-174.

Karr, J. R., and I. J. Schlosser. 1977. Impact of Nearstream Vegetation and Stream Morphology on Water Quality and Stream Biota. Document No. EPA-600/3-77-097. U.S. Environmental Protection Agency.

Kauffman, J.B., M. Mahrt, L.A. Mahrt, and W.D. Edge. 2001. Wildlife of riparian habitats. Chapter 14 (pages 361 – 388) in D.H. Johnson and T.A. O'Neil (eds.), Wildlife-Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press.

Kauffman, J.B., R.L. Beschta, N. Otting, and D Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries 22:12-24.

Kazumi, J. and D.G. Capone. 1995. Microbial aldicarb transformation in aquifer, lake, and salt marsh sediments. Applied and Environmental Microbiology 61: 2820-2829.

Keller, A.E. 1993. Acute toxicity of several pesticides, organic compounds, and a wastewater effluent of the freshwater mussels, *Anodonta imbecillis, Ceriodaphnia dubia, and Pimephales promelas*. Bulletin of Environmental Contamination and Toxicology 51(5):696-702.

Keller, A.E. and T.L. Crisman. 1990. Factors influencing fish assemblages and species richness in subtropical lorida lakes and a comparison with temperate lakes. Canadian Journal of Fisheries and Aquatic Sciences 47:2137-2146.

Kellogg, C.H. and S.D. Bridgham. 2002. Colonization during early succession of restored freshwater marshes. Canadian Journal of Botany 80:176-185.

Kelly, C.A., J.W.M. Rudd, R.A. Bodaly, N.P. Roulet, V.L. St. Louis, A. Heyes, T.R. Moore, S. Schiff, R. Aravena, K.J. Scott, B. Dyck, R. Harris, B. Warner, and G. Edwards. 1997. Increases in fluxes of greenhouse gases and methyl mercury following flooding of an experimental reservoir. Environmental Science and Technology 31(5): 1334-1344.

Kelsch, S.W. 1994. Lotic fish-community structure following transitions from severe drought to high discharge. Journal of Freshwater Ecology 9(4):331-342.

Kemp, S.J. and J.R. Spotila. 1996. Effects of urbanization on brown trout *Salmo trutta*, other fishes and macroinvertebrates in Valley Creek, Valley Forge, Pennsylvania. American Midland Naturalist 138: 55-68.

Kentula, M., J.C. Sifneos, J.W. Good, M. Rylko, and K. Kunz. 1992. Trends and patterns in Section 404 permitting requiring compensatory mitigation in Oregon and Washington, USA. Environmental Management 16(1): 109-119.

Kentula, M.E. 1995. Establishing quantitative performance criteria for wetland restoration and creation projects. In R. Harris, R. Kattelmann H. Kerner J. Woled, Watersheds '94, Respect, Rethink and Restore. Proceedings of the Fifth Biennial Watershed Manangement Conference. Report No. 86. Davis, CA: University of California, Davis, Water Resources Center.

Kentula, M.E. 1996. Wetland restoration and creation. National Water Summary on Wetland Resources. U.S. Geological Survey Water-Supply Paper 2425.

Kentula, M.E. 2000. Perspectives on setting success criteria for wetland restoration. Ecological Engineering 15: 199-209.

Kiesecker, J. M. and A.R. Blaustein. 1998. Effects of introduced bullfrogs and smallmouth bass on microhabitat use, growth, and survival of native red-legged frogs (*Rana aurora*). Conservation Biology 12(4): 776-787.

(Kiffney and Clements 1994a). Kiffney, P.M., and W.H. Clements. 1994. Effects of heavy metals on a macroinvertebrate assemblage from a Rocky Mountain stream in experimental microcosms. Journal of the North American Benthological Society 13(4):511-523.

(Kiffney and Clements 1994b). Kiffney, P.M., and W.H. Clements. 1994. Structural responses of benthic macroinvertebrate communities from different stream orders to zinc. Environmental Toxicology and Chemistry 13:389-395.

King, C.M. 1983. Factors regulating mustelid populations. Acta Zoolica Fennica 174:217-220.

King, D.M. and C.C. Bohlen. 1994. Compensation Ratios for Wetland Mitigation. CEES Report UMCEES-CBL-94-10. University of Maryland.

King, D.M., C.C. Bohlen, and K.J. Adler. 1993. Watershed Management and Wetland Mitigation : A Framework for Determining Compensation Ratios. Chesapeake Biological Laboratory. Solomons, MD.

King, D.M., L.A. Wainger, C.C. Bartoldus, and J.S. Wakeley. 2000. Expanding wetland assessment procedures: Linking indices of wetland function with services and values. U.S. Army Corps of Engineers, Wetlands Research Program ERDC/EL TR-00-17.

King, S.E. and J.B. Grace. 2000. The effects of soil flooding on the establishment of cogongrass (*Imperata cylindrica*), a non-indigenous invader of the southeastern United States. Wetlands 20(2): 300-306.

Kirkman, L.K. and R.R. Sharitz. 1993. Growth in controlled water regimes of three grasses common in freshwater wetlands of the southeastern USA. Aquatic Botany 44:345-359.

Kirkman, L.K. and R.R. Sharitz. 1994. Vegetation disturbance and maintenance of diversity in intermittently flooded Carolina bays in South Carolina. Ecological Applications 49(1):177-188.

Kirkman, L.K., S.W. Golladay, L .Laclaire, and R. Sutter. 1999. Biodiversity in southeastern, seasonally ponded, isolated wetlands: Management and policy perspectives for research and conservation. Journal of the North American Benthological Society 18 (4): 553-562.

Klein, M.L. 1993. Waterbird behavioral responses to human disturbances. Wildlife Society Bulletin 21: 31-39.

Klerks, P.L. and S.A. Lentz. 1998. Resistance to lead and zinc in the western mosquitofish Gambusia affinis inhabiting contaminated Bayou Trepagnier. Ecotoxicology 7:11-17.

Klinger, L.F. 1996. The myth of the classic hydrosere model of bog succession. Arctic & Alpine Research 28(1): 1-9.

Knapton, R.W., S.A. Petrie, and G. Herring. 2000. Human disturbance of diving ducks on Long Point Bay, Lake Erie. Wildlife Society Bulletin 28(4): 923-930.

Knight, R.L. 1988. Relationships of birds of prey and riparian habitat in the Pacific Northwest: An overview. In Streamside Management: Riparian Wildlife and Forestry Interactions. Proceedings of a Symposium on Riparian Wildlife and Forestry Interactions. Contribution No. 59. Seattle, WA: University of Washington, Institute of Forest Resources.

Knowlton, M.F., T.P. Boyle, and J.R. Jones. 1983. Uptake of lead from aquatic sediment by submersed macrophytes and crayfish. Archives of Environmental Contamimation and Toxicology 12:535-541.

Knutson, K.L. and V.L. Naef. 1997. Management Recommendations for Washington's Priority Habitats: Riparian. Olympia, WA: Washington Department of Fish and Wildlife. Report.

Knutson, M.G., J.R. Sauer, D.A. Olsen, M.J. Mossman, L.M. Hemesath, and M.J. Lannoo. 1999. Effects of landscape composition and wetland fragmentation on frog and toad abundance and species richness in Iowa and Wisconsin, USA. Conservation Biology 13(6): 1437-1446.

Knutson, M.G., W.B. Richardson, D.M. Reineke, B.R. Gray, J.R. Parmelee, and S.E. Weick. 2004. Agricultural ponds support amphibian populations. Ecological Applications 14:669-684.

Koehler, D.A. and A.E. Thomas. 2000. Managing for Enhancement of Riparian and Wetland Areas of the Western United States: An Annotated Bibliography. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Kolozsvary, M.B. and R.K. Swihart. 1999. Habitat fragmentation and the distribution of amphibians: Patch and landscape correlates in farmland. Canadian Journal of Zoology 77(8): 1288-1299.

Koncalova, H. 1990. Anatomical adaptations to waterlogging in roots of wetland graminoids: Limitations and drawbacks. Aquatic Botany 38: 127-134.

Kondolf, G.M. 1997. Hungry water: Effects of dams and gravel mining on river channels. Environmental Management 21:533-551.

Konrad, C.P. 2000. The frequency and extent of hydrologic disturbances in streams in the Puget Lowland, Washington. PhD Thesis, University of Washington.

Konrad, C.P. and D.B. Booth. 2002. Hydrologic trends associated with urban development for selected streams in the Puget Sound Basin, western Washington. U.S. Geological Survey, Water Resources Investigation Report 02-4040.

Kovalchik, B. L. and R.R. Clausnitzer 2004. Classification and management of aquatic, riparian, and wetland sites on the national forests of eastern Washington: series description. Gen. Tech. Rep. PNW-GTR-593. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 354 p.

Krapu, G.L., D.R. Parsons, and M.W. Weller. 1970. Waterfowl in relation to land use and water levels on the Spring Run area. Iowa St. J. Sci. 44:437-452.

Krapu, G.L., R.J. Greenwood, C.P. Dwyer, K.M. Kraft, and L. M. Cowardin. 1997. Wetland use, settling patterns, and recruitment in mallards. Journal of Wildlife Management 61(3): 736-746.

Krausman, P.R., B.C. Leopold, and D.L. Scarbrough. 1986. Desert mule deer response to aircraft. Wildlife Society Bulletin 14(1): 68-70.

Kreithen, M. and D. Quine. 1979. Infrasound detection by the homing pigeon: A behavioral audiogram. Journal of Comparative Physiology 129: 1-4.

Kreutzweiser, D.P., S.B. Holmes, and D.C. Eichenberg. 1994. Influence of exposure duration on the toxicity of triclopyr ester to fish and aquatic insects. Archives of Environmental Contamimation and Toxicology 26:124-129.

Krieger, K.A. 1992. The ecology of invertebrates in Great Lakes coastal wetlands: Current knowledge and research needs. Journal of Great Lakes Research 18(4): 634-650.

Krueger, H.O., J.P. Ward, and S.H. Anderson. 1988. A Resource Manager's Guide for Using Aquatic Organisms to Assess Water Quality for Evaluation of Contaminants. Biological Report 88(20). Washington, DC: U.S. Fish and Wildlife Service.

Kukoy, S.J. and L.W. Canter. 1995. Mitigation banking as a tool for improving wetland preservation via Section 404 of the Clean Water Act. The Environmental Professional 17:301-308.

Kulzer, L. 1990. Water Pollution Control Aspects of Aquatic Plants: Implications for Stormwater Quality Management. Seattle, WA: Municipality of Metropolitan Seattle.

Kunz, K., M. Rylko, and E. Somers. 1988. An assessment of wetland mitigation practices pursuant to Section 404 permitting activities in Washington State. Pages 515-531 in Proceedings First Annual Meeting on Puget Sound Research, Volume 2. Seattle, Washington, March 18-19, 1988. Seattle, WA: Puget Sound Water Quality Authority.

Kunze, L.M. 1994. Preliminary classification of native, low elevation, freshwater wetland vegetation in western Washington. Washington Natural Heritage Program, Department of Natural Resources, Olympia, WA 120pp.

Kusler, J. 1994. Flood response and the restoration of wetlands, riparian areas and broader floodplains: Lessons learned from the Great Flood of 1993. Water-Resources Update 97:25-28. Carbondale, IL: The Universities Council on Water Resources.

Kusler, J. and W. Niering. 1998. Wetland assessment: Have we lost our way? National Wetland Newsletter 20: 8-14.

Kusler, J.A. 1988. No net loss and the role of wetlands restoration/creation in a regulatory context. In J.A. Kusler, S. Daly, and G. Brooks (eds.), Proceedings of the National Wetland Symposium: Urban Wetlands. June 26-29 1988, Oakland, California.

Kusler, J.A. and M.E. Kentula. 1990. Executive Summary. In J.A. Kusler and M.E. Kentula (eds.), Wetland Creation and Restoration – The Status of the Science. Island Press.

Laan, R. and B. Verboom. 1990. Effects of pool size and isolation on amphibian communities. Biological Conservation 54: 251-262.

LaBaugh, J.W., T.C. Winter, V.A. Adomaitis, and G.A. Swanson. 1987. Geohydrology and Chemistry of Prairie Wetlands, Stutsman County, North Dakota. U.S. Geological Survey Professional Paper 1431.

Landin, M.C. 1985. Bird and Mammal Use of Selected Lower Mississippi River Borrow Pits. Ph.D. Dissertation. Mississippi State University.

Lang, B. 2000. Intermittent Seasonal and Ephemeral (Vernal) Wetland Assessment. Washington State Department of Ecology Publication No. C9900176.

Laposata, M.M. and W.A. Dunson. 2000. Effects of spray-irrigated wastewater effluent on temporary pond-breeding amphibians. Ecotoxicology and Environmental Safety, Environmental Research, Section B 46: 192-201

Larimore, R.W. and P.B. Bayley. 1996. The fishes of Champaign County, Illinois, during a century of alterations of prairie ecosystem. Illinois Natural History Survey Bulletin 35(2): 53-183.

Larkin, R.P., L.L Pater, and D.J. Tazik. 1996. Effects of Military Noise on Wildlife: A Literature Review. Technical Report Numbers AD-A305234; USACERL-TR-96/21. Army Construction Engineering Research Lab.

Laursen, A.E., S.P. Seitzinger, R. Dekorsey, J.G. Sanders, D.L. Breitburg, and R.W. Osman. 2002. Multiple stressors in an estuarine system: Effects of nutrients, trace elements, and trophic complexity on benthic photosynthesis and respiration. Estuaries 25: 57-69.

Layzer, J.B., M.E. Gordon, and R.M. Anderson. 1993. Mussels: The forgotten fauna of regulated rivers. A case study of the Caney Fork River. Regulated Rivers Research & Management 8(1-2):63-71.

Lee, M.A. 1991. Remnant seed banks and wetland restoration. Restoration and Management Notes 9: 42-43.

Leeper, D.A. and B.E. Taylor. 1998. Abundance, biomass, and production of aquatic invertebrates in Rainbow Bay, a temporary wetland in South Carolina, USA. Archive fur Hydrobiologie 143:335-362.

Lehtinen, R.M. and S.M. Galatowitsch. 2001. Colonization of restored wetlands by amphibians in Minnesota. American Midland Naturalist 145(2): 388-396.

Lehtinen, R.M., S.M. Galatowitsch, and J.R. Tester. 1999. Consequences of habitat loss and fragmentation for wetland amphibian assemblages. Wetlands 19 (1): 1-12.

Leibowitz, S.G. 2003. Isolated wetlands and their functions: an ecological perspective. Wetlands 23:517-531.

Leibowitz, S.G. and T. Nadeau. 2003. Isolated wetlands: state-of-the-science and future directions. Wetlands 23:663-684.

Leitman, H.M., M.R. Darst, and J.J. Nordhaus. 1991. Fishes in the Forested Floodplain of the Ochlockonee River, Florida, During Flood and Drought Conditions. Water-Resources Investigations Report 90-4202. Denver, CO: U.S. Department of the Interior, U.S. Geological Survey.

Lejeune, K., H. Galbraith, J. Lipton, and L.A. Kapustka. 1996. Effects of metals and arsenic on riparian communities in southwest Montana. Ecotoxicology 5: 297-312.

Leland, H.V., S.V. Fend, T.L. Dudley, and J.L. Carter. 1989. Effects of acid precipitation on freshwater organisms. Pages 87-111 in F.H. Braekke (ed.), Impact of Acid Precipitation on Forest and Freshwater Ecosystems of Norway. Research Report. 6/76. SNSF Project.

Lemly, A.D. 1994. Irrigated agriculture and freshwater wetlands: A struggle for coexistence in the western United States. Wetlands Ecology and Management 3:3-15.

Lemly, A.D. 1996. Selenium in aquatic organisms. Pages 427-445 in N. Beyer, G.H. Heinz and A.W. Redmon-Norwood (eds.), Environmental Contaminants In Wildlife: Interpreting Tissue Concentration. Boca Raton, FL: Lewis Publishers, CRC Press.

Leonard, W.P. and K.O. Richter. 1994. Long-toed salamander (*Ambystoma macrodactylum*) breeding habitat in a small vernal wetland in the Puget Sound Lowlands. Page 96 in Wetlands: Local Functions, Global Dependence. Abstracts of the Society of Wetland Scientists 15th Annual Meeting. Portland, OR.

Leonard, W.P., H.A. Brown, L.L.C. Jones, K.R. Mcallister, and R. M. Storm. 1993. Amphibians of Washington and Oregon. Seattle, WA: Seattle Audubon Society.

Leopold, A. 1933. Game Management, Scribner, NY.

Lepzcyk, C.A., A.G. Mertig, and J. Liu. 2003. Landowners and cat predation across rural-to-urban landscapes. Biological Conservation 115:191-201.

Levin, S.A. 2001. Immune systems and ecosystems. Conservation Ecology 5:17. [online] URL: http://www.consecol.org/vol5/iss1/art17

Lewis, J., R. Sylvia-Mori, E.T. Keppeler, and R.R. Ziemer. 2001. Pages 85-125 in M.S. Wigmosta and S.J. Burges (eds.), Land Use and Watersheds: Human Influence on Hydrology and Geomorphology in Urban and Forest Areas. Water Science and Application Volume 2. Washington, DC: American Geophysical Union.

Lichatowich, J.A. and L.E. Mobrand. 1995. Analysis of Chinook Salmon in Columbia River from an Ecoregional Perspective. Research Paper #92-18. U.S. Department of Energy, Bonneville Power Administration.

Licht, L.E. 1969. Comparative breeding behavior of the red-legged frog (Rana aurora aurora) and the western spotted frog (Rana pretiosa pretiosa) in southwestern British Columbia. Canadian Journal of Zoology 47:1287-1299.

Lieffers, H.J. 1990. Effects of the Lampricide 3-Trifluoromethyl-4-Nitrophenol on Macroinvertebrate Populations in a Small Stream. Great Lakes Fishery Committee Technical Report 55.

Lienert, J. and M. Fischer. 2003. Habitat fragmentation affects the common wetland specialist *Primula farinosa* in north-east Switzerland. Journal of Ecology 91:587-599.

Lienert, J., M. Diemer, and B. Schmid. 2002. Effects of habitat fragmentation on population structure and fitness components of the wetland specialist *Swertia perennis* L. (Gentianaceae). Basic Applied Ecology 3:101-114.

Lienert, J., M. Fischer, and M. Diemer. 2002. Local extinctions of the wetland specialist *Swertia perennis* L. (Gentianaceae) in Switzerland: a revisitation study based on herbarium records. Biological Conservation 103:65-76.

Lienert, J., M. Fischer, J. Schneller, and M. Diemer. 2002. Isozyme variability of the wetland specialist *Swertia perennis* L. (Gentianaceae) in relation to habitat size, isolation, and plant fitness. American Journal of Botany 89:801-811.

Lindeman, P.V. and F.W. Rabe. 1990. Effect of drought on the western painted turtle *Crysemys picta* belli in a small wetland ecosystem. Journal of Freshwater Ecology 5(3): 359-364.

Linz, G.M., D.C. Blixt, D.L. Bergman, and W.J. Bleier. 1996. Responses of red-winged blackbirds, yellowheaded blackbirds and marsh wrens to glyphosphate-induced alterations in cattail density. Journal of Field Ornithology 67:167-176.

Lipton, D.W., K. Wellman, I.C. Sheifer, and R.F. Weiher. 1995. Economic Valuation of Natural Resources: A Handbook for Coastal Resource Policymakers. NOAA Coastal Ocean Program Decision Analysis Series No. 5. Silver Springs, MD: NOAA Coastal Ocean Office.

Liquori, M. 2000. Riparian buffer structure and functional dynamics: Considerations for riparian design. In P.J. Wigington and R.L. Beschta, Riparian Ecology and Management in Multi-Land Use Watersheds. American Water Resources Association. Middleburg VA

Lodge, D.M. 1985. Macrophyte-gastropod associations: Observations and experiments on macrophyte choice by gastropods. Freshwater Biology 15:695-708.

Loftus, W.F. and A.M. Eklund. 1994. Long-term dynamics of an Everglades small-fish assemblage. Pages 461-483 in M. Davis and J.C. Ogden (eds.), The Everglades: The Ecosystem and its Restoration. West Palm Beach, FL: St. Lucie Press.

Loredo, I., D. VanVuren, and M.L. Morrison. 1996. Habitat use and migration behavior of the California tiger salamander. Journal of Herpetology 30:282-285.

Lougheed, V.L. and P. Chow-Fraser. 1998. Factors that regulate the zooplankton community structure of a turbid, hypereutrophic Great Lakes wetland. Canadian Journal of Fisheries and Aquatic Sciences 55(1): 150-161.

Lougheed, V.L., B. Crosbie, and P. Chow-Fraser. 1998. Predictions on the effect of common carp (Cyprinus carpio) exclusion on water quality, zooplankton, and submergent macrophytes in a Great Lakes wetland. Canadian Journal of Fisheries and Aquatic Sciences 55(5): 1189-1197.

Lovvorn, J.R., W.M. Wollheim, and E.A. Hart. 1999. High Plains wetlands of southeast Wyoming: Salinity, vegetation, and invertebrate communities. Pages 603-634 in D.P. Batzer, R.B. Rader, and S.A. Wissinger (eds.), Invertebrates in Freshwater Wetlands of North America: Ecology and Management. John Wiley and Sons, Inc.

Lovvorn, J.R. and J.R. Baldwin. 1996. Intertidal and Farmland Habitats of Ducks in the Puget Sound Region: A Landscape Perspective. Biological Conservation 77: 97-114.

Lowrance, R., R.G. Williams, S.P. Inamdar, D.D. Bosch, and J.M. Sheridan. 2001. Evaluation of coastal plain conservation buffers using the riparian ecosystem management model. Journal of the American Water Resources Association 37(6):1445-1455.

Lowrance, R., R.K. Hubbard, and G. Vellidis. 1995. Riparian forest restoration to control agricultural water pollution. Conference Proceedings: Clean Water, Clean Environment, 21st Century Team Agriculture, Working to Protect Water Resources. March 5-8, 1995, Kansas City, Missouri/St. Joseph, Michigan.

Lowrance, R. R. 1992. Groundwater nitrate and denitrification in a coastal plain riparian forest. Journal of Environmental Quality 21:401-5.

Ludwa, K.A. 1994. Urbanization Effects on Palustrine Wetlands: Empirical Water Quality Models and Development of a Macroinvertebrate Community-Based Biological Index. M.S. Thesis. Seattle, WA: University of Washington.

Ludwa, K.A. and K.O. Richter. 2001a. Emergent macroinvertebrate communities in relation to watershed development. Chapter 11, pages 265-274 in A.L. Azous and R.R. Horner (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Ludwa, K.A. and K.O Richter. 2001b. Macroinvertebrate distribution, abundance, and habitat use. Chapter 4 in R. Horner and A. Azous (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Lynch, J. A., E. S. Corbett, and K. Mussallem. 1985. Best management practices for controlling non-point source pollution on forested watersheds. Journal of Soil and Water Conservation 40**:**164-7.

Maceina, M.J., P.W. Bettoli, W.G. Klussmann, R.K. Betsill, and R.L. Noble. 1991. Effect of aquatic macrophyte removal on recruitment and growth of black

crappies and white crappies in Lake Conroe, Texas. North American Journal of Fisheries Management 11: 556-563.

Mack, R.N., D. Simberloff, W.M. Lonsdale, H. Evans, M. Clout, and F.A. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. Ecological Applications 10:689-710.

Mackie, G.L. 1991. Biology of the exotic zebra mussel, Dreissena polymorpha, in relation to native bivalves and its potential impact on Lake St. Clair. Hydrobiologia 219:251-268.

Mackun, I.R., D.J. Leopold, and D.J. Raynal. 1994. Short-term responses of wetland vegetation after liming of an Adirondack watershed. Ecological Applications 4(3): 535-543.

Magee, P.A., L.H. Fredrickson, and D.D. Humburg. 1993. Aquatic macroinvertebrate association with willow wetlands in northeastern Missouri. Wetlands 13(4): 304-310.

Magee, T., T.L. Ernst, M.E. Kentula, and K.A. Dwire. 1999. Floristic comparison of freshwater wetlands in an urbanizing environment. Wetlands 19:517-534.

Mahaney, W.M., D.H. Wardrop, and R.P. Brooks. 2004. Impacts of stressors on the emergence and growth of wetland plant species in Pennsylvania, USA. Wetlands 24:538-549.

Malecki, R.A. and J.D. Sullivan. 1987. Assessment of an agricultural drainage improvement program in New York State. Journal of Soil and Water Conservation 42:271-276.

Mallin, M.A. et al. 2000. North and South Carolina coasts. Marine Pollution Bulletin 41: 56-75.

Mallory, M.L., P.J. Blancher, P.J. Weatherhead, and D.K. McNicol. 1994. Presence or absence of fish as a cue to macroinvertebrate abundance in boreal wetlands. Pages 345-351 in J.J. Kerekes (ed.), Aquatic Birds in the Trophic Web of Lakes. Proceedings of a Symposium in Sackville, NB, Canada, 1991.

Manci, K.M., D.N. Gladwin, R. Villella, and M.G. Cavendish. 1988. Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis. (NERC-88/29). Ft. Collins, CO: U.S. Fish and Wildlife Service, National Ecology Research Center.

Mander, U., A. Kull, V. Kuusemets, and T. Toomas. 2000. Nutrient runoff dynamics in a rural catchment: Influence of land-use changes, climatic fluctuations and ecotechnological measures. Ecological Engineering 14: 405-417.

Manning, A.D., D.B. Lindenmayer, and H.A. Nix. 2004. Continua and Umwelt: novel perspectives on viewing landscapes. Oikos 104:621-628.

Marco, A., C. Quilchano, and A.R. Blaustein. 1999. Sensitivity to nitrate and nitrite in pond-breeding amphibians from the Pacific Northwest, USA. Environmental Toxicology and Chemistry 18: 2836-2839.

Marschall, E.A. and L.B. Crowder. 1996. Assessing population responses to multiple anthropogenic effects: A case study with brook trout. Ecological Applications 6(1):152-167.

Martin, A.C., H.S. Zim, and A.L. Nelson. 1951. American Wildlife & Plants: A guide to wildlife food habits. Dover Publications, New York. 500pp.

Martin, T.H., D.M. Johnson, and R.D. Moore. 1991. Fish-mediated alternative life-history strategies in Epitheca cynosura (Say.). Journal of the North American Benthological Society 10:271-279.

Martin, T.H., L.B. Crowder, C.F. Dumas, and J.M. Burkholder. 1992. Indirect effects of fish on macrophytes in Bays Mountain Lake: Evidence for a littoral trophic cascade. Oecologia 89:476-481

Martin-Yanny, E. 1992. The Impacts of Urbanization on Wetland Bird Communities. M.S. Thesis. Seattle, WA: University of Washington.

Marvin-Dipasquale, M.C. and R.S. Oremland. 1998. Bacterial methylmercury degradation in Florida Everglades peat sediment. Environmental Science and Technology 32: 2556-2563.

Maser, C., R.F. Tarrant, J.M. Trappe, and J.F. Franklin. 1988. From the Forest to the Sea: A Story of Fallen Trees. General Technical Report PNW-GTR-229. U.S. Forest Service, Pacific Northwest Research Station.

Matches, A.G. 1992. Plant responses to grazing: A review. Journal of Prod. Agriculture 5: 1-7.

Materna, E.J., C.F. Rabeni, and T.W. LaPoint. 1995. Effects of the synthetic pyrethroid insecticide, esfenvalerate, on larval leopard frogs (*Rana* spp.). Environmental Toxicology and Chemistry 14:613-622.

Matherne, A.M. 1995. Irrigation, Geology and Wetlands in Semi-arid Regions. Groundwater Management International Symposium, Water Resources Engineering Division, American Society of Civil Engineers 0(0):5.

Matuszek, J.E., J. Goodier, and D.L. Wales. 1990. The occurance of cyprinidae and other small fish species in relation to pH in Ontario lakes. Transactions of the American Fisheries Society 119: 850-861.

Maurer, D.A., R. Lindig-Cisneros, K.J. Werner, S. Kercher, R. Miller, and J.B. Zedler. 2003. The replacement of wetland vegetation by reed canarygrass (*Phalaris arundinaceae*). Ecological Restoration 21:116-119.

Maxell, B.A. 2000. Management of Montana's Amphibians: A Review of Factors that May Present a Risk to Population Viability and Accounts on the Identification, Distribution, Taxonomy, Habitat Use, Natural History and the Status and Conservation of Individual Species. Report to U.S. Forest Service Region 1, Order Number 43-0343-0-0224. Missoula, MT: University of Montana, Wildlife Biology Program.

May, C. 1996. Assessment of Cumulative Effects of Urbanization on Small Streams in the Puget Sound Lowland Ecoregion: Implications for Salmonid Resource Management. Ph.D. Dissertation. Seattle, WA: University of Washington.

McCall, T.C., T.P. Hodgman, D.R. Diefenbach and R.B.Owen Jr. 1996. Beaver populations and their relation to wetland habitat and breeding waterfowl in Maine. Wetlands 16:163-172.

McClelland, W.T. and M.A. Brusven. 1980. Effects of sedimentation on the behavior and distribution of riffle insects in a laboratory stream. Aquatic Insects 2:161-169.

McCreary, S.T. and M.B. Adams. 1995. Managing wetlands through advanced planning and permitting: The Columbia River Estuary Study Taskforce. Pages 103-138 in D.R. Porter and D.A. Salvesen (eds.), Collaborative Planning for Wetlands and Wildlife: Issues and Examples. Island Press.

McElveen, J.D. 1977. The edge effect on a forest bird community in North Florida. Proceeding of the South East Association of Fish and Wildlife Agencies 31:212-5.

McGarrigle, M.L. 1980. The distribution of Chironomos communities and controlling sediment parameters in L. Derravaragh, Ireland. Pages 275-282 in D.A. Murray (ed.), Chironomidae: Ecology, Systematics, Cytology and Physiology. New York: Pergamon Press.

McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wissmar, S.E. Clarke, G.H. Reeves, and L.A. Brown. 1994. Historical changes in fish habitat for select river basins in eastern Oregon and Washington. Northwest Science 8:36-53.

McIntosh, M.D., J.S. Valaitis, B.T. Condon, M.E. Benbow, and A.J. Burky. 1999. A preliminary inventory of aquatic macroinvertebrate taxa from restored and natural wetlands of the Beavercreek Watershed. Ohio Journal of Science 99(1): A-7.

McKinstry, M.C. and S.H. Anderson. 1994. Evaluation of wetland creation and waterfowl use in conjunction with abandoned mine lands in Northeast Wyoming. Wetlands 14(4): 284-292.

McLaughlin, D.B. and H.J. Harris. 1990. Aquatic insect emergence in two Great Lakes marshes. Wetlands Ecology and Management 1:111-121.

McLeod, K.W., M.R. Reed, and E.A. Nelson. 2001. Influence of a willow canopy on tree seedling establishment for wetland restoration. Wetlands 21(3): 395-402.

McMahon, T.E. 1983. Habitat Suitability Index Models: Coho Salmon. FWS/OBS-82/10.49. Ft. Collins, CO: U.S. Fish and Wildlife Service, Habitat Evaluation Procedure Group.

McMillan, A. 1998. How Ecology Regulates Wetlands. Publication No. 97-112. Washington State Department of Ecology. Olympia, WA.

McMillan, A. 2000. The Science of Wetland Buffers and Its Implication for the Management of Wetlands. M.S. Thesis. The Evergreen State College. Olympia, WA.

McSweeney, K. 2004. Soil morphology, classification and mapping. Class notes. University of Wisconsin Department of Soil Science http://www.soils.wisc.edu/courses/SS325/soilorders.htm#Andisols accessed November 2, 2004.

Means, D.B. 1996. A preliminary consideration of highway impacts on herpetofauna inhabiting small isolated wetlands in the southeastern U.S. coastal plain. In Transportation and Wildlife: Reducing Wildlife Mortality and Improving Wildlife Passageways Across Transportation Corridors. Proceedings of the Florida Department of Transportation/Federal Highway Administration Transportation-Related Wildlife Mortality Seminar. April 30-May 2, 1996. Orlando, FL.

Megharaj, M., I. Singleton, N.C. McClure, and R. Naidu. 2000. Influence of petroleum hydrocarbon contamination on microalgae and microbial activities in a long-term contaminated soil. Archives of Environmental Contamination and Toxicology 38: 439-445

Mehlhop, P. and C.C. Vaughn. 1994. Threats to and Sustainability of Ecosystems for Freshwater Mollusks. USDA Forest Service General Tech Report RM-247. Flagstaff, AZ.

Melendez, A.L., R.L. Kepner, Jr., J.M. Balczon, and J.R. Pratt. 1993. Effect of diquat on freshwater microbial communities. Archives of Environmental Contamination and Toxicology 25: 95-101

Melquist, W.E. and M.G. Hornocker. 1983. Ecology of River Otters in West Central Idaho. Journal of Wildlife Management Wildlife Monograph No. 83.

Melquist, W.E., J. Whitman, and M.G. Hornocker. 1981. Resource partitioning and coexistence of sympatric mink and river otter populations. Pages 187 – 220 in J.A. Chapman and D. Parsley (eds), Worldwide Furbearer Conference Proceedings: Volume 1. Frostberg, MD.

Mengel, K. and E.A. Kirkby. 1982. Principles of Plant Nutrition. Third edition. International Potash Institute. Switzerland

Mensing, D.M., S.M. Galatowitsch, and J.R. Tester. 1998. Anthropogenic effects on the biodiversity of riparian wetlands of a northern temperate landscape. Journal of Environmental Management 53(4): 349-377.

Merendino, M.T. and L.M. Smith. 1991. Influence of drawdown date and reflood depth on wetland vegetation establishment. Wildlife Society Bulletin 19:143-150.

Merendino, M.T., D.G. Dennis, and C.D. Ankney. 1992. Mallard harvest data: an index of wetland quality for breeding waterfowl. Wildlife Society Bulletin 20(2):171-175.

Merendino, M.T., L.M. Smith, H.R. Murkin, and R.L. Pederson. 1990. The response of prairie wetland vegetation to seasonality of drawdown. Wildlife Society Bulletin 18:245-251.

Merritt, R.W., M.S. Wipfli, and R.W. Wotton. 1991. Changes in feeding habits of nontarget aquatic insects in response to live and *Bacilus thuringiensis* var israelensis de Barjac-killed black fly larvae (Diptera:Simuliidae). Canadian Entomologist 123:179-185.

Metcalfe, J.L. and M.N. Charlton. 1990. Freshwater mussels as biomonitor for organic industrial contaminants and pesticides in the St. Lawrence River. Science of the Total Environment 97-98:595-615.

Metwalli, A.A. and C.A. Shearer. 1989. Aquatic hyphomycete communities in clear-cut and wooded areas of an Illinois stream. Transactions of the Illinois State Academy of Science 82:5-16.

Michigan Department of Environmental Quality. 2000. Michigan Wetland Mitigation and Permit Compliance Study. Lansing, MI: Land and Water Management Division.

Miller, A.M. and S.W. Golladay. 1996. Effects of spates and drying on macroinvertebrate assemblages of an intermittent and a perennial prairie stream. Journal of the North American Benthological Society 15(4): 670-689.

Milligan, D.A. 1985. The Ecology of Avian Use of Urban Freshwater Wetlands in King County, Washington. Thesis submitted in partial fulfillment of degree. University of Washington, College of Forest Resources. Seattle, WA.

Minns, C.K., J.E. Moore, D.W. Schindler, and M.L. Jones. 1990. Assessing the potential extent of danger to inland lakes in eastern Canada due to acidic deposition: III. Predicted impacts on species richness in seven groups of aquatic biota. Canadian Journal of Fisheries and Aquatic Sciences 44(1):3-5.

Minshall, G.W. 1984. Aquatic insect-substratum relationships. Pages 358 – 400 in V.R. Rosenberg and D.M. Rosenberg (eds.), The Ecology of Aquatic Insects. Praeger. New York.

Minton, S.A. 1968. The fate of amphibians and reptiles in a suburban area. Journal of Herpetology 2(3-4): 113-116.

Mitchell, J.C. and R.A. Beck. 1992. Free-ranging domestic cat predation on native vertebrates in rural and urban Virginia. Virginia Journal of Science 43(1 Part B): 197-207.

Mitsch, W.J. 1992. Landscape design and the role of created, restored, and natural riparian wetlands in controlling nonpoint source pollution. Ecological Engineering 1: 27-47.

Mitsch, W.J. and J.G. Gosselink. 2000. Wetlands. Third edition. John Wiley & Sons.

Mitsch, W.J. and N. Wang. 2000. Large-scale coastal wetland restoration on the Laurentian Great Lakes: Determining the potential for water quality improvement. Ecological Engineering 15: 267-282.

Mitsch, W.J. and R.F. Wilson. 1996. Improving the success of wetland creation and restoration with know-how, time, and self-design. Ecological Applications 6(1): 77-83.

Mitsch, W.J., J.K. Cronk, X. Wu, and R. Nairn. 1995. Phosphorus retention in constructed freshwater riparian marshes. Ecological Applications 5: 830-845. 1995.

Mockler, A, L.Casey, M. Bowles, N. Gillen, and J. Hansen. 1998. Results of Monitoring King County Wetland and Stream Mitigations. King County Department of Development and Environmental Services. Seattle, WA

Moler, P.E, and R. Franz. 1987. Wildlife values of small, isolated wetlands in the Southeastern Coastal Plain. In R.R. Odom, K.A.Riddleberger, J.C. Ozier (eds.), Proceedings of the Third Southeastern Nongame and Endangered Wildlife Symposium.

Monellow, R.J. and R.G. Wright. 1999. Amphibian habitat preference among artificial ponds in the Palouse region of Northern Idaho. Journal of Herpetology 33: 298-303.

Montgomery, D.R., G.E. Grant, and K. Sullivan. 1995. Watershed analysis as a framework for implementing ecosystem management. Water Resources Bulletin 31: 369-396.

Moore, H.H., W.A. Niering, L.J. Marsicano, and M. Dowdell. 1999. Vegetation change in created emergent wetlands (1988-1996) in Connecticut (USA). Wetlands Ecology and Management 7(4): 177-191.

Moore, J.R.J., P.A. Keddy, C.L. Guadet, and I.C. Wisheu. 1989. Conservation of wetlands: Do infertile wetlands deserve higher priority? Biological Conservation 47:203-217.

Moore, J.W., D.E. Schindler, M.D. Scheuerell, D. Smith, and J. Frodge. 2003. Lake eutrophication at the urban fringe, Seattle region, USA. Ambio 32:13-18.

Moore, P.D. and D.J. Bellamy. 1974. Peatlands. Elek Science. London GB

Moorman, A.M., T.E. Moorman, G.A. Baldassarre, and D.M. Richard. 1991. Effects of saline water on growth and survival of mottle duck ducklings in Louisiana. Journal of Wildlife Management 55:471-476.

Morgan, J.T. 1998. Annotated Bibliography for Washington's Priority Habitats: Freshwater Wetlands and Fresh Deepwater. Olympia, WA: Washington Department of Fish and Wildlife.

Morgan, K.L. and T.H. Roberts. 2003. Characterization of wetland mitigation projects in Tennessee, USA. Wetlands 23(1): 65-69.

Morgan, K.L. and T.H. Roberts. 1999. An Assessment of Wetland Mitigation in Tennessee. Nashville, TN: Tennessee Department of Environment and Conservation.

Morin, E., A. Bouchard, and P. Jutras. 1989. Ecological analysis of disturbed riverbanks in the Montreal area of Quebec. Environmental Management 13:215-225

Morrison, S. and T. Julius. 2001. Tracking Development on Streams and Wetlands. Thurston Regional Planning Council, Olympia WA.

Moshiri, G.A. ed. 1993. Constructed Wetlands for Water Quality Improvement. Lewis Publishers, Inc. Chelsea MI. 656 pp.

Munkittrick, K.R. and D.G. Dixon. 1992. Relationship between concentrations of copper and zinc in water, sediment, benthic invertebrates, and tissues of white sucker (Catostomus commersoni) at metal-contamination sites. Candian Journal of Fisheries and Aquatic Sciences 49(5):978-984.

Munro, J.W. 1991. Wetland restoration in the mitigation context. Restoration Management Notes 9(2): 80-86.

Murkin, E.J., H.R. Murkin, and R.D. Titman. 1992. Nektonic invertebrate abundance and distribution at the emergent vegetation-open water interface in the Delta Marsh, Manitoba, Canada. Wetlands 12:45-52.

Murkin, H.G., J.A. Kadlec, and E.J. Murkin. 1991. Effects of prolonged flooding on nektonic invertebrates in small diked marshes. Canadian Journal of Fisheries and Aquatic Sciences 48:2155-3264.

Murkin, H.R. and B.D.J. Batt. 1987. The interactions of vertebrates and invertebrates in peatlands and marshes. Memoirs of the Entomological Society of Canada 140:15-30.

Muscutt, A.D., G.L. Harris, S.W. Bailey, and Davies. 1993. Buffer zones to improve water-quality: A review of their potential use in UK agriculture. Agriculture, Ecosystems, and Environment 45: 59-77.

Myers, M.J. and V.H. Resh. 1999. Spring-formed wetlands of the arid west: Islands of aquatic invertebrate biodiversity. In Batzer, D.P, R.B. Rader, and S.A. Wissinger (eds) Invertebrates in Freshwater Wetlands of North America. John Wiley & Sons, New York.p. 811-828.

Naiman, R. and K.H. Rodgers. 1997. Large animals and system-level characteristics in river corridors. Bioscience 47:521-529.

Naiman, R.J., H. De'camps, and M. Pollock. 1993. The Role of Riparian Corridors in Maintaining Regional Biodiversity. Ecological Applications: 3: 209–212.

Naiman, R.J.T., L. Beechie, D. Benda, P. Berg, L. Bisson, M. McDonald, P. O'Connor, P. Olson, and E. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest coastal ecosystem. Pages 127-188 in R.J.T. Naiman (ed.), Watershed Management. Springer-Verlag.

Nalepa, T. and D. Schloesser (eds.). 1993. Zebra Mussels: Biology, Impacts, and Control. Chelsea, MI: Lewis Publishers.

Narver, D.W. 1978. Ecology of juvenile coho salmon: Can we use present knowledge for stream enhancement? In B.G. Shepherd and R.M.J Ginetz (eds.), Proceedings of the Northeast Pacific Chinook and Coho Salmon Workshop. Canada: Fisheries Marine Service.

National Research Council. 1984. Developing Strategies for Rangeland Management. National Academy of Sciences. Westview Press, Boulder CO.

National Research Council. 1995. Wetlands: Characteristics and Boundaries. Washington, DC: Water Science and Technology Board, Commission on Geosciences, Environment and Resources, National Academy Press.

National Research Council. 2001. Compensating for Wetland Losses under the Clean Water Act. Washington, DC: National Academy Press.

Natural Resources Conservation Service. 1997. U.S. Department of Agriculture data. Available: http://www.wa.nrcs.usda.gov/NRI/Data/WA_weq_table.pdf. Accessed: May 22, 2003.

Natural Resources Conservation Service. 1992. Soil Survey of Whatcom County Area, Washington. Available: http://www.or.nrcs.usda.gov/soil/mo/mo_reports_wa.htm. Accessed: February 14, 2003.

Naugle, D.E., K.F. Higgins, S.M. Nusser, and W.C. Johnson. 1999. Scale-dependent habitat use in three species of prairie wetland birds. Landscape Ecology 14(3): 267-276.

Naugle, D.E., R.R. Johnson, M.E. Estey, and K.F. Higgins. 2001. A landscape approach to conserving wetland bird habitat in the prairie pothole region of eastern South Dakota. Wetlands 21: 1-17.

Neary, D. G., P. B. Bush, and J. L. Michael. 1993. Fate, dissipation and environmental effects of pesticides in southern forests: A review of a decade of research progress. Environmental Toxicology and Chemistry 12: 411-428.

Needham, J.G. and P.R. Needham. 1962. A Guide to the Study of Fresh-Water Biology. San Francisco, CA: Holden-Day Inc.

Neely, R.K. and J.L. Baker. 1985. Nitrogen and phosphorous dynamics and the fate of agricultural runoff. In A. van der Valk (ed.), Northern Prairie Wetlands: Symposium Papers.

Neely, R.K. and J.A. Wiler. 1993. The effect of sediment loading on germination from the seed bank of three Michigan wetlands. Michigan Botany 32(3):199-207.

(Neill 1990a). Neill, C. 1990. Effects of nutrients and water levels on emergent macrophyte biomass in a prairie marsh. Canadian Journal of Botany 68:1007-1014.

(Neill 1990b). Neill, C. 1990. Effects of nutrients and water levels on species composition in prairie whitetop (Scolochloa festucacea). Canadian Journal of Botany 68:1015-1020.

Nelson, S.M., R.A. Roline, J.S. Thullen, J.J. Sartoris, and J.E. Boutwell. 2000. Invertebrate assemblages and trace element bioaccumulation associated with constructed wetlands. Wetlands 20(2): 406-415.

Newman, R.M. 1991. Herbivory and detritivory on freshwater macrophytes by invertebrates: A review. Journal of the North American Benthological Society 10:89-114

Newton, R.B. 1989. The Effects of Stormwater Surface Runoff on Freshwater Wetlands. Amherst, MA: The Environmental Institute, Blaisdell House, University of Massachusetts.

Niederlehner, B.R. and J. Cairns. 1990. Effects of increasing acidity on aquatic protozoan communities. Water, Air, and Soil Pollution 52: 183-196

Nilsson, C. and M. Dynesius. 1994. Ecological effects of river regulation on mammals and birds: A review. Regulated Rivers Research & Management 9:45-53.

Niswander, S.F. and W.J. Mitsch. 1995. Functional analysis of a two-year-old created in-stream wetland: Hydrology, phosphorus retention, and vegetation survival and growth. Wetlands 15(3): 212-225.

Nordquist, G.E. and E.C. Birney. 1980. The Importance of Peatland Habitats to Small Mammals in Minnesota. St. Paul, MN: Minnesota Department of Natural Resources.

Norman, A.J. 1996. The Use of Vegetative Buffer Strips to Protect Wetlands in Southern Ontario. Boca Raton, FL: Lewis Publishers.

North Carolina State University. 2002. WATERSHEDSS A decision support system for nonpoint source pollution. Available: http://h2osparc.wq.ncsu.edu/index.html. Accessed February 24, 2003.

North Carolina State University. No date. Functions of Wetlands (Processes). Available: http://h2osparc.wq.ncsu.edu/info/wetlands/function.html. Accessed February 13, 2003.

Novotony, V. and H. Olem. 1994. Water Quality Prevention, Identification, and Management of Diffuse Pollution. New York: Van Nostrand Reinhold.

Nowak, R. 1980. Impacts of Technology on Cropland and Rangeland Productivity: Managerial Capacity of Farmers. Office of Technology Assessment, U.S. Congress. Springfield, VA: National Technical Information Service.

Nyman, J.A. 1999. Effect of crude oil and chemical additives on metabolic activity of mixed microbial populations in fresh marsh soils. Microbial Ecology 37(2): 152-162.

Oakley, A.L., J.A. Collins, L.B. Everson, D.A. Heller, J.A. Howerton, and R.E. Vincent. 1985. Riparian Zones and Freshwater Wetlands. Washington, DC: U.S. Forest Service, U.S. Department of Agriculture.

Obot, E.A., A. Chinda, and S. Braid. 1992. Vegetation recovery and herbaceous production in a freshwater wetland 19 years after a major oil spill. African Journal of Ecology 30: 149-156.

Odum E.P. 1959. Fundamentals of Ecology, Second Edition, W.B. Saunders Company, Philadelphia, 278 pp.

Office of Community Development (Washington State). Internal report summarizing components of critical area ordinances of local jurisdictions. December 2002.

Ohlendorf, H.M., R.L. Hothem, C.M. Bunck, and K.C. Marvois. 1990. Bioaccumulation of selenium in birds at Keterson Reservoir, California. Archives of Contamination and Toxicology 19(4):495-507.

Oke, T.R. 1987. Boundary Layer Climates. Methuen-Wiley.

Olson, M.H., S.R. Carpenter, P. Cunningham, S. Gafny, B.R. Herwig, N.P. Nibbelink, T. Pellett, C. Storlie, A.S. Trebitz, and K.A. Wilson. 1998. Managing macrophytes to improve fish growth: A multi- lake experiment. Fisheries 23:6- 12

Omernik, J.M. 1977. Nonpoint Source Stream Nutrient Level Relationship: A Nationwide Study. EPA-600/3-77-105. Washington, DC: U.S. Environmental Protection Agency.

Omernik, J.M. and A.L. Gallant. 1986. Ecoregions of the Pacific Northwest. EPA/600/3-86/033. U.S. Environmental Protection Agency.

O'Neil, T.A. and D.H. Johnson. 2001. Oregon and Washington wildlife species and their habitats. (Chapter 1 p. 1-21) in D.H. Johnson and T.A. O'Neil (eds.), Wildlife-Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press.

Oring, L.W. and J.M. Reed. 1997. Shorebirds of the western Great Basin of North America: Overview and importance to continental populations. International Wader Studies 9:6-12.

Ossinger, M. 1999. Success Standards for Wetland Mitigation Projects: A Guideline. Environmental Affairs Office, Washington State Department of Transportation.

Ostendorp, W., C. Iseli, M. Krauss, P. Krumscheid-Plankert, J.L. Moret, M. Rollier, and F. Schanz. 1995. Lake shore deterioration, reed management and bank restoration in some Central European lakes. Ecological Engineering 5(1): 51-75.

Ostergaard, E.C. 2000. Effects of Urbanization on Pond-Breeding Amphibians: An Annotated Literature Review. Regional Applied Research Project: Influences of Landscape Context, Hydrology, and Non-Native Species on Wetland Faunal Communities, Implications for Regional Conservation and Mitigation Practices. U.S. Environmental Protection Agency.

Ostergaard, E.C. 2001. Pond-Breeding Amphibian Use of Stormwater Ponds in King County, Washington. Report, University of Washington, Seattle, WA.

Owen, C.R. 1999. Hydrology and history: Land use changes and ecological responses in an urban wetland. Wetlands Ecology and Management 6(4): 209-219.

Paerl, H.W. and D.R. Whitall. 1999. Anthropogenically-derived atmospheric nitrogen deposition, marine eutrophication and harmful algal bloom expansion: Is there a link? Ambio 28:308-311.

Pahlsson, A.M.B. 1989. Toxicity of heavy metals (Zn, Cu, Cd, Pb) to vascular plants: A literature review. Water, Soil and Air Pollution 47: 287-319.

Parker, M.S. and A.W. Wright. 1992. Aquatic invertebrates inhabiting saline evaporation ponds in the southern San Joaquin Valley, California. Bulletin of the Southern California Academy of Science 91(1): 39-43.

Parkos III, J.J., V.J. Santucci, Jr., and D.H. Wahl. 2003. Effects of adult common carp (Cyprinus carpio) on multiple trophic levels in shallow mesocosms. Canadian Journal of Fisheries and Aquatic Sciences 60:182-192.

Parr, J.F. and S. Smith. 1976. Degradation of toxaphene in selected anaerobic soil environments. Soil Science 121:52-57.

Parsons, J.K. and R.A. Matthews. 1995. Analysis of the association between macroinvertebrates and macrophytes in a freshwater pond. Northwest Science 69(4):265-275.

Patterson, J.H. 1976. The role of environmental heterogeneity in the regulation of duck populations. Journal of Wildlife Management 40(1):22-32.

Patty, L., R. Benoit, and J. Joel Gril. 1997. The use of grassed buffer strips to remove pesticides, nitrate and soluble phosphorus compounds from runoff water. Pesticide Science 49:243-51.

Paveglio, F.L., C.M. Bunck, and G.H. Heinz. 1992. Selenium and boron in aquatic birds from Central California. Journal of Wildlife Management 56(1):31-42.

Pavelis, G.A. 1987. Economic survey of farm drainage. Pages 110-136 in G.A. Pavelis (ed.), Farm Drainage in the United States: History, Status, and Prospects. U.S. Department of Agriculture Miscellaneous Publication No. 1455. Washington, DC: U.S. Government Printing Office.

Pechmann, J.H.K. and H.M. Wilbur. 1994. Putting declining amphibian populations in perspective: Natural fluctuations and human impacts. Herpetology 50: 65-84.

Pechmann, J.H.K., D.E. Scott, R.D. Semlitsch, J.P. Caldwell, L.J. Vitt, and J.W. Gibbons. 1991. Declining amphibian populations: The problem of separating human impacts from natural fluctuations. Science 253: 892-895.

Pechmann, J.H.K., R.A. Estes, D.E. Scott, and J.W. Gibbons. 2001. Amphibian colonization and use of ponds created for trial mitigation of wetland loss. Wetlands 21(1): 93-111.

Peck, D.E. and J.R. Lovvorn. 2001. The importance of flood irrigation in water supply to wetlands in the Laramie Basin, Wyoming, USA. Wetlands 21(3): 370-378.

Peters, M.S. and A.D. Afton. 1993. Effects of deep tillage on redistribution of lead shot and chufa flatsedge at Catahoula Lake, Louisiana. Wildlife Society Bulletin 21:471-479.

Peterson, M.S., N.J. Musselman, J. Francis, G. Habron, and K. Dierolf. 1993. Lack of salinity selection by freshwater and brackish populations of juvenile bluegill, Lepomis macrochirus. Wetlands 13(3): 194-199.

Peterson, N.P. 1982. Population characteristics of juvenile coho salmon overwintering in riverine ponds. Canadian Journal of Fisheries and Aquatic Science 39:1303-1307.

Pezeshki, S.R., A. Jugsujinda, and R.D. Delaune. 1998. Responses of selected U.S. Gulf Coast marsh macrophyte species to oiling and commercial cleaners. Water, Air, and Soil Pollution 107(1-4): 185-195.

Pezeshki, S.R., J.H. Pardue, and R.D. DeLaune. 1996. Leaf gas exchange and growth of flood-tolerant and flood-sensitive tree species under low soil redox conditions. Tree Physiology 16: 453-458.

Phillips, J.D. 1989. An evaluation of factors determining the effectiveness of water quality buffer zones. Journal of Hydrology 107:133-45.

Phipps, J.B. 1986. Sediment trapping in Northwest wetlands: The state of our understanding. In R. Strickland (ed.), Wetland Functions, Rehabilitation and Creation in the Pacific Northwest: The State of Our Understanding. Olympia, WA: Washington State Department of Ecology.

Pickett, S.T.A and P.S. White 1985. The Ecology of Natural Disturbance and Patch Dynamics. Elsevier Science & Technology Books. 472pp

Pimental, et al. 1995. Environmental and economic costs of soil erosion and conservation benefits. Science 267: 1117-1123.

Pitt, R, R.F. Field, M. Lalor, and M. Brown. 1995. Urban stormwater toxic pollutants: assessment, sources, and treatability. Water Environment Research 67:260-275.

Plassman, W. and M. Kadel. 1991. Low-frequency sensitivity in a gerbelline rodent, Pachyuromys durasi. Brain, Behavior, and Evolution 38:115-126.

Platin, T.J. 1994. Wetland Amphibians Ambystoma gracile and Rana aurora as Bioindicators of Stress Associated with Watershed Urbanization. M.S. Thesis. Seattle, WA: University of Washington.

Platin, T.J. and K.O. Richter. 1995. Amphibians as bioindicators of stress associated with watershed development. Pages 163-170 in Robichaud (ed.), Puget Sound Research '95 Proceedings, Volume 1. Olympia, WA: Puget Sound Water Quality Authority.

Platt, J.B. 1977. The Breeding Behavior of Wild and Captive Gyrfalcons in Relation to Their Environment and Human Disturbance. Ph.D. Dissertation. Ithaca, NY: Cornell University.

Poiani, K.A. and W.C. Johnson. 1989. Effect of hydroperiod on seed-bank composition in semipermanent prairie wetlands. Canadian Journal of Botany 67:856-864.

Poiani, K.A., B.L. Bedford, and M.D. Merrill. 1996. A GIS-based index for relating landscape characteristics to potential nitrogen leaching to wetlands. Landscape Ecology 11:237-255.

Pollock, M.M. and P. Kennard. 1998. A Low-Risk Strategy for Preserving Riparian Buffers Needed to Protect and Restore Salmonid Habitat in Forested Watersheds of the Pacific Northwest. Seattle, WA: 10,000 Years Institute.

Pollock, M.M., R.J. Naiman, and T.A. Hanley. 1998. Plant species richness in riparian wetlands: A test of biodiversity theory. Ecology 79(1): 94-105.

Popolizio, C.A., H. Goetz, and P.L. Chapman. 1994. Short-term response of riparian vegetation to 4 grazing treatments. Journal of Range Management 47: 48-53.

Portland Metro. 2002. Metro's Technical Report for Goal 5. Revised draft July 2002. Available: http://www.metro-region.org/library_docs/nat_resource/tech_report_goal5.pdf.

Pounds, J.A. and M.L. Crump. 1994. Amphibian declines and climate disturbance: The case of the golden toad and the harlequin frog. Conservation Biology 8: 72-85.

Pourang, N. 1995. Heavy metal bioaccumulation in different tissues of two fish species with regards to their feeding habits and trophic levels. Environmental Monitoring & Assessment 35(3): 207-219.

Press, D., D.F. Doak, and P. Steinberg. 1996. The role of local government in the conservation of rare species. Conservation Biology 10(6): 1538-1548.

Preston, E.M. and B.L. Bedford. 1988. Evaluating cumulative effects on wetland functions: A conceptual overview and generic framework. Environmental Management 12:.565-584.

Pringle, R.F. 1990. Soil survey of Thurston County, Washington. U.S. Dept. of Agriculture, Soil Conservation Service (now called NRCS). 283pp.

Prospero, J.M., K. Barret, T. Church, F. Detener, R.A. Duce, J.N. Galloway, H. Levy, J. Moody, and P. Quinn. 1996. Atmospheric deposition of nutrients to the North Atlantic Basin. Biogeochemistry 35:27-73.

PSMFC (Pacific States Marine Fisheries Commission). 2001. Anadromous Fish Life History Profiles. Available: http://www.psmfc.org/habitat/edu_anad_table.html. Accessed: February 19, 2003.

Pyke, C.R. and K.J. Havens. 1999. Distribution of the invasive reed *Phragmites australis* relative to sediment depth in a created wetland. Wetlands 19(1): 283-287.

Quinn, T., J. Gallie, and D.P. Volsen. 2001. Amphibian occurrence in artificial and natural wetlands of the Teanaway and lower Swauk River drainages of Kittitas County, Washington. Northwest Science 75(1): 84-89.

Race, M.S. and M.S. Fonseca. 1996. Fixing compensatory mitigation: What will it take? Ecological Applications 6: 94-101.

Rader, R.B. and C.J. Richardson. 1992. The effects of nutrient enrichment on algae and macroinvertebrates in the Everglades: A review. Wetlands 12(2):121-135.

Raisin, G.W. and D.S. Mitchell. 1995. The use of wetlands for the control of non-point source pollution. Pages 177 – 186 in R.H. Kadlec and H. Brix (eds.), Selected Proceedings of the 4th International Conference on Wetland Systems for Water Pollution Control. Guangzhou, China, November 6-10, 1994.

Ratti, J.T., A.M. Rocklage, J.H. Giudice, E.O. Garton, and D.P. Golner. 2001. Comparison of avian communities on restored and natural wetlands in North and South Dakota. Journal of Wildlife Management 65(4): 676-684.

Reddy, K.N. and M. Singh. 1992. Germination and emergence of hairy beggarsticks (Bidens pilosa). Weed Science 40: 195-199.

Reddy, K.R. and P.M. Gale. 1994. Wetland processes and water quality: A symposium overview. Journal of Environmental Quality 23:875-877.

Reese, D.A. and H.H. Welsh. 1997. Use of terrestrial habitat by western pond turtles, *Clemmys marmorata*: implications for management. Pp 352-357 in J. Van Abbema, editor. Proceedings: Conservation, Restoration and Management of Tortoises and Turtles--an International Conference. State University of New York, Purchase, NY.

Reeve, A.S., D.I. Siegel, and P.H. Glaser. 2000. Simulating vertical flow in large peatlands. Journal of Hydrology 227:207-217.

Reeves, G.H., F.H. Everest, and T.E. Nickelson et al. 1989. Identification of Physical Habitats Limiting the Production of Coho Salmon in Western Washington and Oregon. General Technical Report PNW-GTR-245. U.S. Forest Service, Pacific Northwest Research Station.

Reice, S.R. 1991. Effects of detritus loading and fish predation on leafpack breakdown and benthic macroinvertebrates in a woodland stream. Journal of the North American Benthological Society 10:42-56.

Reid, L.M. 1998. Cumulative watershed effects and watershed analysis. Chapter 19, pages 476-501. in: Naiman, R.J., and R.E. Bilby, (eds.) River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York N.Y.

Reijnen, R., R. Foppen, and H. Meeuwsen. 1996. The effects of traffic on the density of breeding birds in Dutch agricultural grasslands. Biological Conservation 75:255-260.

Reijnen, R., R. Foppen, C. Terbraak, and J. Thissen. 1995. The effects of car traffic on breeding bird populations in woodland: 3. Reduction of density in relation to the proximity of main roads. Journal of Applied Ecology 32:187-202.

Reilly, W. 1991. Testimony before the Senate Subcommittee on Environmental Protection, July 10, 1991, Section 404 of the Clean Water Act.

Reinartz, J.A. and E.L. Warne. 1993. Development of vegetation in small created wetlands in southeastern Wisconsin. Wetlands 13(3): 153-164.

Reinelt, L.E. and B.L. Taylor. 2001. Effects of watershed development on hydrology. Chapter 8, pages 221-236 in A.L. Azous and R.R. Horner (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Reinelt, L.E. and R.R. Horner. 1995. Pollutant removal from stormwater runoff by palustrine wetlands based on comprehensive budgets. Ecological Engineering 4:77-97.

Reinelt, L.E., R.R. Horner, and A. Azous. 1998. Impacts of urbanization on palustrine (depressional freshwater) wetlands research and management in the Puget Sound region. Urban Ecosystems 2:219-236.

Rempel, L.L., J.S. Richardson, and M.C. Healy. 1999. Flow refugia for benthic macroinvertebrates during flooding of a large river. Journal of the North American Benthological Society 18(1): 34-48.

Rendig, V.V. and H.M. Taylor. 1989. Principles of Soil-Plant Interrelationships. New York: McGraw-Hill.

Rheinhardt, R.D., M.M. Brinson, and P.M. Farley. 1997. Applying wetland reference data to functional assessment, mitigation, and restoration. Wetlands 17(2): 195-215.

Rhoads, F.M., S.M. Olson, and D.G. McDonald. 1989. Copper toxicity in tomato plants. Journal of Environmental Quality 18: 195-197.

Richardson, C.J. 1985. Mechanisms controlling phosphorus retention capacity in freshwater wetlands. Science 228:1424-1427.

Richardson, C.J. and E.J. McCarthy. 1994. Effect of land development and forest management on hydrologic response in southeastern coastal wetlands: A review. Wetlands 14: 56-71.

Richardson, J. and M. Vepraskas. 2001. Wetland Soils. Lewis publishers, Boca Raton, Florida.

Richardson, M.S. and R.C. Gatti. 1999. Prioritizing wetland restoration activity within a Wisconsin watershed using GIS modeling. Journal of Soil and Water Conservation 54: 537-542.

Richter, B.D., J.V. Baumgartner, J. Powell, and D. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10(4): 1163-1174.

Richter, K. 1996. Criteria for the Restoration and Creation of Wetland Habitats for Lentic-Breeding Amphibians of the Puget Sound Basin: 1. Site Selection Criteria. Manuscript. King County Natural Resources Division.

Richter, K.O. 1997. Criteria for the restoration and creation of wetland habitats of lentic-breeding amphibians of the Pacific Northwest. Pages 72-94 in K.B. Macdonald and F. Weinmann (eds.), Wetland and Riparian Restoration: Taking a Broader View. EPA 910-97-007. Seattle, WA: U.S. Environmental Protection Agency, Region 10.

Richter, K.O. 2001. Macroinvertebrate distribution, abundance, and habitat use. Chapter 4, pages 97-142 in A.L. Azous and R.R. Horner (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Richter, K.O. and A.L. Azous. 1995. Amphibian occurrence and wetland characteristics in the Puget Sound basin. Wetlands 15: 305-312.

Richter, K.O. and A.L. Azous. 2001a. Amphibian distribution, abundance, and habitat use. Chapter 5, pages 143-166 in A.L. Azous and R.R. Horner (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Richter, K.O. and A.L. Azous. 2001b. Bird distribution, abundance, and habitat use. Chapter 6, pages 167-200 in A.L. Azous and R.R. Horner (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Richter, K.O. and A.L. Azous. 2001c. Terrestrial small mammal distribution, abundance, and habitat use. Chapter 7, pages 201-220 in A.L. Azous and R.R. Horner (eds.), Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Richter, K.O. and E.C. Ostergaard. 1999. King County Wetland-Breeding Amphibian Monitoring Program: 1993-1997 Summary Report. Seattle,WA: King County Department of Natural Resources, Water and Land Resources Division.

Rickerl, D.H., L.L Janssen, and R. Woodland. 2000. Buffered wetlands in agricultural landscapes in the prairie Pothole Region: Environmental, agronomic, and economic evaluations. Journal of Soil and Water Conservation 55: 220-225.

Rigg, G.B. 1918. Growth of trees in sphagnum. Botanical Gazette 65: 359-362.

Rigg, G.B. 1958. Peat Resources of Washington. Bulletin No. 44. Division of Mines and Geology, State of Washington.

Rivard, P.G. and P.M. Woodard. 1989. Light, ash, and pH effects on the germination and seedling growth of Typha latifolia (cattail). Canadian Journal of Botany 67: 2783-2787.

Robb, J.T. 2002. Assessing wetland compensatory mitigation sites to aid in establishing mitigation ratios. Wetlands 22(2): 435-440.

Roberts, L. 1993. Wetlands trading is a loser's game, say ecologists. Science 260: 1890-1892.

Roberts, L. 1990. Zebra mussel invasion threatens U.S. waters. Science 249:1370-1372.

Robinson, A. 1995. Small and seasonal does not mean insignificant: Why it's worth standing up for tiny and temporary wetlands. Journal Soil Water Conservation 50(6):586-590.

Rodgers, J.A. and H.T. Smith. 1997. Buffer zone distances to protect foraging and loafing waterbirds from human disturbance in Florida. Wildlife Society Bulletin 25:139-145.

Rolauffs, P., D. Hering, and S. Lohse. 2001. Composition, invertebrate community and productivity of a beaver dam in comparison to other stream habitat types. Hydrobiologia 459: 201-212.

Romero, J.A., F.A. Comin, and C. Garcia. 1999. Restored wetlands as filters to remove nitrogen. Chemosphere 39(2): 323-332.

Rood, S.B., A.R. Kalischuk, and J.M. Mahoney. 1998. Initial cottonwood seedling recruitment following the flood of the century of the Oldman River, Alberta, Canada. Wetlands 18(4): 557-570.

Rood, S.B., and J.M. Mahoney. 1990. Collapse of riparian poplar forests downstream from dams in western prairies: Probable causes and prospects for mitigation. Environmental Management 14(4):451-464.

Rosenberg, D.M. and H.V. Danks. 1987. Aquatic insects of peatlands and marshes in Canada. Memoirs of the Entomological Society of Canada No. 140:174.

Ross, L.C.M. and H.R. Murkin. 1993. The effect of above-normal flooding of a northern prairie marsh on Agraylea multipuntata. Journal of Freshwater Ecology 8(1): 27-35.

Rotella, J.J., and J.T. Ratti. 1992. Mallard brood survival and wetland habitat conditions in southwestern Manitoba. Journal of Wildlife Management 56:499–507.

Roth, E.M., R.D. Olsen, P.L. Snow, R.R. Sumner and S.G. McCannel. 1993. Oregon Freshwater Wetland Assessment Methodology. Salem, OR: Oregon Division of State Lands.

Rowe, C.L. and W.A. Dunson. 1993. Relationships among abiotic parameters and breeding effort by three amphibians in temporary wetlands of central Pennsylvania. Wetlands 13(4):237-246.

Rubega, M.A. and J.A. Robinson. 1997. Water salinization and shorebirds: Emerging issues. International Wader Studies 9:45-54.

Rybicki, N.B. and V. Carter. 1986. Effect of sediment depth on sediment type on the survival of *Vallisneria americana* grown from tubers. Aquatic Botany 24:233-240.

Samson, F.B., F.L. Knopf, and L.B. Hass. 1988. Small mammal response to the introduction of cattle into a cottonwood floodplain. Pages 432-438 in R.C. Szaro, K.E. Severson, and D.R. Patton. Management of Amphibians, Reptiles, and Small Mammals in North America. General Technical Report RM-166. Ft. Collins, CO: U.S. Forest Service.

Santelmann, M.V. 1991. Influences on the distribution of *Carex exilis*: An experimental approach. Ecology 72(6): 2025-2037.

Saunders, D.A. and C.P. DeRebeira. 1991. Values of corridors to avian populations in a fragmented landscape. In D.A. Saunders and R. Hobbs (eds.), Nature Conservation 2: The Role of Corridors. Surrey Beatty & Sons PTY Limited.

Saunders, D.L. and J. Kalff. 2001. Nitrogen retention in wetland, lakes and rivers. Hydrobiologie 443:205-212.

Savard, J.P., W.S. Boyd, and G.E.J. Smith. 1994. Waterfowl-wetland relationships in the Aspen Parkland of British Columbia: Comparison of analytical methods. Hydrobiologia 279/280:309-325.

Schell, V.A. and J.J. Kerekes. 1989. Distribution, abundance, and biomass of benthic macroinvertebrates relative to pH and nutrients in eight lakes of Nova Scotia, Canada. Water, Air, and Soil Pollution 46(1-4):359-374.

Schmitke, R. 1971. Some Aspects of Muskrat Ecology at Big Island Lake, Alberta. M.S. Thesis. Utah State University.

Schouwenaars, J.M. 1995. The selection of internal and external water management options for bog restoration. Pp. 331-346 In: B.D. Wheeler, S.C. Shaw, W.J. Fojt and R.A. Robertson, Restoration of Temperate Wetlands. John Wiley & Sons Ltd.

Schrautzer, J., M. Asshoff, and F. Muller. 1996. Restoration strategies for wet grasslands in northern Germany. Ecological Engineering 7: 255-278.

Schueler, T.R. and H.K. Holland. 2000. The impact of stormwater on Puget Sound wetlands. In The Practice of Watershed Protection. Center for Watershed Protection.

Schuytema, G.S. and A.V. Nebeker. 1996. Amphibian Toxicity Data for Water Quality Criteria Chemicals. EPA/600/R-96/124. Corvallis, OR: U.S. Environmental Protection Agency, Environmental Research Laboratory.

Scott, J.M., R.J.F Abbitt, and C.R. Groves. 2001. What are we protecting? Conservation Biology in Practice 2(1): 18-19.

Scott, M.L., G.T. Auble, and J.M. Friedman. 1997. Flood dependency of cottonwood establishment along the Missouri River, Montana. Ecological Applications 7:677-690.

Scott, M.L., J.M. Friedman, and G.T. Auble. 1996. Fluvial process and the establishment of bottomland trees. Geomorphology 14:327-339.

Searls, D.A. 1974. Influence of Vegetation on the Distribution of Small Mammals on a Waterfowl Production Area. M.S. Thesis. Brookings, SD: South Dakota State University.

Sedell, J. R. and K. J. Luchessa. 1982. Acquisition and utilization of aquatic habitat inventory information: proceedings of a symposium held 28-30 October, 1981, Hilton Hotel, Portland, Oregon / Neil B. Armantrout, editor; organized by the Western Division, American Fisheries Society

Semlitsch, R. 1998. Biological delineation of terrestrial buffer zones for pond-breeding salamanders. Conservation Biology 12(5): 1113-1119.

Semlitsch, R.D. 2000. Principles for management of aquatic-breeding amphibians. Journal of Wildlife Management 64(3).

Semlitsch, R.D. and J.R. Bodie. 1998. Are small, isolated wetlands expendable? Conservation Biology 12(5): 1129-1133.

Shabman, L., D. King, and P. Scodari. 1993. Wetland mitigation success through credit market systems. Wetland Journal 5(2): 9-12.

Shaffer, P., M.E. Kentula, and S.E. Gwin. 1999. Characterization of wetland hydrology using hydrogeomorphic classification. Wetlands 19: 490-504.

Shaffer, P.W. and T.L. Ernst. 1999. Distribution of soil organic matter in freshwater emergent/open water wetlands in the Portland, Oregon metropolitan area. Wetlands 19(3): 505-516.

Shaich, J.A. and K.T. Franklin. 1995. Wetland Compensatory Mitigation in Oregon: A Program Evaluation with a Focus on Portland Metro Area Projects. Oregon Division of State Lands.

Sharitz, R.R. and C.A. Gresham. 1997. Pocosins and Carolina bays. Pages 343-377 in M.G. Messina and W.H. Conner (eds.), Southern Forested Wetlands: Ecology and Management. Boca Raton, FL: Lewis Publishers, CRC Press.

Sharma, P.K., D.L. Balkwill, A. Frenkel, and M.A. Vairavamurthy. 2000. A new *Klebsiella planticola* strain (Cd-1) grows anaerobically at high cadmium concentrations and precipitates cadmium sulfide. Applied and Environmental Microbiology 66:3083-3087

Shay, J.M., P.M.J. de Geus, and M.R.M. Kapinga. 1999. Changes in shoreline vegetation over a 50-year period in the Delta Marsh, Manitoba in response to water levels. Wetlands 19(2): 413-425.

Sheldon, D. and D.A. Dole. 1992. Replacement ratios: A field assessment of mitigation replacement ratios in Puget Sound. In A.J. Castelle et al. (eds.), Wetland Mitigation Replacement Ratios: Defining Equivalency. Publication No. 92-08. Olympia, WA: Washington Department of Ecology.

Sheridan, J.M., R. Lowrance, and D.D. Bosch. 1999. Management effects on runoff and sediment transport in riparian forest buffers. Transactions of the American Society of Agricultural Engineers 42(1): 55-64.

Shisler, J.K., R.A. Jordan, and R.N. Wargo. 1987. Coastal Wetland Buffer Delineation. Trenton, NJ: New Jersey Department of Environmental Protection, Division of Coastal Resources.

Short, F. and D. Burdick. 1995. Mesocosm experiments quantify the effects of eutrophication on eelgrass, *Zostera marina*. Limnology and Oceanography 40: 740-749.

Short, H.L. and R.J. Cooper. 1985. Habitat Suitability Index Models: Great Blue Heron. FWS/BR-82(10.99). U.S. Fish and Wildlife Service.

Sikora, F.J., L.L Behrends, G.A. Brodie, and H.N. Taylor. 2000. Design criteria and required chemistry for removing manganese in acid mine drainage using subsurface flow wetlands. Water Environment Research 72: 536-544.

Silvertown, J., M.E. Dodd, D.J.G. Gowing, and J.O. Mountford. 1999. Hydrologically defined niches reveal a basis for species richness in plant communities. Nature 400:61-63.

Simons, L.H. 1985. Small mammal community structure in old growth and logged riparian habitat. Pages 505-506 in R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Ffolliott, R.H. Hamre (eds), Riparian Ecosystems and their Management: Reconciling Conflicting Uses. General Technical Report RM-120. Ft. Collins, CO: U.S. Forest Service.

Sinsch, U. 1992. Structure and dynamic of a natterjack toad metapopulation (Bufo calamita). Oecologia 90:489-499.

Sipple, W. 2002. Wetland Functions and Values. Available: http://www.epa.gov/watertrain/wetlands/. Accessed: February 24, 2003. U.S. Environmental Protection Agency.

Skovlin, J.M. 1984. Impacts of grazing on wetlands and riparian habitat: A review of our knowledge. In: National Research Council. Developing strategies for rangeland management. Westview Press, Boulder CO. p.1001-1103.

Slater, J.R. 1936. Notes on *Ambystoma gracile* Baird and *Ambystoma macrodactylum* Baird. Copeia 1936:234-236.

Slough, B.G. and R. Sadleir. 1977. A land capacity classification system for beaver (Castor canadensis). Canadian Journal of Zoology 55(8):1324-1335.

Smith, M.E., B.J. Wyskowski, C.M. Brooks, C.T. Driscoll, and C.C. Cosentini. 1990. Relationships between acidity and benthic invertebrates of low-order woodland streams in the Adirondack Mountains, New York. Canadian Journal of Fisheries and Aquatic Sciences 47(7):1318-1329.

Smith, R.D. 1996. Composition, structure, and distribution of woody vegetation on the Cache River floodplain, Arkansas. Wetlands 16: 264-278.

Smith, R.D., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, Technical Report WRP-DE-9.

Snodgrass, J.W., J.W. Ackerman, A.L. Bryan, and J. Burger. 1999. Influence of hydroperiod, isolation, and heterospecifics on the distribution of aquatic salamanders (siren and amphiuma) among depression wetlands. Copeia 1999(1): 107-113.

Snodgrass, J.W., M.J. Komoroski, A.L. Bryan, and J. Burger. 2000. Relationships among isolated wetland size, hydroperiod, and amphibian species richness: Implications for wetland regulations. Conservation Biology 14(2): 414-419.

Snowden (nee Cook), R.E.D., and B.D. Wheeler. 1993. Iron toxicity to fen plant species. Journal of Ecology 81:35-46.

Snyder, N.J., S. Mostaghimi, D.F. Berry, R.B. Reneau, S. Hong, P.W. McClellan, and E.P. Smith. 1998. Impact of riparian forest buffers on agricultural nonpoint source pollution. Journal of the American Water Resources Association 34(2): 385-395.

Sofgren, G.P. 1991. Extinction and isolation gradients in metapopulations: The case of the pool frog (*Rana lessonae*). Biological Journal of the Linnean Society (London) 42:135-147.

Sofgren, G.P. 1994. Distribution and extinction patterns within a northern metapopulation of the pool frog *Rana lessonae*. Ecology 75:1357-1367.

Solberg, K.L., and K.F. Higgins. 1993. Effects of glyphosate herbicide on cat-tails, invertebrates, and waterfowl in South Dakota wetlands. Wildlife Society Bulletin 21:299–307.

Soster, F.M. and McCall, P.L. 1990. Benthos response to disturbance in western Lake Erie: Field experiments. Canadian Journal of Fisheries and Aquatic Sciences 47: 1970-1985.

Sparling, D.W. 1990. Acid precipitation and food quality: Inhibition of growth and survival in black ducks and mallards by dietary aluminum, calcium, and phosphorus. Archives of Environmental Contamination and Toxicology 19:457-463.

Sparling, D.W. 1991. Acid precipitation and food quality: Effects of dietary Al, Ca, and P on bone and liver characteristics in American black ducks and mallards. Archives of Environmental Contamination and Toxicology 21:281-288.

Sparling, D.W., G. Linder, and C.A. Bishop. 2000. Ecotoxicology of Amphibians and Reptiles. Pensacola, FL: SETAC Press.

Spaulding, M.G. and D.J. Forrester. 1993. Pathogenesis of *Eustrongylides ignotus* (Nematoda: Dioctophymatoidea) in Ciconiiformes. Journal of Wildlife Diseases 29: 250-260.

Spaulding, M.G., G.T. Bancroft and D.J. Forrester. 1993. The epizootiology of Eustrongylidosis in wading birds (Ciconiiformes). Journal of Wildlife Diseases 29: 237-249.

Spencer, W.F., M.M. Cliath, W.J. Farmer, and R.A. Shepard. 1974. Volatility of DDT residues in soil as affected by flooding and organic matter applications. Journal of Environmental Quality 3:126-129.

Spooner, J. 2004. Maries River Basin: Analysis of the Effects of Instream Gravel Mining. US Geologic Survey http://gam.usgs.gov/IntegratedScience/mariesriver.shtml (accessed January 21, 2005).

Squires, L. and A.G. van der Valk. 1992. Water-depth tolerances of the dominant emergent macrophytes of the Delta Marsh, Manitoba. Canadian Journal of Botany 70: 1860-1867.

Srivastava, D.S., C.A. Staicer, and B. Freeman. 1995. Aquatic vegetation of Nova Scotia lakes differing in acidity and trophic status. Aquatic Botany 51:181-196.

Sriyaraj, K. and R.B.E. Shutes. 2001. An assessment of the impact of motorway runoff on a pond, wetland and stream. Environment International 26 (2001) 443-439.

St. Louis, V.L., L. Breebaart, and J.C. Barlow. 1990. Foraging behavior of tree swallows over acidified and nonacidic lakes. Canadian Journal of Zoology 68:2385-2392.

Stakhiv, E.Z. 1988. An evaluation paradigm for cumulative impact analysis. Environmental Management 12(5): 725-748.

Stalmaster, M.V. 1987. The Bald Eagle. New York: Universe Books.

Stanley, E.H., D. Buschman, A.J. Boulton, N.B. Grimm, and S.G. Fisher. 1994. Invertebrate resistance and resilience to intermittency in a desert stream. American Midland Naturalist 131(2):288-300.

Stanley, S. and S. Grigsby. 2003. Assessing ecosystem function using a landscape scale approach. Proceedings of the 2003 Georgia Basin/Puget Sound Research Conference. Vancouver, BC (in publication).

Stanley, S., S. Grigsby, C. Donoghue, and G. Menzies. 2003. Draft Drayton Harbor Focused Watershed Analysis, Remediating Water Quality Impacts through Application of Landscape Principles. Washington State Department of Ecology Publication #03-06-025. Olympia WA

Stanley, T.R., G.J. Smith, D.J. Hoffman, G.H. Heinz, and R. Roscoe. 1996. Effects of boron and selenium on mallard reproduction and duckling growth and survival. Environmental Toxicology and Chemistry. 15:1124-1132.

Stanturf, J.A., S.H. Schoenholtz, C.J. Schweitzer, and J.P. Shepard. 2001. Achieving restoration success: Myths in bottomland hardwood forests. Restoration Ecology 9:189-200.

Stauffer, A.L. and R.P. Brooks. 1997. Plant and soil repsonses to salvaged marsh surface and organic matter amendments at a created wetland in central Pennsylvania. Wetlands 17(1): 90-105.

Steedman, R.J. 1988. Modification and assessment of an index of biotic integrity to quantify stream quality in southern Ontario. Canadian Journal of Fisheries and Aquatic Sciences 45:492-501.

Stein, E.D. 2001. Watershed scale analysis and management of cumulative impacts. In: P.J. Wigington and R.L. Beschta (eds) Riparian Ecology and Management in Multi-Land Use Watersheds. American Water Resources Association. Middleburg VA

Stein, E.D., M. Mattson, E. Fetschner, and K.J. Halama. 2004. Influence of geologic setting on slope wetland hydrodynamics. Wetlands 24:244-260.

Steinberg, C.E.W., and R.F. Wright (eds.). 1992. Acidification of Freshwater Ecosystems: Implications for the Future. New York: John Wiley & Sons.

Steinberg, N.A. and R.S. Oremland. 1990. Dissimilatory selenate reduction potentials in a diversity of sediment types. Applied and Environmental Microbiology 56: 3550-3557.

Steinblums, I.J., H.A. Froehlich, J.K. Lyons. 1984. Designing Stable Buffer Strips for Stream Protection. J. Forestry, 82(1):49-52.

Stevenson, J.C., L. Staver, and K. Staver. 1993. Water quality associated with survival of submersed aquatic vegetation along an estuarine gradient. Estuaries 16(2): 346-361.

Stewart, C.N., Jr. and E.T. Nilsen. 1993. Association of edaphic factors and vegetation in several isolated Appalachian peat bogs. Bulletin of the Torrey Botanical Club 120(2): 128-135.

Stockwell, S.S. 1985. Distribution and Abundance of Amphibians, Reptiles, and Small Mammals in Eight Types of Maine Peatland Vegetation. M.S. Thesis. University of Maine.

Stolt, M., M.H. Genthner, W.L. Daniels, V.A. Groover, S. Nagle, and K.C. Haering. 2000. Comparison of soil and other environmental conditions in constructed and adjacent palustrine reference wetlands. Wetlands 20(4): 671-683.

Storm, L. and J. Stellini. 1994. Interagency Follow-Through Investigation of Compensatory Wetland Mitigation Sites: Joint Agency Staff Report. Seattle and Olympia, WA: EPA, Region 10, USFWS, Ecological Services.

Streever, B. 1999. Performance standards for wetland creation and restoration under Section 404. National Wetlands Newsletter 21(3): 10-13.

Streever, W.J., K.M. Portier, T.L. Crisman. 1996. A comparison of dipterans from ten created and ten natural wetlands. Wetlands 16(4): 416-428.

Strijbosch, H. 1979. Habitat selection of amphibians during their aquatic phase. Oikos 33:363-372.

Sudol, M.F. and R.F. Ambrose. 2002. The U.S. Clean Water Act and habitat replacement: Evaluation of mitigation sites in Orange County, California, USA. Environmental Management 30(5): 727-734.

Sutter, L.A. 2001. Spatial Wetland Assessment for Management and Planning (SWAMP): Technical Discussion. Publication No. 20129-CD. Charleston, SC: NOAA Coastal Services Center.

Sutton, D.L. 1996. Growth of torpedo grass from rhizomes planted under flooded conditions. Journal of Aquatic Plant Management 34: 50-53.

Swanson, G.A., V.A. Adomaitis, F.B. Lee, S.R. Serie, and J.A. Shoesmith. 1984. Limnological conditions influencing duckling use of saline lakes in south-central North Dakota. Journal of Wildlife Management 48:340-349.

Syme, G.J., D.M. Fenton, and S. Coakes. 2001. Lot size, garden satisfaction and local park and wetland visitation. Landscape and Urban Planning 56: 161-170.

Tasker, G.D. and N.E. Driver. 1988. Nationwide regression models for predicting urban runoff water quality at unmonitored sites. Water Resources Bulletin 24:1091-1101.

Tattersall, G.J. and R.G. Boutilier. 1999. Behavioural oxy-regulation by cold-submerged frogs in heterogeneous oxygen environments. Canadian Journal of Zoology 77(6): 843-850

Taylor, B.L. 1993. The Influence of Wetland and Watershed Morphological Characteristics on Wetland Hydrology and Relationships to Wetland Vegetation Communities. M.S. Thesis. Seattle, WA: University of Washington.

Taylor, G.M. and E. Nol. 1989. Movements and hibernation sites of overwintering painted turtles in southern Ontario. Canadian Journal of Zoology 67: 1877-1881.

Temple, S.A. and J.R. Cary. 1988. Modeling dynamics of habitat-interior bird populations in fragmented landscapes. Conservation Biology 2(4): 340-347.

Teutsch, C.D. and R.M. Sulc. 1997. Influence of seedling growth stage on flooding injury in alfalfa. Agronomy Journal 89: 970-975.

The Conservation Foundation. 1988. Protecting America's Wetlands: An Action Agenda. The Final Report of the National Wetlands Policy Forum. Washington, DC.

Thom, R.M., A.B. Borde, K.O. Richter, and L.F. Hibler. 2001. Influence of urbanization on ecological processes in wetlands. Water Science and Application 2: 5-16.

Thomas, J.W., C. Maser, and J.E. Rodiek. 1979. Edges. p. 48 In: J.W. Thomas (ed,) Wildlife Habitats in Managed Forests: The Blue Mountains of Oregon and Washington. U.S. Dept. of Agriculture, Agriculture Handbook No. 553. Washington, DC.

Thompson, D. B., T. L. Loudoun, and J. B. Gerrish. 1978. Winter and spring runoff from manure application plots. American Society of Agricultural Engineers Paper No. 78-2032. St. Joseph, MI.

Thormann, M.N., A.R. Szumigalski, and S.E. Bayley. 1999. Aboveground peat and carbon accumulation potentials along a bog-fen-marsh wetland gradient in southern boreal Alberta, Canada. Wetlands 19(2):305-317.

Thurston, K.A. 1999. Lead and petroleum hydrocarbon changes in an urban wetland receiving stormwater runoff. Ecological Engineering 12:387-399.

Tilton, D.L. 1995. Integrating wetlands into planned landscapes. Landscape and Urban Planing 32: 205-209.

Timmermans, K.R. 1993. Accumulation of trace metals in freshwater invertebrates. Pages 133-148 in R. Dallinger and P.S. Rainbow (eds.), Ecotoxicology of Metals in Invertebrates. Boca Raton, FL: Lewis Publishers.

Tiner, R.W. 1984. Wetlands of the United States: Current status and recent trends. National Wetland Inventory, US Dept. of Interior Fish and Wildlife Service, Washington D.C. 58p.

Tiner, R.W., H.C. Bergquist, G.P. DeAlessio, and M.J. Starr. 2002. Geographically Isolated Wetlands: A Preliminary Assessment of their Characteristics and Status in Selected Areas of the United States. Hadley, MA: U.S. Department of the Interior, Fish and Wildlife Service, Northeast Region.

Titre, J.P. and J.E. Henderson. 1989. Summary of Valuation Methods for Wetlands. Environmental Effects of Dredging Technical Notes EEDP-06-8. U.S. Army Corps of Engineers.

Titus, J.E. and D.T. Hoover. 1993. Reproduction in two submersed macrophytes declines at progressively low pH. Freshwater Biology 30:63-72.

Titus, J.H., and J. Leps. 2000. The response of arbuscular mycorrhizae to fertilization, mowing, and removal of dominant species in a diverse oligotrophic wet meadow. American Journal of Botany 87: 392-401.

Todd, A.H. 2000. Making decisions about riparian buffer width. In P.J. Wigington and R.L. Beschta, Riparian Ecology and Management in Multi-Land Use Watersheds. American Water Resources Association. Middleburg VA

Toner, M. and P. Keddy. 1997. River hydrology and riparian wetlands: A predictive model for ecological assembly. Ecological Applications 7(1): 236-246.

Torok, L.S., S. Lockwood, and D. Fanz. 1996. Environmental auditing, review and comparison of wetland impacts and mitigation requirements between New Jersey, USA, Freshwater Wetlands Protection Act and Section 404 of the Clean Water Act. Environmental Management 20(5): 741-752.

Townsend, L. and J. Robinson. 2001. Riparian forest buffer design strategies in U.S. agricultural areas. In P.J. Wigington and R.L. Beschta, Riparian Ecology and Management in Multi-Land Use Watersheds. American Water Resources Association. Middleburg VA.

Towson University. No date. Chesapeake Bay & Mid-Atlantic from Space Project. Available: http://chesapeake.towson.edu/landscape/impervious/habitat.asp Accessed August 8, 2003.

Travnichek, V.H. and M.J. Maceina. 1994. Comparison of flow regulation effects on fish assemblages in shallow and deep water habitats in the Tallapoosa River, Alabama. Journal of Freshwater Ecology 9(3):207-216.

Trettin, C.C. and Jurgensen, M.F. 1992. Organic Matter Decomposition Response Following Disturbance in a Forested Wetland in Northern Michigan, USA. Oak Ridge National Laboratory Technical Report CONF-9206117-1.

Troelstrup, N.H., Jr. and G.L. Hergenrader. 1990. Effects of hydropower peaking flow fluctuations on community structure and feeding guilds of invertebrates colonizing artificial substrates in a large impounded river. Hydrobiologia 199(3):217-228.

Tuchman, N.C. 1993. Relative importance of microbes versus macroinvertebrate shredders in the process of leaf decay in lakes of differing pH. Canadian Journal of Fisheries and Aquatic Sciences 50(12):2907-2712.

Tucker, J.K. 1994. Colonization of unionid bivalves by the zebra mussel, Dreissena polymorpha, in Pool 26 of the Mississippi River. Journal of Freshwater Ecology 9:129-134.

Tucker, J.K. and E.R. Atwood. 1995. Contiguous backwater lakes as possible refugia for unionid mussels in areas of heavy zebra mussel (Dreissena polymorpha) colonization. Journal of Freshwater Ecology 10(2):43-47.

Turner, B.C., G.S. Hochbaum, F.D. Caswell, and D.J. Nieman. 1987. Agricultural impacts on wetland habitats on the Canadian prairies, 1981-85. Proceedings of the North American Wildlife and Natural Resources Conference 52: 206-215.

U.S. Army Corps of Engineers. 1987. Corps of Engineers wetlands delineation manual. Technical Report Y-87-1. Environmental Laboratory. NTIS No. AD A176 912. Vicksburg, MS: U.S. Army Engineers Waterways Experiment Station.

U.S. Army Corps of Engineers. 2000. Mill Creek Special Area Management Plan (SAMP), King County, Washington. Available: http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=REG&pagename=Mill_Creek_SAMP. Accessed: March 7, 2003. Seattle District.

U.S. Department of the Interior. 1978. Terrestrial Habitat Evaluation Criteria Handbook for Ecoregion 2410 (Willamette Valley-Puget Trough). Portland, OR: U.S. Fish and Wildlife Service, Division of Ecological Services.

U.S. Environmental Protection Agency. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA 840-B-92-002. January 1993.

U.S. Environmental Protection Agency. 1999. Consideration of Cumulative Impacts in EPA review of NEPA documents. Office of Federal Activities, publication EPA 315-R-99-002/May 1999.

U.S. Environmental Protection Agency. 2002. Wetland Loss Index, 1780s to 1990s. Available: http://www.epa.gov/iwi/1999sept/iv7_usmap.html. Accessed December 17, 2002.

U.S. Environmental Protection Agency. 2003. Managing Urban Runoff Pointer No. 7. EPA841-F-96-004G. Available: http://www.epa.gov/owow/nps/facts/point7.htm Accessed May 22, 2003.

U.S Environmental Protection Agency. 2004. Nonpoint Source Pollution: The Nation's Largest Water Quality Problem, http://www.p2pays.org/ref/05/04749.htm accessed February 4, 2005.

U.S. General Accounting Office. 2001. Wetlands Protection: Assessments Needed to Determine Effectiveness of In-Lieu-Fee Mitigation. GAO-01-325. Washington, DC.

U.S.Geological Suvey (USGS) Mid-Continent Mapping Center (MO) http://gam.usgs.gov/IntegratedScience/mariesriver.shtml accessed February 4 2005.

U.S. Department of the Interior, Office of Surface Mining. 2003. Factors Controlling Acid Mine Drainage Formation. Available: http://www.osmre.gov/amdform.htm. Accessed: May 23, 2003.

Urban, N.H., S.M. Davis, and N.G. Aumen. 1993. Fluctuations in sawgrass and cattail densities in Everglades Water Conservation Area 2A under varying nutrient, hydrologic, and fire regimes. Aquatic Botany 26:203-223.

Valiela,I., K. Foreman, M. LaMontagne, D. Hersh, J. Costa, C. Davanzo, M. Babione, P. Peckol, B. DeMeo-Andreson, C. Sham, J. Brawley, K. Lajtha. 1993. Coupling of watersheds and coastal waters: Sources and consequences of nutrient enrichment in Waquoit Bay, Massachusetts. Estuaries 15, 443-457.

Valigura, R., W.T. Luke, R.S. Artz, and B.B. Hicks. 1996. Atmospheric Nutrient Inputs to Coastal Areas: Reducing the Uncertainties. Decision Analysis Series No. 9. Washington, DC: NOAA Coastal Ocean Program.

Van der Kamp, G. and M. Hayashi. 1998. The groundwater recharge function of small wetlands in the semi-arid northern prairies. Great Plains Research 8: 39-56.

van der Valk, A.G. 1994. Effects of prolonged flooding on the distribution and biomass of emergent species along a freshwater wetland coenoline. Vegetatio 110(2): 185-196.

van der Valk, A.G. and R.W. Jolly. 1992. Recommendations for research to develop guidelines for the use of wetlands to control rural NPS pollution. Ecological Engineering 1:115-134.

van der Valk, A.G., L. Squires, and C.H. Welling. 1994. Assessing the impacts of an increase in water level on wetland vegetation. Ecological Applications 4:525-534.

van der Valk, A.G., R.L. Pederson, and C.B. Davis. 1992. Restoration and creation of freshwater wetlands using seed banks. Wetlands Ecology and Management 1:191-197.

Van Dyke, G.D., L.M. Shem and R.E. Zimmerman. 1993. Comparison of Revegetation of a Gas Pipeline Right-of-Way in Two Forested Wetland Crossings Involving Conventional Methods of Pipeline Installation and Horizontal Drilling, Nassau County, Florida. IL: Argonne National Lab.

Vanderholm, D. H. and E.C. Dickey. 1978. ASAE Paper 78-2570. ASAE Winter Meeting, Chicago, IL. ASAE, St. Joseph, MI.

VanRees-Siewert, K.L. and J.J. Dinsmore. 1996. Influence of wetland age on bird use of restored wetlands in Iowa. Wetlands 16(4): 577-582.

Vasquez, M.D., C. Poschemrieder, and J. Barcelo. 1989. Pulvinius structure and leaf abscission in cadmium treated bean plants (Phaseolus vulgaris). Canadian Journal of Botany 67: 2756-2764.

Velde, B. 1995. Composition and mineralogy of clay minerals. In: Velde, B. ed., Origin and Mineralogy of Clays. Springer-Verlag, New York, p. 8-12.

Verhoeven, J.T.A., R.H. Kemmers, and W. Koerselman. 1993. Nutrient enrichment of freshwater wetlands. Pages 33-59 in C.C. Vos and P. Opdam (eds.), Landscape Ecology of Stressed Environments. London: Chapman & Hall.

Vermont Department of Environmental Conservation. 1999. Wetlands Fact Sheet, Topic: Vermont Wetland Rules Summary.

Vivian-Smith, G. 1997. Microtopographic heterogeneity and floristic diversity in experimental wetland communities. Journal of Ecology 85:71-82.

Voesenek, L.A.C.J., F.J.M.M. Van Oorschot, A.J.M. Smits, and C.W.P.M. Blom. 1993. The role of flooding resistance in the establishment of Rumex seedlings in river flood plains. Functional Ecology 7: 105-114.

Voigts, D.K. 1976. Aquatic invertebrate abundance in relation to changing marsh vegetation. The American Midland Naturalist 95:313-323.

Vos, C.C. and A.H.P. Stumpel. 1995. Comparison of habitat-isolation parameters in relation to fragmented distribution patterns in the tree frog (*Hyla arborea*). Landscape Ecology 11(4): 203-214.

Vos, C.C. and J.P. Chardon. 1998. Effects of habitat fragmentation and road density on the distribution pattern of the moor frog (*Rana arvalis*). Journal of Applied Ecology 35: 44-56.

Voss, F., S. Embrey, J. Ebbert, D. Davis, A. Frahm, and G. Perry. 1999. Pesticides detected in urban streams during rainstorms and relations to retail sales of pesticides in King County, Washington. U.S. Geological Survey Fact Sheet 097-99. Tacoma, Washington.

Voss, F.D., S.S. Embrey, J.C. Ebbert, D.A. Davis, A.M. Frahm and G.H. Perry. 1999. Pesticides detected in urban streams during rainstorms and relations to retail sales of pesticides in King County, Washington. U.S. Geological Survey, USGS fact sheet 097-99.

Vought, L.B.M., G. Pinay, A. Fuglsang, and C. Ruffinoni. 1995. Structure and function of buffer strips from a water quality perspective in agricultural landscapes. Landscape and Urban Planning 31: 323-333.

Waalwijk, C., A. Dullemans, G. Wiegers, and P. Smits. 1992. Toxicity of Bacillus thuringiensis variety israelensis against tipulid larvae. Journal of Applied Entomology 114:415-420.

Walbridge, M.R. 1993. Functions and values of forested wetlands in the southern United States. Journal of Forestry 91:15-19.

Waldrop, M.M. 1992. Complexity: the emerging science at the edge of order and chaos. Simon & Schuster, New York, NY.

Wang, S., T.W. Jurik, and A.G. van der Valk. 1994. Effects of sediment load on various stages in the life and death of cattail (*Typha x glauca*). Wetlands 14(3):166-173.

Warnock, N. 1997. Synthesis: Shorebirds in the arid western Great Basin of North America. International Wader Studies 9:80- 81.

Washington State Department of Ecology. 1991. Washington State Wetland Rating System for Eastern Washington. Ecology Publication #91-58. Olympia, WA.

Washington State Department of Ecology. 1993. Washington State Wetland Rating System - Western Washington. Second edition. Ecology Publication #93-74. Olympia, WA.

Washington State Department of Ecology. 1997. Washington State Wetlands Identification and Delineation Manual. Publication #96-94. Olympia, WA.

Washington State Department of Ecology. 2001. Letter regarding isolated wetlands. From Gordon White, Program Manager, Shorelands and Environmental Assistance Program, to All Interested Parties. August 21, 2001.

Washington State Department of Ecology. 2003. Mercury in edible fish tissue and sediments from selected lakes and rivers of Washington State. Publication #03-03-026. available at http://www.ecy.wa.gov/pubs/0303026.pdf

(Washington State Department of Fish and Wildlife 1999a). Washington State Department of Fish and Wildlife 1999. Priority Habitats and Species. Available: http://www.wa.gov/wdfw/hab/phslist.htm. Accessed October 15, 2002.

(Washington State Department of Fish and Wildlife 1999b). Washington State Department of Fish and Wildlife 1999. Warmwater Fish of Washington. Available: http://www.wa.gov/wdfw/outreach/fishing/warmwtr.htm. Accessed: June 2003.

Washington State Department of Wildlife. February 12, 1992. Buffer Needs of Wetland Wildlife. Appendix C. *In:* Castelle, A. J. et al. Wetland Buffers: Use and Effectiveness. Shorelands and Coastal Zone Management Program, Washington State Department of Ecology, Olympia, Publication #92-10.

Washington State Department of Natural Resources. 1998. Our Changing Nature: Natural Resource Trends in Washington State. Olympia, WA.

Washington State Department of Natural Resources. No date. About the Washington Natural Heritage Program. Available: http://www.dnr.wa.gov/nhp/about.html. Accessed: August 2003.

Washington State Department of Transportation. 1999. Mitigation Tools for Special Circumstances: Preservation of High Quality Wetlands. Report. No publication number.

Wassen, M.J., A. Barendreft, M.C. Bootsma, and P.P. Schot. 1989. Groundwater chemistry and vegetation of gradients from rich fen to poor fen in the Naardermeer (the Netherlands). Vegetation 79:117-132.

Wassen, M.J., and A. Barendregt. 1992. Topographic position and water chemistry of fens in a Dutch river plain. Journal of Vegetation Science 3:447-456.

Waters, I. and J.M. Shay. 1990. A field study of the morphometric response of Typha glauca shoots to a water depth gradient. Canadian Journal of Botany 68 (11): 2339-2343.

Waters, I. and J.M. Shay. 1992. Effect of water depth on population parameters of a Typha glauca stand. Canadian Journal of Botany 70(2): 349-351.

WDFW. See Washington State Department of Fish and Wildlife.

Weber, T. and J. Wolf. 2000. Maryland's green infrastructure: Using landscape assessment tools to identify a regional conservation strategy. Environmental Monitoring and Assessment 63: 265-277.

Weems, W.A. and L.W. Canter. 1995. Planning and operational guidelines for mitigation banking for wetland impacts. Environmental Impact Assessment Review 15(3): 197-218.

Weiher, E., C.W. Boylen, and P.A. Buckavekas. 1994. Alterations in aquatic plant community structure following liming of an acidic Adirondack lake. Canadian Journal of Fisheries and Aquatic Sciences 51:20-24.

Weisberg, S.B., A.J. Janick, J. Gerritsen, and H.T. Wilson. 1990. Enhancement of benthic macroinvertebrates by minimum flow from a hydroelectric dam. Regulated Rivers: Research and. Management 5:265-277.

Wellborn, G.A., D.K. Skelly, and E.E. Wemer. 1996. Mechanisms creating community structure across a freshwater habitat gradient. Annual Review of Ecology and Systematics 27:337-363.

Weller, M.W. 1988. Issues and approaches in assessing cumulative impacts on waterbird habitat in wetlands. Environmental Management 12(5): 695-701.

Welsch, D.J. 1991. Riparian forest buffers: Function and design for protection and enhancement of water resources. United States Department of Agriculture Forest Service No. NA-PR-07-91. Radnor, PA. 24 pp.

Welsh, P.G., J.F. Skidmore, D.J. Spry, D.G. Dixon, P.V. Hodson, N.J. Hutchinson, and B.E. Hickie. 1993. Effect of pH and dissolved organic carbon on the toxicity of copper to larval fathead minnow (Pimephales promelas) in natural lake waters of low alkalinity. Canadian Journal of Fisheries and Aquatic Sciences 50:1356-1362.

Wetzel, P.R. and A.G. van der Valk. 1998. Effects of nutrient and soil moisture on competition between Carex stricta, Phalaris arundinacea, and Typha latifolia. Plant Ecology 138: 179-190.

Wetzel, R. 2001. Limnology- Lake and River Ecosystems. Academic Press, San Diego, California.

Whigam, D.F. and T.E. Jordan. 2003. Isolated wetlands and water quality. Wetlands 23:541-549.

Whigham, D.F. 1999. Ecological issues related to wetland preservation, restoration, creation and assessment. Science of the Total Environment 240(1-3): 31-40.

Whigham, D.F., C. Chitterling, and B. Palmer. 1988. Impacts of freshwater wetlands on water quality: A landscape perspective. Environmental Management 12: 663-671.

Whipple, A.M. and W.A. Dunson. 1992. Amelioration of the toxicity of H+ to larval stoneflies by metals found in coal mine effluent. Archives of Environmental Contamimation and Toxicology 24(2):194-200.

White, D.H. and J.T. Seginack. 1994. Dioxins and furans linked to reproductive impairment in Wood Ducks. Journal of the Wildlife Management 58(1):100-106.

White, J.S., S.E. Bayley, and P.J. Curtis. 2000. Sediment storage of phosphorus in a northern prairie wetland receiving municipal and agro-industrial wastewater. Ecological Engineering 14(1-2): 127-138.

Whiteman, H.H., R.D. Howard, and K.A. Whitten. 1995. Effects of pH on embryo tolerance and adult behavior in the tiger salamander, Ambystoma tigrinum tigrinum. Canadian Journal of Zoology 73:1529-1537.

Whittecar, G.R. and W.L. Daniels. 1999. Use of hydrogeomorphic concepts to design created wetlands in southeastern Virginia. Geomorphology 31(1-4): 355-371.

Whittier, T.R., A.T. Herlihy, and S.M. Pierson. 1995. Regional susceptibility of Northeast lakes to zebra mussel invasion. Fisheries 20:20-27.

Wiedemann, A.M. 1984. The ecology of the Pacific Northwest coastal sand dunes: A community profile. U.S. Fish and Wildlife Service FWS/OBS-84/04. 130pp.

Wiggins, G.B., R.J. Mackay, and I.M. Smith. 1980. Evolutionary and ecological strategies of animals in annual temporary pools. Archiv Fur Hydrobiologie 99:206.

Wilcox, D.A. 1995. Wetland and aquatic macrophytes as indicators of anthropogenic hydrologic disturbance. Natural Areas Journal 15(3): 240-248.

Williams, N.E. 1991. Geographical and environmental patterns in caddisfly (Trichoptera) assemblages from coldwater springs in Canada. Pages 107-124 in D.D. Williams and H.V. Danks, Arthropods of Springs, with Particular Reference to Canada. Memoirs of the Entomological Society of Canada. Vol. 155. 217 pp.

Williamson, A.K., M.D. Munn, S.J. Ryker, R.J. Wagner, J.C. Ebert, and A.M. Vanderpool. 1998. Water Quality in the Central Columbia Plateau, Washington and Idaho, 1992-1995. U.S. Geological Survey Circular #1144.

Willis, C. and R.T. Heath. 1993. Effects of phosphate on bacterioplankton growth in Old Woman Creek N.E.R.R. wetland. Ohio Journal of Science 93(2): 44-45.

Wilson, R.F. and W.J. Mitsch. 1996. Functional assessment of five wetlands constructed to mitigate wetland loss in Ohio, USA. Wetlands 16(4): 436-451.

Wilson, S.D. and P.A. Keddy. 1991. Competition, survivorship, and growth in macrophyte communities. Freshwater Biology 25:331-337.

Wind-Mulder, H.L. and D.H. Vitt. 2000. Comparisons of water and peat chemistries of a post-harvested and undisturbed peatland with relevance to restoration. Wetlands 20(4): 616-628.

Winter, T.C. 1983. The interaction of lakes with variably saturated porous media. Water Resources 19: 1203-1218

Winter, T.C. 1986. Effect of groundwater recharge on configuration of the water-table beneath sand dunes and on seepage in lakes in the sandhills of Nebraska. Journal of Hydrology 86:221-237.

Winter, T.C. 1988. Conceptual framework for assessment of cumulative impacts on the hydrology of non-tidal wetlands. Environmental Management 12:605-620.

Winter, T.C. 1989. Hydrologic studies of wetlands in the northern prairie. Pages 16-54 in A. van der Valk (ed.), Northern Prairie Wetlands. Ames, IA: Iowa State University Press.

Winter, T.C. 1992. A physiographic and climatic framework for hydrologic studies of wetlands. Pages 127-148 in R.D. Robarts and M.L. Bothwell (eds.), Aquatic Ecosystems in Semi-Arid Regions: Implications for Resource Management. N.H.R.I Symposium Series 7. Saskatoon, Saskatchewan, Canada: Environment Canada.

Winter, T.C. and J.W. LaBaugh. 2003. Hydrologic considerations in defining isolated wetlands. Wetlands 23:532-540.

Winter, T.C. and M.K. Woo. 1990. Hydrology of lakes and wetlands. Pages 159-187 in M.G. Wolman and H.C. Riggs (eds.), The Geology of North America, Vol 0-1, Surface Water Hydrology. Boulder, CO: Geological Society of America.

Winter, T.C. and D.O. Rosenberry. 1995. The interaction of groundwater with prairie pothole wetlands in the Cottonwood Lake area, east-central North Dakota, 1979-1990. Wetlands 15(3): 193-211.

Wipfli, M.S. and R.W. Merritt. 1994. Effects of Bacillus thuringiensis var. israelensis on nontarget benthic insects through direct and indirect exposure. Journal of the North American Benthological Society 13(2):190-205.

Wisenden, P.A. and R.C. Bailey. 1995. Development of macroinvertebrate community structure associated with zebra mussel (Dreissena polymorpha) colonization of artificial substrates. Canadian Journal of Zoology 73:1438-1443.

Wisheu, I.C. and P.A. Keddy. 1991. Seed banks of a rare wetland plant community: Distribution patterns and effects of human-induced disturbance. Journal of Vegetation Science 2: 181-188.

Wissinger, S.A. 1999. Ecology of wetland invertebrates. Chapter 41 in: Batzer, D.P, R.B. Rader, and S.A. Wissinger (eds) Invertebrates in Freshwater Wetlands of North America. John Wiley & Sons, New York. P. 1043-1075.

Wissinger, S.A., A.J. Bohonak, H.H. Whiteman, and W.S. Brown. 1999. Subalpine wetlands in Colorado: Habitat permanence, salamander predation, and invertebrate communities. In D.P. Batzer, R.B. Rader, and S.A. Wissinger (eds.), Invertebrates in Freshwater Wetlands of North America: Ecology and Management. John Wiley and Sons, Inc.

Wissmar, R.C. and R.L. Beschta. 1998. Restoration and management of riparian ecosystems: A catchment perspective. Freshwater Biology 40(3): 571-585.

Witmer, G.W. and J.C. Lewis. 2001. Introduced wildlife of Oregon and Washington. In D.H. Johnson and T.A. O'Neil (eds.), Wildlife Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press.

Woltemade, C.J. 2000. Ability of restored wetlands to reduce nitrogen and phosphorus concentrations in agricultural drainage water. Journal of Soil and Water Conservation 55: 303-309.

Wong, S. L. and R. H. McCuen. 1982. Design of Vegetative Buffer Strips for Runoff and Sediment Control. Annapolis, MD: Maryland Department of Natural Resources, Coastal Resources Division, Tidewater Administration.

Woodin, M.C. 1994. Use of saltwater and freshwater habitats by wintering redheads in southern Texas. Hydrobiologia 279/280:279-287.

Wren, C.D. and G.L. Stephenson. 1991. Effect of acidification on the accumulation and toxicity of metals to freshwater invertebrates. Environmental Pollution 71(2/4):205-241.

Wright, D.A. and P.M. Welbourn. 1994. Cadmium in the aquatic environment: A review of ecological, physiological, and toxicological effects on biota. Environmental Reviews 2:187-214.

Wyman, R.L. and J. Jancola. 1991. Degree and scale of terrestrial acidification and amphibian community structure. Journal of Herpetology 26(4):392-401.

Xu, L., J.W. Gilliam, and R.B. Daniels. 1992. Nitrate movement and loss in riparian buffer areas. P. 342. *In* Agronomy abstracts. ASA, Madison, WI.

Yocom, T.G., R.A. Leidy, and C.A. Morris. 1989. Wetlands protection through impact avoidance: A discussion of the 404(b)(1) alternatives analysis. Wetlands 9(2): 283-297.

Young, R.A., T. Huntrods, and W. Anderson. 1980. Effectiveness of vegetated buffer strips in controlling pollution from feedlot runoff. Journal of Environmental Quality 9:483-497.

Zedler, J.B. 2000. Progress in wetland restoration ecology. Trends in Ecology and Evolution 15(10): 402-407.

Zedler, J.B. and J.C. Callaway. 1999. Tracking wetland restoration: Do mitigation sites follow desired trajectories? Restoration Ecology 7:69-73.

Zedler, J.B. and J.C. Callaway. 2000. Evaluating the progress of engineered tidal wetlands. Ecological Engineering 15: 211-225.

Zedler, P.H. 1987. The Ecology of Southern California Vernal Pools: A Community Profile. U.S. Fish and Wildlife Service Biology Report 85 (7.11).

Ziemer, Robert R. and Thomas E. Lisle. 1998. Chapter 3. Hydrology. Pages 43-68, in: Naiman, Robert J., and Robert E. Bilby, eds. River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, N.Y.

Zilberman, D. 1991. Preliminary assessment of the effects of selenium in agricultural drainage on fish in the San Joaquin Valley. Pages 369-385 in: Dinar, A. and D. Zilberman (eds) The Economics and Management of Water and Drainage in Agriculture. Kluwer Academic Publishers, Amsterdam.

Glossary

Terms defined in the context of the sentence in which they appear in this document may not be included in the glossary.

Adventitious roots. Additional roots that develop in some plants, such as willows and alders, as an adaptation to saturated or flooded conditions.

Aquatic resources (systems). Refers to ecological systems where the regular or occasional presence of water is the dominant factor determining the characteristics of the site. Aquatic systems are made up of wetlands, rivers, streams, lakes and other deepwater habitats.

Assessment methods. Methods that generate a number representing an estimate of the performance of a wetland function. The number generated is relative to a predetermined standard (e.g., level of function provided by reference wetlands). Numbers do not reflect an actual level of function performance (Hruby 1999). Examples include the Washington State Methods for Assessing Wetland Functions (WFAM) (Hruby et al. 1999 and 2000) and the HGM approach to wetland function assessment (Brinson et al. 1995).

Biological wetland. A biological wetland is a wetland that meets the three parameter criteria of either the 1987 Corps of Engineers Delineation Manual or the 1997 Washington State Wetlands Identification and Delineation Manual (WAC 173-22-035). Compare to jurisdictional wetland.

Bog. A unique type of wetland dominated by mosses that form organic peat. Bogs form in areas where the climate allows the accumulation of peat to exceed its decomposition. Bog hydrology is dominated by precipitation rather than surface inflow. The plant community is specialized to survive in the nutrient-poor and highly acidic conditions typical of bog systems.

Buffers or buffer areas. Vegetated areas adjacent to wetlands, or other aquatic resources, that can reduce impacts from adjacent land uses through various physical, chemical, and/or biological processes.

Canopy cover. The degree to which the foliage of the highest vegetation layer in a plant community blocks sunlight or obscures the sky.

Class. A grouping based on shared characteristics in a classification scheme. In the Cowardin et al. (1979) classification of wetlands a class is the third level in the 'taxonomy' of wetlands whereas in the Hydrogeomorphic Classification (Brinson 1993) it is the highest taxonomic unit.

Compensatory mitigation. The compensation stage of the mitigation sequence where impacts to the functions and values of wetlands are replaced through creation, restoration, or enhancement of other wetlands. Because regulatory requirements and policies tend to focus on the compensation stage, the term "mitigation" is often used to refer to compensation, which is just one part of the overall mitigation sequence. See *mitigation.*

Conductivity. A measure of the amount of dissolved constituents (ions) in water, based on the water's ability to conduct electricity. See *specific conductance*.

Connectivity. The structures on the landscape that facilitate movement of living organisms between patches or their habitat that are found across the landscape. The movement can occur either within the lifetime of an organism or over a period of generations. The purpose of facilitating movement is to maintain viable populations that allow species and communities of species to persist in time. Connectivity can be achieved via a continuous and linear habitat feature (as in a corridor) or discrete habitat patches comprised of but not limited to individual forests, wetlands, shrub lands, and shorelines.

Conservation easement. A restriction placed on a piece of property to protect the resources (natural or man-made) associated with the parcel. It restricts the type and amount of development that can take place on a parcel of land. For example, the landowner may sell or donate the development rights while retaining the ownership of the property. Easements are recorded on the property deed and are held in trust by a conservation easement "holder" such as a land trust or government agency. The holder polices the terms of the easement for the duration of its existence, which is usually into perpetuity.

Contingency plan. A plan outlining actions that would be triggered if monitoring of a project revealed a problem that would prevent the site from attaining its stated goals, objectives, and performance standards. Contingency plans should identify anticipated problems and the specific maintenance activity that would be implemented to rectify each problem.

Contributing basin. The geographic area from which surface water drains to a particular wetland.

Corixids. A group of aquatic insects commonly called "water boatmen."

Corridor: Corridors are areas that contain relatively undisturbed habitat and/or vegetation that maintain connections for wildlife throughout the landscape. Corridors usually represent linear habitats with the range of environmental functions necessary to permit the movement of animals between larger and more fully functioning habitats. Corridors can include but are not limited to, annual or seasonal migration corridors that connect wintering and breeding habitat, or intra-seasonal corridors that connect foraging and nesting habitat or breeding and dispersal habitat.

Cowardin classification. The first commonly used classification system for wetlands developed in 1979 by the U.S. Fish and Wildlife Service. The Cowardin system classifies wetlands based on water flow, substrate types, vegetation types, and dominant plant species.

Cumulative impacts. The incremental effect of an impact added to other past, present, and reasonably foreseeable future impacts.

Deed restriction (definition from legal dictionary). Clauses in a deed limiting the future uses of the property. Deed restrictions may impose a vast variety of limitations and conditions, for example, they may limit the density of buildings, dictate the types of structures that can be erected or prevent buildings from being used for specific purposes or even from being used at all.

Depressional wetland. A *class* of wetlands in the *hydrogeomorphic classification*. These are wetlands that occur in topographic depressions that exhibit closed contour interval(s) on three sides and elevations that are lower than the surrounding landscape.

Dioxin. A group of several hundred chemical compounds that share certain chemical structures and biological characteristics. They include the chlorinated dibenzo-*p*-dioxins (CDDs), chlorinated dibenzofurans (CDFs), and some polychlorinated biphenyls (PCBs). The term dioxin is also used to refer to a well-studied and toxic dioxin, 2, 3, 7, 8-tetrachlorodibenzo-*p*-dioxin (TCDD).

Disturbance. An event that disrupts the processes or structure of ecological systems. Disturbances may occur naturally (e.g., wildfires, storms, floods) or be caused by human actions (e.g., clearing land, building roads, altering stream channels). The effects of disturbances on ecological systems are controlled in large part by their intensity, duration, frequency, timing, and size and shape of area affected.

Ditch. Any channel that has been specifically dug to facilitate drainage.

Drainage systems. Often called basins, sub-basins, watersheds, or river basins depending on the size of the area. In this document, drainage systems are generally referred to using one of two terms: 1. *Watershed.* A geographic area of land bounded by topographic high points in which water drains to a common destination; and 2. *Contributing basin.* A geographic area from which surface water drains to a particular wetland.

Drawdown. A lowering of the ground-water surface caused by pumping.

Dytiscids. Predaceous diving beetles.

Ecoregion. Geographic regions where climatic conditions are similar and the ecosystems (including wetlands) are relatively homogeneous. Omernik and Gallant (1986) mapped the following ecoregions in Washington: Coast Range, Puget Lowland, Cascades, Eastern Cascades Slopes and Foothills, North Cascades, Columbia Plateau, Blue Mountains, and Northern Rockies.

Ecosystem. A loosely defined assemblage of co-occurring organisms and the geographic location which they inhabit. The term is an operational convenience defined by the user of the term for the convenience of description (Levin 2001). There is no basic geographic scale associated with the term ecosystem, and that also has to be defined by a user. For example, the term can be used to describe the micro-organisms co-occurring in a spoonful of soil (soil ecosystem) at one end of the scale to the ecosystem of the world that encompasses all organisms on the planet.

Ecotone. An area that is transitional between two different types of ecosystems and has some of the features of both. Wetlands are often characterized as being ecotones between aquatic and terrestrial ecosystems.

Edge. The boundary where habitats meet or where successional stages of plant communities come together.

Emergence trap. A device placed over the water or sediment in a wetland to capture flying aquatic insects as they emerge from their non-flying larval state into their winged adult form.

Environmental processes. The same as *landscape processes*.

Eutrophication. The undesirable overgrowth of vegetation caused by high concentrations of plant nutrients in bodies of water, especially nitrogen and phosphorous, often as a result of human activities.

Evapotranspiration. The combination of water that is evaporated from the surface and that is transpired from the leaves of plants as part of their metabolic process.

Fen. A type of wetland that is similar to a bog, containing accumulated peat. Fens support marsh-like vegetation including sedges and wildflowers. Fens differ from bogs in their plant communities, hydrology, and water chemistry. They are fed by groundwater and are not as acidic as bogs.

Flats. A class of wetlands in the *hydrogeomorphic classification*. These are wetlands that occur in topographically flat areas that are hydrologically isolated from surrounding ground or surface water. They are primarily maintained by precipitation.

Forb. Any herbaceous plant that is not a grass or sedge.

Forested wetland. A wetland *class* in the Cowardin classification where woody plants taller than 20 feet form the dominant cover. Shrubs often form a second layer beneath the forest canopy, with a layer of herbaceous plants growing beneath the shrubs.

Fragmentation. The breaking up of ecosystems into patches of habitat that are separated by areas altered by human land uses. Fragmentation always consists of both the reduction in the area of the original habitat and a change in spatial configuration of what remains.

Functions. The physical, biological, chemical, and geologic interactions among different components of the environment. See *wetland functions*.

Functional feeding group. A group of animals (aquatic insects, birds, etc) that feed in a similar way. For example, insects that scrape algae from rocks in a stream are called scrapers; those that shred leaf material are caked shredders; and those that filter small particles from the water column are filter feeders.

Furans. A chemical substance resulting from the manufacture of organic compounds, such as nylon.

Geomorphic setting. The topographic location of a site within the surrounding landscape and the geology that underlies it.

Geomorphology. The geologic composition and structure of a landscape—its topography, landforms, soils, and geology.

Hemipterans. A group of insects with straw-like, sucking mouth parts.

Herbaceous (stratum). A layer of non-woody vegetation, usually less than 6 feet (2 m) tall.

Hertz (Hz). A unit of frequency equal to one cycle per second.

Humic. Of or pertaining to humus, which consists of partially or wholly decayed plant matter.

Hydrodynamics. Refers to the movement of water and its capacity to do work. There are three qualitative categories of hydrodynamics: (1) vertical fluctuations of the water levels or water table, (2) unidirectional surface or near-surface flows that range from strong currents contained in channels to slow sheet flow down a slope, and (3) bidirectional flows resulting from tides or wind-driven currents in lakes.

Hydrogeomorphic (HGM) classification. A system used to classify wetlands based on the position of the wetland in the landscape (geomorphic setting), the water source for the wetland, and the flow and fluctuation of the water once in the wetland.

Hydroperiod. The pattern of water level fluctuations in a wetland. Includes the depth, frequency, duration, and timing of inundation or flooding. Patterns can be daily, monthly, seasonal, annual, or longer term.

Impact. Changes to the environment that are caused by human disturbances. Impacts can be either beneficial or detrimental to the ecosystem, environmental process, or species.

Interior (species). Animal species that require the conditions found on the interior of a habitat type and which are subject to disturbance in areas toward the edges of that habitat. For example, forest interior birds find optimum conditions within the center of a forested area where they are not subject to domestic pets, noise, severe weather, or other disturbances that penetrate the outer forest edge.

Jurisdictional wetland. A wetland that is regulated by the provisions of the law under the jurisdiction of one or more federal, state, or local agencies. Not all areas of the landscape that have the biological characteristics of wetlands are regulated or jurisdictional wetlands.

Lacustrine. Pertaining to lakes or lake shores.

Lacustrine (lake) fringe wetlands. A wetland *class* under the *hydrogeomorphic classification*. These are wetlands that occur at the margins of topographic depressions in which surface water is greater than 8 hectares (20 acres) and greater than 2 meters deep in western Washington and 3 meters in eastern Washington.

Landscape processes. Environmental factors that occur at larger geographic scales such as basins, sub-basins, and watersheds. Processes are dynamic and usually represent the movement of a basic environmental characteristic such as water, sediment, nutrients and chemicals, energy, or animals and plants. The interaction of landscape processes with the physical environment creates specific geographic locations where groundwater is recharged, flood waters are stored, stream water is oxygenated, pollutants are removed, and wetlands are created.

Landscape scale. The geographic scale that encompasses the broader landscape (i.e., large areas such as basins, sub-basins, watersheds, and habitat corridors). Also see *site scale* and *large scale*.

Large scale. Large in scope. This term is used specifically to indicate geographic areas that extend beyond the boundaries of an individual site, wetland, or resource. Please note that this term has the opposite meaning when it is used in cartography. Large scale maps are ones that cover a smaller geographic area than a small scale map.

Large woody debris (LWD). Large pieces of downed wood, such as logs, rootwads, and limbs, that are in or near a body of water. LWD provides habitat structure for fish and other aquatic organisms.

Lentic. Having slow moving or still water, such as a pond or lake (as compared to lotic – having running water, such as a river or stream).

Metapopulation. A group of local populations between which individuals can migrate.

Microbe. A microscopic organism, such as a bacterium.

Microhm. A unit of measure describing the resistance of a substance to electrical current.

MilliSiemens. A unit of measure for conductivity. See *specific conductance*.

Mitigation (or mitigation sequencing). Mitigation is a series of actions that requires addressing each action, or step, in a particular order. This sequence of steps is used to reduce the severity of negative impacts from activities that potentially affect wetlands. Mitigation involves the following: 1. Avoiding the impact altogether by not taking a certain action or parts of an action; 2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps, such as project redesign, relocation, or timing, to avoid or reduce impacts; 3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment; 4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; 5. Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and 6. Monitoring the required compensation and taking remedial action when necessary (WAC 197.11.768). See *compensatory mitigation*.

Natural Heritage (Wetlands) (as defined by the Natural Heritage Program of the Washington State Department of Natural Resources). Wetlands that are either high quality undisturbed wetlands or wetlands that support threatened, endangered, or sensitive plant species.

Niche. The area within a habitat occupied by an organism; the set of functional relationships of an organism or population to the environment it occupies.

PCBs. Polychlorinated biphenyls, a type of toxic chemical compound once widely used in electrical equipment. See *dioxin*.

Phreatic zone. The area above the groundwater table.

Redox (potential). Reduction-oxidation potential, or a measure of the potential movement of electrons in a system. Reduction refers to the chemical process whereby molecules of a substance gain an electron. Oxidation refers to loss of electrons. Measuring the redox potential of a wetland soil provides information about the types of chemical reactions that are occurring in the soil, and thus whether the soil is more aerobic (contains oxygen) or anaerobic (lacks oxygen).

Richness. The number of different species of organisms present in a community.

Riparian. The strip of land adjacent to a body of water that is transitional between the aquatic system and the upland. Some riparian areas contain wetlands.

Riverine wetlands. A *class* of wetlands in the *hydrogeomorphic classification*. Wetlands that occur in floodplains and riparian corridors in association with stream or river channels where there is frequent overbank flooding.

Rotifers. Minute organisms that live in fresh and salt water. A crown of hair-like structures (cilia) propels them through the water.

Roughness. The amount of friction or resistance a surface provides against water flow. For example, an area containing shrubs and downed branches has greater roughness than a mowed lawn.

Site processes. Environmental factors that occur within the wetland itself or within its buffer. The interactions of site processes with landscape processes define how a wetland functions.

Site scale. The geographic scale that encompasses the area within the boundary of a single wetland and its immediate surroundings. Also see *landscape scale*.

Slope wetlands. A *class* of wetlands in the *hydrogeomorphic classification***.** These are wetlands that occur on the slopes of hills or valleys. The principal water source is usually seepage from groundwater.

Specific conductance. A measure of electrical conductivity standardized to 25^{o}C. Use of specific conductance accounts for the fact that the conductivity of water changes as its temperature changes. It is measured in units of milliSiemens per centimeter.

Sub-basin. A smaller drainage basin that is part of a larger drainage basin or watershed. For example, the watershed of a large river may be composed of several sub-basins, one for each of the river's tributaries.

Temporal loss (of functions). The concept that there is a time lag between the loss of existing wetland functions through human or natural disturbance and the reestablishment of functions over time.

Tidal Fringe wetlands. A *class* of wetlands in the *hydrogeomorphic classification*. Wetlands that occur on continental margins where marine waters are greater than 2 meters deep and more than 8 hectares (20 acres) in size.

Trophic level. A concept used to describe feeding levels in a foodweb. Plants fill the first trophic level by utilizing sunlight to create carbohydrates and other compounds. Plants are consumed by plant-eating animals (herbivores) in the second trophic level, which in turn become food for predators in the next trophic level, and so on.

Values. See *wetland values***.**

Watershed. A geographic area of land bounded by topographic high points in which water drains to a common destination.

Wetland functions. The physical, biological, chemical, and geologic interactions among different components of the environment that occur within a wetland. Wetlands perform many valuable functions and these can be grouped into three categories: functions that improve water quality, functions that change the water regime in a watershed such as flood storage, and functions that provide habitat for plants and animals.

Wetland rating. Also called a wetland rating system. is a tool for dividing or grouping wetlands into groups that have similar needs for protection. One method used in Washington is the Washington State wetland rating systems (Hruby 2004a,b), which places wetlands in categories based on their rarity, sensitivity, our inability to replace them, and their functions.

Wetland Values. Wetland processes, characteristics, or attributes that are considered to benefit society.

Appendix 1-A
Team Guiding Production of Volume 1

An interagency team (the Core Team) guided all aspects of and participated in the search and reading of the scientific literature, wrote the synthesis, and produced Volume 1. Additional members were added during the production of Volume 2 (see Volume 2).

For Volume 1, the team consisted of staff from the Washington State Department of Ecology, the Washington State Department of Fish and Wildlife, the U.S. Environmental Protection Agency, and Sheldon and Associates, the consulting firm hired to assist with production. Additional Ecology staff served as authors (see the list of authors on the title page of this document). The editor was included on the Core Team in the later stages of production of draft of Volume 1 and was involved through the development of the review draft of Volume 2.

The Core Team included the following individuals (alphabetical by last name):

Teri Granger	Washington State Department of Ecology (coordinator)
Kim Harper	Sheldon and Associates[1]
Tom Hruby	Washington State Department of Ecology
Katherine March	Washington State Department of Fish and Wildlife
Andy McMillan	Washington State Department of Ecology
Sara Noland	2N Publications (editor of the draft)
Ralph Rogers	U.S. Environmental Protection Agency
Dyanne Sheldon	Sheldon and Associates
Erik Stockdale	Washington State Department of Ecology

[1] Currently with the Washington State Department of Ecology.

Appendix 1-B

Characteristics of a Valid Scientific Process

The characteristics of a valid scientific process in the context of "best available science" are defined below, as quoted directly from WAC 365-195-905:

1. ***Peer review.*** *The information has been critically reviewed by other persons who are qualified scientific experts in that scientific discipline. The criticism of the peer reviewers has been addressed by the proponents of the information. Publication in a refereed scientific journal usually indicates that the information has been appropriately peer-reviewed.*

2. ***Methods.*** *The methods that were used to obtain the information are clearly stated and able to be replicated. The methods are standardized in the pertinent scientific discipline or, if not, the methods have been appropriately peer-reviewed to assure their reliability and validity.*

3. ***Logical conclusions and reasonable inferences.*** *The conclusions presented are based on reasonable assumptions supported by other studies and consistent with the general theory underlying the assumptions. The conclusions are logically and reasonably derived from the assumptions and supported by the data presented. Any gaps in information and inconsistencies with other pertinent scientific information are adequately explained.*

4. ***Quantitative analysis.*** *The data have been analyzed using appropriate statistical or quantitative methods.*

5. ***Context.*** *The information is placed in proper context. The assumptions, analytical techniques, data, and conclusions are appropriately framed with respect to the prevailing body of pertinent scientific knowledge.*

6. ***References.*** *The assumptions, analytical techniques, and conclusions are well referenced with citations to relevant, credible literature and other pertinent existing information.*

Information derived from one of these sources can be considered scientific information if it possesses the required characteristics shown in Table 1B-1.

Table 1B-1. Source and characteristics of scientific information.

Sources of Scientific Information	Characteristics					
	Peer Review	**Methods**	**Logical Conclusions & Reasonable Inferences**	**Quantitative Analysis**	**Context**	**References**
A. **Research**. Research data collected and analyzed as part of a controlled experiment (or other appropriate method) to test a specific hypothesis.	X	X	X	X	X	X
B. **Monitoring**. Monitoring data collected periodically over time to determine a resource trend or evaluate a management program.	NA	X	X	Y	X	X
C. **Inventory**. Inventory data collected from an entire population or population segment (e.g., individuals in a plant or animal species) or an entire ecosystem or ecosystem segment (e.g., the species in a particular wetland).	NA	X	X	Y	X	X
D. **Survey**. Survey data collected from a statistical sample from a population or ecosystem.	NA	X	X	Y	X	X
E. **Modeling**. Mathematical or symbolic simulation or representation of a natural system. Models generally are used to understand and explain occurrences that cannot be directly observed.	X	X	X	X	X	X
F. **Assessment**. Inspection and evaluation of site-specific information by a qualified scientific expert. An assessment may or may not involve collection of new data.	NA	X	X	NA	X	X
G. **Synthesis**. A comprehensive review and explanation of pertinent literature and other relevant existing knowledge by a qualified scientific expert.	X	X	X	NA	X	X
H. **Expert Opinion**. Statement of a qualified scientific expert based on his or her best professional judgment and experience in the pertinent scientific discipline. The opinion may or may not be based on site-specific information.	NA	NA	X	NA	X	X

X = Characteristic must be present for information derived to be considered scientifically valid and reliable.
Y = Presence of characteristic strengthens scientific validity and reliability of information derived, but is not essential to ensure scientific validity and reliability.
NA = The characteristic does not apply to the source type. For example, monitoring data are not typically peer reviewed.

Appendix 1-C

Methods Used for Searching and Reviewing the Literature

Searching the Literature

To begin the literature review for Volume 1, personal bibliographies were solicited from a small number of professionals known to have extensive libraries on wetlands in the Pacific Northwest. Other published reference lists were reviewed for relevant documents. In addition to the specified reference lists, computer searches were conducted of databases that are publicly available using a variety of keywords. Table 1C-1 lists the sources of reference lists and the names of the databases searched, as well as the approximate number of documents contained in each source.

Table 1C-2 lists the keywords that were used in the searches of computer databases. This list was developed by the Core Team and expanded based on comments from focus groups (see Chapter 1 for information on focus groups). The searches were done combining the word "wetland" plus one of the keywords. The words in the last column were used to exclude wetland types not covered by this report. Specific wetland types not found in Washington and known to be very dissimilar from Washington wetlands were also excluded, as were estuarine and marine wetlands. Lists resulting from the searches of the computer databases were compiled into a ProCite® database for the project.

Table 1C-1. Summary of reference lists and databases searched for Volume 1.

List Source	Approx. No. of Documents	Notes
Personal Bibliographies		
Dr. Paul Adamus, EPA	1,600	Broad range of documents
Dr. Tom Hruby, WA Ecology	600	Broad range of documents, many focus on wetland functions
Mary Kentula, EPA	170	Focus on wetland mitigation, management, policy effectiveness
Dr. Klaus Richter, King County	3,500	Focus on amphibians w/Pacific NW emphasis
Published Reference Lists		
Management recommendations for WA priority habitats: freshwater wetlands and fresh deepwater (Morgan 1998)	640	Focus on wildlife and aquatic habitats
Management recommendations for WA priority habitats: riparian (Knutson and Naef 1997)	550	Focus on riparian habitats, not necessarily wetlands
Managing for enhancement of riparian and wetland areas of the Western U.S.: an annotated bibliography (Koehler and Thomas 2000)	1,900	Broad application to western U.S.; many documents not relevant to Pac. NW
Classification and management of aquatic, riparian and wetland sites on the national forests of Eastern Washington (Kovalchik 2004)	400	Focus on eastside and forested areas
Effects of urbanization on pond-breeding amphibians: an annotated literature review (Ostergaard 2000)	100	Focus on amphibians and urban effects
Database Searches		
Keyword searches of various databases	9,800	Databases searched included Ovid, ProQuest, Biosis, Dissertation Abstracts, Agricola, Current Contents, Biological Abstracts
Total	**~17,860**	**Total includes an unknown number of duplicates among the various sources**

Table 1C-2. Keywords used in searching computer databases of literature.

Base Word	Keywords		Exclusions
Wetland	Aesthetics Agriculture Alkali Alluvial Amphibians Aquifer Recharge Arid Land Artesian Birds Bog Buffers Compensation Conservation Cumulative Impacts Development Disturbed Dynamic Economics Enhancement Erosion Farmed Fen Fish Floodplain Fluvial Functions Geology Geomorphology Grazing Groundwater Habitat Hydraulic Hydric Hydrology Hyporheic Industrial Inventory Invertebrates Irrigation Isolated	Land Use Landscape Maintenance Mammals Mapping Mining Mitigation Mollusks Monitoring Nutrients Perched Policy Public Access Recreation Regulation Reptiles Residential Restoration River Rural Seasonal Septic Slope Soils Spatial Stewardship Stormwater Transportation Corridors Urban Utility Corridors Values Variation Vegetation Types Vernal Pools (not Calif.) Water Quality Water Regime Wells Wildlife	Bottomland Hardwood California Vernal Pools Estuarine Intertidal Lacustrine Marine Mississippi Floodplain Mudflats Salt Marsh Saltwater

Reviewing, Sorting, and Prioritizing the Reference Lists

All reference lists were reviewed by one or more of the Core Team members. From these lists, the Core Team selected those documents that were determined to be relevant to the project, based solely on the title of the article and its date. Those marked documents were then prioritized using a two-tiered system in which those considered most critical to the project were designated as those to be obtained first. Eventually, attempts were made

to obtain all the documents on the lists that were believed to be relevant based on their titles. In addition, references were found while individual authors searched for subjects for which information was lacking. These references are provided in the list of references cited in the report.

Criteria Used to Identify Articles Relevant to the Project

When screening lists of articles, the Core Team used the following criteria to determine, through reading the title and looking at the date, which were relevant to the project and should be obtained. Those that were deemed a "definite yes" were those that were:

- Related to wetland protection and management
- Applied to Washington or the Pacific Northwest
- Were out of region but dealt with land uses
- The only paper on a subject

Those that were rejected out-right were those that were:

- Very old and superceded by newer information
- Related to estuarine and marine systems, which were not going to be covered in the document
- Primarily scientific minutia that weren't useful to managing and protecting wetlands
- Not related because of region
- Related to wetlands and waste-water treatment, which was not going to be covered in the document

Obtaining & Reading Documents & Writing the Report

Of the more than 17,000 documents on all lists used, copies of over 1,400 documents were obtained after review of the titles and dates, as prioritized using the screening process described above. References were skimmed and those dealing with Washington or the Pacific Northwest and with practical application to the protection and management of wetlands were prioritized for reading.

Each reader summarized the article in the ProCite® database. Searches of the database or the original articles were used by each author to write their portions of the draft document. Additional articles were discovered during the course of writing the draft document. These references were not included in the ProCite® database.

The documents used to write the synthesis included scientific journal articles, government publications, technical books, and other sources, all of which meet the definition and characteristics of BAS in WAC 365-195-905 (see Appendix 1-B and Chapter 1). Conference proceedings and personal communications were occasionally used when no other information was available. In most cases, we were unable to ascertain to what level these additional sources were peer reviewed.

For the most part, available documents from the past ten years were used as the primary sources for this report. It was assumed that this more recent literature would incorporate relevant science from the preceding years. Older documents were used in instances where they had not been superseded by more recent studies.

In a few instances, we used unpublished data collected during the calibration of the Washington State wetland function assessment methods and the Washington State wetland rating systems. These data have not been published in scientific journals. However, these observations reported as "unpublished data" in Volume 1, were collected in the field by interdisciplinary teams of wetland experts and used to support and calibrate the assessment methods and the wetland rating system. The methods and rating system have been extensively reviewed and field tested by peer experts, as well as the public. The data were offered for review upon request during public review and continue to be available on request. See Chapter 1 for discussion of the occasional use of hypotheses and assumptions made by the authors based on the literature or their professional experience.

Obtaining References Suggested by Reviewers

A questionnaire was circulated with the review draft of the document. The draft of Volume 1 was reviewed by peer experts. In addition, we invited anyone who so desired to review it. Reviewers were asked to provide additional references that we may have missed, for topics for which we lacked information, or to support suggested changes to the document. Many references were provided and a screening process was used to prioritize and obtain references. See the document containing our responses to comments for a table listing the references that were suggested, the references which were obtained, and notes of explanation for each reference suggested. (The Comments and Responses for Volume 1 can be found at http://www.ecy.wa.gov/biblio/0506007.html.)

Establishing a Repository

The ProCite® database is not available for general use because of technical reasons and the time and money required in making it accessible to a wide variety of users and their varied software programs. However, paper copies of many of the articles reviewed for the synthesis of the science are being held in an archive at the Washington State Department of Ecology. The archive is accessible to the public by appointment.

A number of theses, dissertations, and books are not included in the archive, as well as some articles in private libraries, due to copyright laws and the limited options for purchasing some documents. In these cases, borrowed copies were used and returned, with only the title pages and tables of contents copied for the archive.

Appendix 1-D

Reviewers of Volume 1

Name of Individual or Organization	Affiliation at the Time of Review (if individual)
Paul Adamus, PhD	Private Consultant
Jeff Azerrad, Wildlife Biologist	WA State Department of Fish and Wildlife
Joann Bartlett, PWS	Wiltermood Associates
Doug Beyerlein, PE	Aqua Terra Consultants
Elizabeth Binney, PhD, PWS	ATSI
Catherine Conolly, PWS and Teresa H. Vanderburg, PWS (submitted comments jointly)	Adolfson Associates
Brent Davis, Wetland Biologist	Clark County Community Development Department
Tim Determan, Puget Sound Ambient Monitoring Program Coordinator	WA State Department of Health
Donald F. Flora	Private citizen
Richard R. Horner, PhD	University of Washington
Richard Jack	WA State Department of Ecology
Jim Kelley, PhD	Parametrix, Inc.
Bernard L (Bud) Kovalchik, retired U.S. Forest Service -- Eastern Washington Area Ecologist	Kovalchik Riparian Wetland Consulting
Ivan Lines, Regional Biologist	Ducks Unlimited, Inc.
Scott Luchessa, Certified Ecologist, MS.	Ecological Solutions, Inc.
Chris L. McAuliffe, Ecologist	Private citizen, retired from the Seattle District of the Army Corps of Engineers
Elliot Menashe, Environmental Consultant	Greenbelt Consulting
Jeff Meyer, PWS	Parametrix, Inc.
Jim Mitchell, PE, PWS	Mitchell Consultants L.L.C.
Lyn Morgan-Hill, Natural Resources Specialist	Whatcom County Planning and Development
Francis Naglich	Ecological Land Services, Inc.
Scott Williams, Land Planner	Puget Sound Energy
Klaus Richter, PhD, PWS	King County Department of Natural Resources
Scott J. Rozenbaum, PWS, Certified Professional Soil Scientist	Rozewood Environmental Services, Inc.
Todd Thompson, Fish & Wildlife Program Lead	Spokane District Bureau of Land Mngmt
WETNET (Audubon) Science Committee	
Megan White	WA State Department of Transportation
Bob Zeigler	WA State Department of Fish and Wildlife
Unidentified Individual	

Appendix 2-A

Methods for Organizing and Grouping Information about Wetlands

The following information is adapted from Hruby (1999).

Many groups including federal and state agencies have been developing techniques for analyzing wetland functions ever since wetlands were first subject to regulation in the 1970s. The motivation for developing such methods has primarily been the need to predict the effects of alterations to wetlands and set appropriate requirements for compensatory mitigation.

Methods for organizing knowledge about wetlands have been called classifications, categorizations, characterizations, ratings, assessments, and evaluations. These groupings are meant to indicate the type of information a method provides. Unfortunately, the scientific community has been sloppy in the use of these terms to the extent of misnaming many of the analytical tools developed. Users of methods developed for analyzing wetlands should be aware of some of these problems with definitions. Standard definitions for analytical methods based on Webster's Seventh New Collegiate Dictionary (1963) are described below.

Classification/categorization—a systematic grouping into categories according to established criteria or shared characteristics. The two most common wetland classifications are those of Cowardin et al. (1979), which is based on shared characteristics of vegetation and water regime, and the hydrogeomorphic classification (Brinson 1993b), which is based on shared characteristics of geomorphic setting and water regime. The criteria used for grouping are generally not linked to specific functions, and thus classifications are not true methods for assessing functions. They can, however, provide a basis on which to develop assessment methods (Brinson 1995).

Characterization—a grouping by a distinguishing trait, quality, or property. For example, the Oregon method (Roth et al. 1993) characterizes wetlands by the properties: "provides" a specific function; "has the potential to provide" a function; or "does not provide" a function. These are three distinct attributes that give some information about whether a wetland performs a function, but no information is generated about levels of performance. The Washington State wetland rating systems are characterizations based on five properties (sensitivity to disturbance, rarity, importance, ability to replicate, and relative level of functioning) (Hruby 2004a, b).

Rating—classification based on a grade. Ratings usually group wetlands using the qualitative grades of high, medium, or low on a variety of scales such as the performance of a function or its value. The wetland evaluation technique or WET (Adamus et al. 1987) is probably the most widely used rating method.

Assessment—an estimate or determination of importance or value. This is the first level at which numbers are generated to represent an estimate of performance or value of a function. All commonly used "rapid" numeric methods fall into this category. These methods only provide an assessment that is relative to some predetermined standard. They do not provide an assessment of actual levels of performance or value. The term *assessment* is one of the most commonly misused words in the lexicon of wetland scientists. Almost any method developed is now called an assessment, regardless of whether it might actually be a categorization, a rating, or a true assessment.

Evaluation—a determination or fixing of value. The fixing of value for any item is based on having a generally acceptable currency. Up to now the only currency used has been monetary, and evaluations of wetland functions have most often tried to generate dollar values based on different types of economic models such as the travel cost method, random utility model, hedonic techniques, contingent valuation method (Titre and Henderson 1989, Lipton et al. 1995), or willingness-to-pay method (Farber and Costanza 1987).

References Cited

Adamus, P.R., E.J. Clairain, Jr., R.D. Smith, and R.E. Young. 1987. Wetland Evaluation Technique (WET) Volume II: Methodology. NTIS No. ADA 189968. Vicksburg, MS: U.S. Army Corps of Engineers Waterways Experiment Station.

Brinson, M.M. 1993b. Hydrogeomorphic Classification for Wetlands. Technical Report WRP-DE-4. U.S. Army Corps of Engineers Waterways Experiment Station.

Brinson, M.M. 1995. The HGM approach explained. National Wetland Newsletter Nov-Dec. 1995:7-13.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Washington, DC: U.S. Fish and Wildlife Service.

Farber, S., and R. Costanza. 1987. The economic value of wetland systems. Journal of Environmental Management 24:41-51.

Hruby, T. 1999. Assessments of wetland functions: What they are and what they are not. Environmental Management 23:75-85.

Hruby, T. 2004a. Washington State Wetland Rating System for Eastern Washington – Revised. Washington State Department of Ecology Publication #04-06-015. Olympia, WA.

Hruby, T. 2004b. Washington State Wetland Rating System for Western Washington – Revised. Washington State Department of Ecology Publication #04-06-025. Olympia, WA.

Lipton, D.W., K. Wellman, I.C. Sheifer, and R.F. Weiher. 1995. Economic Valuation of Natural Resources: A Handbook for Coastal Resource Policymakers. NOAA Coastal Ocean Program Decision Analysis Series No. 5. Silver Springs, MD: NOAA Coastal Ocean Office.

Roth, E.M., R.D. Olsen, P.L. Snow, R.R. Sumner and S.G. McCannel. 1993. Oregon Freshwater Wetland Assessment Methodology. Salem, OR: Oregon Division of State Lands.

Titre, J.P. and J.E. Henderson. 1989. Summary of Valuation Methods for Wetlands. Environmental Effects of Dredging Technical Notes EEDP-06-8. U.S. Army Corps of Engineers.

Appendix 2-B

Associations between Species of Wildlife and Wetlands in Washington and Oregon

This appendix shows the level of association between species of wildlife and wetlands in Washington and Oregon in a table. The data are copied directly from the tabulated data on a computer disk provided with Johnson and O'Neil (2001).

Four types of wetland habitat were identified in the document by Johnson and O'Neil. The definitions for these types are summarized below and are from Chappell et al. (2001) and O'Neil and Johnson (2001). Detailed descriptions of the geographic distribution, physical setting, landscape setting, structure, and composition are given in Chappell et al. (2001).

Herbaceous Wetlands (list of species starts on page 4)

Wetlands with the following vegetation types:

- Graminoid Wet Meadow
- Freshwater Aquatic Bed
- Herbaceous and Sedge Wetlands

This habitat is called palustrine emergent wetlands in Cowardin et al. (1979).

Westside Riparian – Wetlands (list of species starts on page 15)

Wetlands with the following vegetation types:

- *Alnus viridis* ssp. *sinuata – Acer circinatum* Shrublands
- Westside Riparian and Wetland Deciduous Forests
- *Picea sitchensis* Wetland Forests and Woodlands
- *Tsuga heterphylla-Thuja plicata* Coniferous Wetlands
- Westside Riparian/Wetland Shrublands
- Shrub/herbaceous Sphagnum Bogs
- Wooded Bogs

This habitat includes all palustrine forested wetlands and scrub-shrub wetlands at lower elevations west of the Cascades as well as a small subset of persistent emergent wetlands, those with sphagnum bogs. However, drier portions of this habitat in riparian flood plains may not qualify as wetlands according to the Cowardin definition.

Montane Coniferous Wetlands (list of species starts on page 29)

Wetlands with the following vegetation types:

- Westside Montane Coniferous Wetlands
- *Picea engelmannii* Forested Wetlands

This habitat includes nearly all the wettest forests within the *Abies amabilis* and *Tsuga mertensiana* zones of western Washington and most of the wet forests in the *Tsuga heterophylla* and *Abies lasiocarpa* zones of eastern Oregon and Washington.

Eastside (Interior) Riparian – Wetlands (list of species starts on page 38)

Wetlands with the following vegetation types:

- Eastside Midmontane *Alnus incana-Salix* spp. Riparian Shrublands
- Eastside Lowland Riparian Shrublands
- Eastside *Populus balsamifera* spp. *trichocarpa*
- *Alnus rhombifolia* Riparian
- *Pinus ponderosa* Riparian Woodlands
- *Populus tremuloides* Riparian/Wetland Forests and Woodlands

This habitat is called palustrine scrub-shrub and palustrine forest in Cowardin and includes some palustrine emergent in the National Wetland Inventory.

Definitions for the Types of Association

(copied from O'Neil and Johnson 2001)

Closely Associated. A species is widely known to depend on a habitat for part or all of its life history requirements. Identifying this association implies that the species has an essential need for this habitat for its maintenance and viability. Some species may be closely associated with more than one habitat; others may be closely associated with only one habitat.

Generally Associated. A species exhibits a high degree of adaptability and may be supported by a number of habitats. In other words, the habitats play a supportive role for its maintenance and viability.

Present. A species demonstrates occasional use of a habitat. The habitat provides marginal support to the species for its maintenance and viability.

The expert panelists developing this list also assigned an overall "confidence rating" to the categorization for each species within each habitat type. The confidence ratings were high (e.g., many peer or published accounts), moderate, and low (e.g., few or no published accounts).

References Cited

Chappell, C.B., R.C. Crawford, C. Barrett, J. Kagan, D.H. Johnson, M. O'Mealy, G.A. Green, H.L. Ferguson, W.D. Edge, E.L. Greda, and T.A. O'Neil. 2001. Wildlife habitats: Descriptions, status, trends and system dynamics. Chpt. 2. p. 22-114. in D.H. Johnson and T.A. O'Neil (eds.), Wildlife-Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Washington, DC: U.S. Fish and Wildlife Service.

Johnson, D.H and T.A. O'Neil (eds.) 2001. Wildlife-Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press. 736pp.

O'Neil, T.A. and D.H. Johnson. 2001. Oregon and Washington wildlife species and their habitats. (Chapter 1 p. 1-21) in D.H. Johnson and T.A. O'Neil (eds.), Wildlife-Habitat Relationships in Oregon and Washington. Corvallis, OR: Oregon State University Press.

PLEASE NOTE: The following tables of data do not contain the Latin name of the species. The original tables on Johnson and O'Neil (2001, data on CD) did not have the Latin names although they do have information on each individual species and its Latin name in other databases on the computer disk.

Wildlife Species Found in Herbaceous Wetlands

Amphibians Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Bullfrog	Closely Associated	Feeds and Breeds	High	Requires warm-water ponds, marshes, or river/stream backwaters for breeding.
Columbia Spotted Frog	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish or bullfrogs occur. Requires shallow water in wet meadows or stream/pond edges with abundant aquatic vegetation for breeding.
Great Basin Spadefoot	Closely Associated	Feeds and Breeds	High	Requires ponds or temporary rain-filled depressions for breeding.
Long-toed Salamander	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish are occur. Requires ponds, shallow lake edges, seasonal pools (like elk wallows) or slow streams for breeding.
Northern Leopard Frog	Closely Associated	Feeds and Breeds	High	Requires ponds or lake edges with dense aquatic and emergent vegetation for breeding.
Northwestern Salamander	Closely Associated	Feeds and Breeds	High	Requires ponds or stream backwaters for breeding.
Oregon Spotted Frog	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish or bullfrogs occur. Requires shallow water in wet meadows or stream/pond edges with abundant aquatic vegetation for breeding.
Pacific Chorus (Tree) Frog	Closely Associated	Feeds and Breeds	High	Requires ponds, seasonal pools, temporary rain-filled depressions or slow streams for breeding.
Red-legged Frog	Closely Associated	Feeds and Breeds	High	Requires cool-water ponds, lake edges or slow streams for breeding.
Rough-skinned Newt	Closely Associated	Feeds and Breeds	High	Requires ponds or stream backwaters with abundant aquatic vegetation for breeding.
Tiger Salamander	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish occur. Requires warm ponds or shallow lake edges for breeding.
Western Toad	Closely Associated	Feeds and Breeds	High	Requires ponds or shallow lake edges for breeding.
Woodhouse's Toad	Closely Associated	Feeds and Breeds	High	Requires warm, shallow water in ponds, lakes, or slow streams for breeding.
Cascades Frog	Generally Associated	Feeds and Breeds	Moderate	Range limited to Cascade axis fringe. Requires bogs or ponds with cold springs for breeding.

Birds Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
American Avocet	Closely Associated	Feeds and Breeds	High	None noted.
American Bittern	Closely Associated	Feeds and Breeds	High	None noted.
American Black Duck	Closely Associated	Feeds and Breeds	Low	None noted.
American Coot	Closely Associated	Feeds and Breeds	High	None noted.
American Wigeon	Closely Associated	Feeds and Breeds	High	None noted.
Baird's Sandpiper	Closely Associated	Feeds	Moderate	None noted.
Barn Swallow	Closely Associated	Feeds	High	Can nest anywhere buildings, bridges, or overhanging cliffs occur in close proximity to water.
Black Tern	Closely Associated	Feeds and Breeds	High	None noted.
Black-crowned Night-heron	Closely Associated	Feeds	High	Requires shrubs or trees for nesting.
Black-necked Stilt	Closely Associated	Feeds and Breeds	High	None noted.
Blue-winged Teal	Closely Associated	Feeds and Breeds	High	None noted.
Bufflehead	Closely Associated	Feeds	High	Nests in tree cavities near ponds or lakes.
Canada Goose	Closely Associated	Feeds and Breeds	High	None noted.
Canvasback	Closely Associated	Feeds and Breeds	High	None noted.
Caspian Tern	Closely Associated	Feeds	High	None noted.
Cattle Egret	Closely Associated	Feeds	High	Requires shrubs or trees for nesting.
Cinnamon Teal	Closely Associated	Feeds and Breeds	High	None noted.
Clark's Grebe	Closely Associated	Feeds and Breeds	High	Nests placed on a floating platform of fresh and decaying vegetation in shallow water.
Common Loon	Closely Associated	Feeds and Breeds	Moderate	Nests in emergent vegetation at lake edges. No nesting confirmed in Oregon.
Common Snipe	Closely Associated	Feeds and Breeds	High	None noted.
Common Yellowthroat	Closely Associated	Feeds and Breeds	High	None noted.

Birds Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Dunlin	Closely Associated	Feeds	Moderate	None noted.
Eared Grebe	Closely Associated	Feeds and Breeds	Moderate	Nests placed on a floating platform of fresh and decaying vegetation in shallow water.
Forster's Tern	Closely Associated	Feeds and Breeds	High	None noted.
Franklin's Gull	Closely Associated	Feeds and Breeds	High	Breeds at Mahleur Lake, Oregon.
Gadwall	Closely Associated	Feeds and Breeds	High	None noted.
Great Blue Heron	Closely Associated	Feeds	High	Requires trees for nesting.
Great Egret	Closely Associated	Feeds	High	Requires tall shrubs or trees for nesting.
Greater White-fronted Goose	Closely Associated	Feeds	High	None noted
Greater Yellowlegs	Closely Associated	Feeds	High	Has bred at least four times at Downy Lake, Wallowa County, Oregon.
Green Heron	Closely Associated	Feeds	High	Requires shrubs or trees for nesting.
Green-winged Teal	Closely Associated	Feeds and Breeds	High	None noted.
Horned Grebe	Closely Associated	Feeds and Breeds	Moderate	Nests placed on a floating platform of fresh and decaying vegetation in shallow water.
Least Bittern	Closely Associated	Feeds and Breeds	High	Rare breeder in Oregon; does not occur in Washington.
Least Sandpiper	Closely Associated	Feeds	Moderate	None noted.
Lesser Scaup	Closely Associated	Feeds and Breeds	High	None noted.
Lesser Yellowlegs	Closely Associated	Feeds	High	None noted.
Lincoln's Sparrow	Closely Associated	Feeds and Breeds	Moderate	None noted.
Long-billed Dowitcher	Closely Associated	Feeds	High	None noted.
Mallard	Closely Associated	Feeds and Breeds	High	None noted.
Marsh Wren	Closely Associated	Feeds and Breeds	Moderate	None noted.
Mute Swan	Closely Associated	Feeds and Breeds	Moderate	This is an introduced species which breeds only in urban wetlands.
Northern Pintail	Closely Associated	Feeds and Breeds	High	None noted.

Birds Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Northern Rough-winged Swallow	Closely Associated	Feeds	High	Requires burrows in dirt banks, usually next to water, for nesting.
Northern Shoveler	Closely Associated	Feeds and Breeds	High	None noted.
Pectoral Sandpiper	Closely Associated	Feeds	Moderate	None noted.
Pied-billed Grebe	Closely Associated	Feeds and Breeds	High	Nests placed on a floating platform of fresh and decaying vegetation in shallow water.
Redhead	Closely Associated	Feeds and Breeds	High	None noted.
Red-necked Grebe	Closely Associated	Feeds and Breeds	High	Nests placed on a floating platform of fresh and decaying vegetation in shallow water.
Red-winged Blackbird	Closely Associated	Feeds and Breeds	High	None noted.
Ross's Goose	Closely Associated	Feeds	High	None noted.
Ruddy Duck	Closely Associated	Feeds and Breeds	High	None noted.
Sandhill Crane	Closely Associated	Feeds and Breeds	High	None noted.
Short-eared Owl	Closely Associated	Feeds and Breeds	Moderate	None noted.
Snow Goose	Closely Associated	Feeds	High	None noted.
Snowy Egret	Closely Associated	Feeds	High	Requires tall shrubs or trees for nesting.
Solitary Sandpiper	Closely Associated	Feeds	Moderate	None noted.
Sora	Closely Associated	Feeds and Breeds	High	None noted.
Swamp Sparrow	Closely Associated	Feeds	High	None noted.
Tree Swallow	Closely Associated	Feeds	Moderate	Requires snags not far from open water for nesting.
Tricolored Blackbird	Closely Associated	Feeds and Breeds	High	None noted.
Trumpeter Swan	Closely Associated	Feeds and Breeds	High	None noted.
Tundra Swan	Closely Associated	Feeds	High	None noted.
Virginia Rail	Closely Associated	Feeds and Breeds	High	None noted.

Birds Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Western Grebe	Closely Associated	Feeds and Breeds	High	Nests placed on a floating platform of fresh and decaying vegetation in shallow water.
Western Sandpiper	Closely Associated	Feeds	Moderate	None noted.
White-faced Ibis	Closely Associated	Feeds and Breeds	High	None noted.
Willet	Closely Associated	Feeds and Breeds	High	None noted.
Wilson's Phalarope	Closely Associated	Feeds and Breeds	High	None noted.
Yellow Rail	Closely Associated	Feeds and Breeds	High	None noted.
Yellow-headed Blackbird	Closely Associated	Feeds and Breeds	High	None noted.
American Goldfinch	Generally Associated	Feeds	High	None noted.
American Kestrel	Generally Associated	Feeds	High	None noted.
American Robin	Generally Associated	Feeds	High	None noted.
American White Pelican	Generally Associated	Feeds	High	Feeds in open water areas of wetlands.
Bald Eagle	Generally Associated	Feeds	High	None noted.
Bank Swallow	Generally Associated	Feeds	High	Requires burrows in dirt banks, usually next to water, for nesting.
Barn Owl	Generally Associated	Feeds	High	None noted.
Barrow's Goldeneye	Generally Associated	Feeds	Moderate	Nests in tree cavities near ponds or lakes.
Black-chinned Hummingbird	Generally Associated	Feeds	Low	None noted.
Bobolink	Generally Associated	Feeds and Breeds	Moderate	None noted.
Brewer's Blackbird	Generally Associated	Feeds and Breeds	Moderate	None noted.
Brown-headed Cowbird	Generally Associated	Feeds and Breeds	High	None noted.
Burrowing Owl	Generally Associated	Feeds	High	None noted.
California Gull	Generally Associated	Feeds and Breeds	Moderate	None noted.
Cliff Swallow	Generally Associated	Feeds	High	Can nest anywhere rimrock, over-hanging cliffs, buildings or bridges occur in close proximity to water.

Birds Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Common Nighthawk	Generally Associated	Feeds	Moderate	None noted.
Common Raven	Generally Associated	Feeds	High	None noted.
Cooper's Hawk	Generally Associated	Feeds	High	None noted.
Double-crested Cormorant	Generally Associated	Reproduces	High	None noted.
Eastern Kingbird	Generally Associated	Feeds	Moderate	None noted.
Eurasian Wigeon	Generally Associated	Feeds	High	None noted.
European Starling	Generally Associated	Feeds	Moderate	Requires snags or trees with cavities or buildings with crevices for nesting. Most likely to use this habitat where adjacent to agriculture or urban habitats.
Glaucous Gull	Generally Associated	Feeds	Low	None noted.
Golden-crowned Sparrow	Generally Associated	Feeds	Moderate	None noted.
Great Gray Owl	Generally Associated	Feeds	High	None noted.
Great Horned Owl	Generally Associated	Feeds	High	None noted.
Gyrfalcon	Generally Associated	Feeds	Moderate	None noted.
Herring Gull	Generally Associated	Feeds	High	None noted.
Hooded Merganser	Generally Associated	Feeds	High	Nests in tree cavities near ponds or lakes.
Killdeer	Generally Associated	Feeds and Breeds	Moderate	None noted.
Long-billed Curlew	Generally Associated	Feeds	Moderate	None noted.
Long-eared Owl	Generally Associated	Feeds	Moderate	None noted.
Northern Goshawk	Generally Associated	Feeds	Moderate	None noted.
Northern Harrier	Generally Associated	Feeds and Breeds	High	None noted.
Palm Warbler	Generally Associated	Feeds	Low	Only along the coast.
Peregrine Falcon	Generally Associated	Feeds	High	None noted.

Birds Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Purple Martin	Generally Associated	Feeds	Low	None noted.
Red-tailed Hawk	Generally Associated	Feeds	High	None noted.
Ring-billed Gull	Generally Associated	Feeds and Breeds	Moderate	None noted.
Ring-necked Duck	Generally Associated	Feeds and Breeds	High	None noted.
Ring-necked Pheasant	Generally Associated	Feeds	High	None noted.
Rough-legged Hawk	Generally Associated	Feeds	Moderate	None noted.
Savannah Sparrow	Generally Associated	Feeds and Breeds	High	None noted.
Sharp-shinned Hawk	Generally Associated	Feeds	High	None noted.
Song Sparrow	Generally Associated	Feeds and Breeds	High	None noted.
Spotted Sandpiper	Generally Associated	Feeds and Breeds	Moderate	None noted.
Swainson's Hawk	Generally Associated	Feeds	Moderate	None noted.
Thayer's Gull	Generally Associated	Feeds	Moderate	None noted.
Turkey Vulture	Generally Associated	Feeds	High	None noted.
Upland Sandpiper	Generally Associated	Feeds and Breeds	High	Has been found at Sycan Marsh, Lake County, Oregon.
Vaux's Swift	Generally Associated	Feeds	Low	None noted.
Violet-green Swallow	Generally Associated	Feeds	Moderate	None noted.
White-crowned Sparrow	Generally Associated	Feeds	Moderate	None noted.
White-throated Swift	Generally Associated	Feeds	Low	Could forage over herbaceous wetlands incidently, such as those found in desert playas.
American Crow	Present	Feeds	High	None noted.
American Dipper	Present	Feeds	Moderate	None noted.
American Pipit	Present	Feeds	Moderate	Winter only.
Bewick's Wren	Present	Feeds	Low	None noted.
Black Swift	Present	Feeds	Low	Black swifts are long-distance foragers that may travel many miles from breeding sites and take advantage of flying insects caught in updrafts over just about any habitat.

Birds Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Black-billed Magpie	Present	Feeds	High	None noted.
Black-capped Chickadee	Present	Feeds	Moderate	None noted.
Calliope Hummingbird	Present	Feeds	Low	None noted.
Cedar Waxwing	Present	Feeds	Moderate	None noted.
Common Goldeneye	Present	Feeds	Moderate	Nests in tree cavities near ponds or lakes.
Golden Eagle	Present	Feeds	High	None noted.
House Finch	Present	Feeds	Moderate	Uses this habitat where it is not too far from urban or agricultural areas.
Lapland Longspur	Present	Feeds	Low	None noted.
Loggerhead Shrike	Present	Feeds	Moderate	None noted.
Merlin	Present	Feeds	Low	None noted.
Northern Pygmy-owl	Present	Feeds	High	None noted.
Northern Shrike	Present	Feeds	High	None noted.
Pine Siskin	Present	Feeds	Low	None noted.
Ruby-crowned Kinglet	Present	Feeds	High	Winter only.
Rufous Hummingbird	Present	Feeds	Moderate	None noted.
Snowy Owl	Present	Feeds	Moderate	None noted.
Western Meadowlark	Present	Feeds	Low	None noted.
Western Screech-owl	Present	Feeds	Moderate	None noted.
Wood Duck	Present	Feeds	Moderate	Nests in tree cavities near ponds or lakes.
Yellow-rumped Warbler	Present	Feeds	Low	None noted.

Mammals Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
American Beaver	Closely Associated	Feeds and Breeds	High	None noted.
Deer Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Long-tailed Vole	Closely Associated	Feeds and Breeds	High	None noted.
Meadow Vole	Closely Associated	Feeds and Breeds	Low	None noted.
Mink	Closely Associated	Feeds	Moderate	None noted.
Montane Vole	Closely Associated	Feeds and Breeds	High	None noted.
Moose	Closely Associated	Feeds	High	None noted.
Muskrat	Closely Associated	Feeds and Breeds	Moderate	None noted.
Northern Bog Lemming	Closely Associated	Feeds and Breeds	Moderate	Cold, wet bogs above 5000 feet.

Mammals Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Northern River Otter	Closely Associated	Feeds and Breeds	High	None noted.
Nutria	Closely Associated	Feeds and Breeds	Moderate	None noted.
Pallid Bat	Closely Associated	Feeds	High	None noted.
Raccoon	Closely Associated	Feeds	Moderate	None noted.
Townsend's Vole	Closely Associated	Feeds and Breeds	High	None noted.
Western Harvest Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Yuma Myotis	Closely Associated	Feeds	High	None noted.
Big Brown Bat	Generally Associated	Feeds	Moderate	None noted.
Black Bear	Generally Associated	Feeds	High	None noted.
Black-tailed Deer	Generally Associated	Feeds	High	None noted.
Bobcat	Generally Associated	Feeds	Moderate	None noted.
Brazilian Free-tailed Bat	Generally Associated	Feeds	High	None noted.
California Myotis	Generally Associated	Feeds	High	None noted.
Columbian White-tailed Deer	Generally Associated	Feeds	High	None noted.
Coyote	Generally Associated	Feeds	High	None noted.
Feral Pig	Generally Associated	Feeds and Breeds	Moderate	Eastern Oregon wet meadows.
Fringed Myotis	Generally Associated	Feeds	Low	None noted.
Hoary Bat	Generally Associated	Feeds	Low	None noted.
Keen's Myotis	Generally Associated	Feeds	Low	None noted.
Little Brown Myotis	Generally Associated	Feeds	High	None noted.
Long-eared Myotis	Generally Associated	Feeds	Moderate	None noted.
Long-legged Myotis	Generally Associated	Feeds	Moderate	None noted.
Long-tailed Weasel	Generally Associated	Feeds	Moderate	None noted.
Mountain Caribou	Generally Associated	Feeds	Moderate	None noted.

Mammals Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Mountain Lion	Generally Associated	Feeds	High	None noted.
Mule Deer	Generally Associated	Feeds	High	None noted.
Pacific Jumping Mouse	Generally Associated	Feeds and Breeds	Moderate	None noted.
Pacific Water Shrew	Generally Associated	Feeds and Breeds	Moderate	Closely tied to water.
Rocky Mountain Elk	Generally Associated	Feeds	High	None noted.
Roosevelt Elk	Generally Associated	Feeds	High	None noted.
Shrew-mole	Generally Associated	Feeds and Breeds	High	None noted.
Silver-haired Bat	Generally Associated	Feeds	Low	None noted.
Spotted Bat	Generally Associated	Feeds	Moderate	None noted.
Striped Skunk	Generally Associated	Feeds	Moderate	None noted.
Townsend's Big-eared Bat	Generally Associated	Feeds	Low	None noted.
Townsend's Mole	Generally Associated	Feeds and Breeds	High	None noted.
Vagrant Shrew	Generally Associated	Feeds and Breeds	Moderate	None noted.
Western Jumping Mouse	Generally Associated	Feeds and Breeds	Low	None noted.
Western Small-footed Myotis	Generally Associated	Feeds	Low	None noted.
White-tailed Deer (Eastside)	Generally Associated	Feeds	High	None noted.
Yellow-bellied Marmot	Generally Associated	Feeds	Low	Requires talus slopes, lava fields, rimrock, or boulder fields in close proximity to grassy openings or meadows.
Common Porcupine	Present	Feeds	Moderate	Needs large shrubs for food.
Feral Horse	Present	Feeds	Low	None noted.
Grizzly Bear	Present	Feeds	Low	None noted.
Preble's Shrew	Present	Feeds and Breeds	Low	None noted.
Wild Burro	Present	Feeds	Low	In southeastern Oregon, this habitat is mostly unavailable due to the fact that they are situated primarily on private lands and are fenced.

Reptiles Associated with Herbaceous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Common Garter Snake	Closely Associated	Feeds and Breeds	High	None noted.
Pacific Coast Aquatic Garter Snake	Present	Feeds and Breeds	Moderate	Uses this habitat where near marshes, streams, rivers, ponds or lakes.
Painted Turtle	Closely Associated	Feeds	Moderate	None noted.
Red-eared Slider Turtle	Closely Associated	Feeds	High	None noted.
Snapping Turtle	Closely Associated	Feeds	Moderate	None noted.
Western Pond Turtle	Closely Associated	Feeds	High	None noted.
Western Terrestrial Garter Snake	Generally Associated	Feeds	High	None noted.

Wildlife Species Found in Westside Riparian - Wetlands

Amphibians Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Bullfrog	Closely Associated	Feeds and Breeds	High	Requires warm-water ponds, marshes, or river/stream backwaters for breeding.
Cascade Torrent Salamander	Closely Associated	Feeds and Breeds	High	Requires very cold, clear seeps, springs, and small streams for breeding.
Columbia Torrent Salamander	Closely Associated	Feeds and Breeds	High	Requires very cold, clear seeps, springs, and small streams for breeding.
Cope's Giant Salamander	Closely Associated	Feeds and Breeds	Moderate	Requires clear, cold steep-gradient streams with a streambed of gravel, boulders and large logs for breeding.
Long-toed Salamander	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish are occur. Requires ponds, shallow lake edges, seasonal pools (like elk wallows) or slow streams for breeding.
Northwestern Salamander	Closely Associated	Feeds and Breeds	High	Requires ponds or stream backwaters for breeding.
Olympic Torrent Salamander	Closely Associated	Feeds and Breeds	High	Requires very cold, clear seeps, springs, and small streams for breeding.
Oregon Spotted Frog	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish or bullfrogs occur. Requires shallow water in wet meadows or stream/pond edges with abundant aquatic vegetation for breeding.
Pacific Chorus (Tree) Frog	Closely Associated	Feeds and Breeds	High	Requires ponds, seasonal pools, temporary rain-filled depressions or slow streams for breeding.
Pacific Giant Salamander	Closely Associated	Feeds and Breeds	Moderate	Requires small to mid-sized streams with a streambed of gravel, boulders and large logs for breeding.
Red-legged Frog	Closely Associated	Feeds and Breeds	High	Requires cool-water ponds, lake edges or slow streams for breeding.
Rough-skinned Newt	Closely Associated	Feeds and Breeds	High	Requires ponds or stream backwaters with abundant aquatic vegetation for breeding.
Southern Torrent Salamander	Closely Associated	Feeds and Breeds	High	Requires very cold, clear seeps, springs, and small streams for breeding.
Tailed Frog	Closely Associated	Feeds and Breeds	Moderate	Requires clear, cold steep-gradient streams for breeding.

Amphibians Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Western Toad	Closely Associated	Feeds and Breeds	High	None noted.
Black Salamander	Generally Associated	Feeds and Breeds	Low	Requires logs, woody debris, or moist talus with woody debris.
California Slender Salamander	Generally Associated	Feeds and Breeds	Moderate	Requires logs.
Cascades Frog	Generally Associated	Feeds and Breeds	Moderate	Requires bogs or ponds with cold springs for breeding.
Dunn's Salamander	Generally Associated	Feeds and Breeds	Moderate	Requires moist or wet rock outcrops, talus, gravel, boulders, or rock crevices
Ensatina	Generally Associated	Feeds and Breeds	High	Requires logs, woody debris, or moist talus with woody debris.
Foothill Yellow-legged Frog	Generally Associated	Feeds and Breeds	High	Requires still-water or gentle gradient portions of streams for breeding.
Oregon Slender Salamander	Generally Associated	Feeds and Breeds	Moderate	Requires large logs, woody debris, or moist talus with woody debris.
Van Dyke's Salamander	Generally Associated	Feeds and Breeds	Moderate	Requires moist talus, rock outcrops, logs, seeps, or woody debris and rocks along streams.
Western Red-backed Salamander	Generally Associated	Feeds and Breeds	High	Requires moist or shaded talus, rocks, or large logs. Occasionally uses springs or stream edges.

Birds Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
American Black Duck	Closely Associated	Feeds and Breeds	Low	None noted.
American Dipper	Closely Associated	Feeds and Breeds	High	None noted.
Band-tailed Pigeon	Closely Associated	Feeds and Breeds	Moderate	None noted.
Barn Swallow	Closely Associated	Feeds and Breeds	High	Can nest anywhere buildings, bridges, or overhanging cliffs occur in close proximity to water.
Belted Kingfisher	Closely Associated	Feeds and Breeds	High	None noted.
Black Phoebe	Closely Associated	Feeds and Breeds	Moderate	None noted.
Black-throated Gray Warbler	Closely Associated	Feeds and Breeds	High	None noted.

Birds Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Bullock's Oriole	Closely Associated	Feeds and Breeds	Moderate	None noted.
Cliff Swallow	Closely Associated	Feeds and Breeds	High	Can nest anywhere rimrock, overhanging cliffs, buildings or bridges occur in close proximity to water.
Common Merganser	Closely Associated	Feeds and Breeds	High	Nests in tree cavities near large lakes or rivers.
Common Yellowthroat	Closely Associated	Feeds and Breeds	High	None noted.
Downy Woodpecker	Closely Associated	Feeds and Breeds	Moderate	None noted.
European Starling	Closely Associated	Feeds and Breeds	High	Requires snags or trees with cavities or buildings with crevices for nesting. Most likely to use this habitat where adjacent to agriculture or urban habitats.
Great Blue Heron	Closely Associated	Feeds and Breeds	High	None noted.
Green Heron	Closely Associated	Feeds and Breeds	High	None noted.
Harlequin Duck	Closely Associated	Feeds and Breeds	High	None noted.
Hooded Merganser	Closely Associated	Feeds and Breeds	High	Nests in tree cavities.
Lesser Goldfinch	Closely Associated	Feeds and Breeds	Moderate	None noted.
Lincoln's Sparrow	Closely Associated	Feeds and Breeds	High	None noted.
Mallard	Closely Associated	Feeds and Breeds	High	None noted.
Mourning Dove	Closely Associated	Feeds and Breeds	High	None noted.
Northern Rough-winged Swallow	Closely Associated	Feeds and Breeds	High	Requires burrows in dirt banks, usually next to water, for nesting.
Northern Waterthrush	Closely Associated	Feeds and Breeds	High	None noted.
Purple Finch	Closely Associated	Feeds and Breeds	Moderate	None noted.
Red-eyed Vireo	Closely Associated	Feeds and Breeds	Moderate	Range of red-eyed vireo overlaps that of large black cottonwood groves.

Birds Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Ring-necked Duck	Closely Associated	Feeds and Breeds	Moderate	None noted.
Ruffed Grouse	Closely Associated	Feeds and Breeds	High	None noted.
Solitary Sandpiper	Closely Associated	Feeds	High	None noted.
Spotted Sandpiper	Closely Associated	Feeds and Breeds	Moderate	None noted.
Swamp Sparrow	Closely Associated	Feeds	High	None noted.
Tree Swallow	Closely Associated	Feeds and Breeds	Moderate	Requires snags not far from open water for nesting.
Warbling Vireo	Closely Associated	Feeds and Breeds	High	None noted.
Western Screech-owl	Closely Associated	Feeds and Breeds	High	None noted.
Willow Flycatcher	Closely Associated	Feeds and Breeds	Moderate	None noted.
Wilson's Warbler	Closely Associated	Feeds and Breeds	High	None noted.
Wood Duck	Closely Associated	Feeds and Breeds	High	Nests in tree cavities.
Yellow Warbler	Closely Associated	Feeds and Breeds	High	None noted.
Yellow-breasted Chat	Closely Associated	Feeds and Breeds	Moderate	None noted.
Allen's Hummingbird	Generally Associated	Feeds and Breeds	Low	None noted.
American Crow	Generally Associated	Feeds and Breeds	High	None noted.
American Goldfinch	Generally Associated	Feeds and Breeds	High	None noted.
American Kestrel	Generally Associated	Feeds and Breeds	High	None noted.
American Robin	Generally Associated	Feeds and Breeds	High	None noted.
American Wigeon	Generally Associated	Feeds	High	None noted.
Bald Eagle	Generally Associated	Feeds and Breeds	High	None noted.
Barn Owl	Generally Associated	Feeds and Breeds	High	Requires cliffs, caves, rimrock, or tree cavities for nesting.

Birds Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Barred Owl	Generally Associated	Feeds and Breeds	Moderate	None noted.
Bewick's Wren	Generally Associated	Feeds and Breeds	Moderate	None noted.
Black Swift	Generally Associated	Feeds and Breeds	Low	Requires suitable cliffs behind waterfalls for breeding.
Black-capped Chickadee	Generally Associated	Feeds and Breeds	Moderate	None noted.
Black-crowned Night-heron	Generally Associated	Feeds	High	Only one and maybe two known breeding sites exist west of the Cascades, though historically a large breeding colony occurred near Portland.
Black-headed Grosbeak	Generally Associated	Feeds and Breeds	High	None noted.
Brewer's Blackbird	Generally Associated	Feeds and Breeds	Moderate	None noted.
Brown Creeper	Generally Associated	Feeds and Breeds	Moderate	None noted.
Brown-headed Cowbird	Generally Associated	Feeds and Breeds	High	None noted.
Bufflehead	Generally Associated	Feeds and Breeds	High	Nests in tree cavities.
Bushtit	Generally Associated	Feeds and Breeds	Moderate	None noted.
California Quail	Generally Associated	Feeds and Breeds	High	Uses this habitat where adjacent to more open habitats.
Cedar Waxwing	Generally Associated	Feeds and Breeds	High	None noted.
Chestnut-backed Chickadee	Generally Associated	Feeds and Breeds	Moderate	None noted.
Common Nighthawk	Generally Associated	Feeds	Moderate	None noted.
Common Raven	Generally Associated	Feeds and Breeds	High	None noted.
Cooper's Hawk	Generally Associated	Feeds and Breeds	High	None noted.
Dark-eyed Junco	Generally Associated	Feeds and Breeds	High	None noted.
Evening Grosbeak	Generally Associated	Feeds and Breeds	Moderate	None noted.

Birds Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Fox Sparrow	Generally Associated	Feeds	High	Winter only.
Golden-crowned Kinglet	Generally Associated	Feeds and Breeds	High	None noted.
Golden-crowned Sparrow	Generally Associated	Feeds	Moderate	None noted.
Gray Jay	Generally Associated	Feeds and Breeds	Moderate	None noted.
Great Egret	Generally Associated	Feeds and Breeds	Moderate	None noted.
Great Horned Owl	Generally Associated	Feeds and Breeds	High	None noted.
Greater Yellowlegs	Generally Associated	Feeds	Low	None noted.
Green-winged Teal	Generally Associated	Feeds	High	None noted.
Hairy Woodpecker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Hermit Thrush	Generally Associated	Feeds	High	None noted.
Hermit Warbler	Generally Associated	Feeds and Breeds	Moderate	None noted.
House Wren	Generally Associated	Feeds and Breeds	Moderate	None noted.
Hutton's Vireo	Generally Associated	Feeds and Breeds	High	None noted.
Killdeer	Generally Associated	Feeds and Breeds	Moderate	None noted.
Lazuli Bunting	Generally Associated	Feeds and Breeds	Moderate	None noted.
Least Flycatcher	Generally Associated	Feeds and Breeds	Low	Found nesting near Monroe, Snohomish County, Washington.
Lesser Yellowlegs	Generally Associated	Feeds	Low	None noted.
Macgillivray's Warbler	Generally Associated	Feeds and Breeds	High	None noted.
Merlin	Generally Associated	Feeds and Breeds	Moderate	None noted.
Mountain Quail	Generally Associated	Feeds and Breeds	Moderate	None noted.

Birds Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Nashville Warbler	Generally Associated	Feeds and Breeds	Moderate	None noted.
Northern Flicker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Northern Goshawk	Generally Associated	Feeds	Moderate	None noted.
Northern Pygmy-owl	Generally Associated	Feeds and Breeds	High	None noted.
Olive-sided Flycatcher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Orange-crowned Warbler	Generally Associated	Feeds and Breeds	High	None noted.
Osprey	Generally Associated	Feeds and Breeds	High	None noted.
Pacific-slope Flycatcher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Palm Warbler	Generally Associated	Feeds	Moderate	Only along the coast.
Peregrine Falcon	Generally Associated	Feeds	High	None noted.
Pied-billed Grebe	Generally Associated	Feeds and Breeds	High	Uncertain about the frequency of breeding in this type of habitat.
Pileated Woodpecker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Pine Siskin	Generally Associated	Feeds and Breeds	Moderate	None noted.
Purple Martin	Generally Associated	Feeds and Breeds	Low	None noted.
Red-breasted Nuthatch	Generally Associated	Feeds and Breeds	Moderate	None noted.
Red-breasted Sapsucker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Red-shouldered Hawk	Generally Associated	Feeds and Breeds	Low	None noted.
Red-tailed Hawk	Generally Associated	Feeds and Breeds	High	None noted.
Red-winged Blackbird	Generally Associated	Feeds and Breeds	Low	None noted.
Ring-necked Pheasant	Generally Associated	Feeds and Breeds	High	None noted.
Ruby-crowned Kinglet	Generally Associated	Feeds	High	Winter only.

Birds Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Rufous Hummingbird	Generally Associated	Feeds and Breeds	Moderate	None noted.
Savannah Sparrow	Generally Associated	Feeds and Breeds	Moderate	None noted.
Song Sparrow	Generally Associated	Feeds and Breeds	High	None noted.
Spotted Towhee	Generally Associated	Feeds and Breeds	Moderate	None noted.
Steller's Jay	Generally Associated	Feeds and Breeds	Moderate	None noted.
Swainson's Thrush	Generally Associated	Feeds and Breeds	High	None noted.
Townsend's Warbler	Generally Associated	Feeds and Breeds	High	None noted.
Turkey Vulture	Generally Associated	Feeds and Breeds	High	Requires rocky outcrops, small caves, boulder piles, ledges on high cliffs or large hollow logs for nesting.
Vaux's Swift	Generally Associated	Feeds and Breeds	Moderate	None noted.
Violet-green Swallow	Generally Associated	Feeds and Breeds	Moderate	None noted.
Western Tanager	Generally Associated	Feeds and Breeds	Moderate	None noted.
Western Wood-pewee	Generally Associated	Feeds and Breeds	Moderate	None noted.
White-breasted Nuthatch	Generally Associated	Feeds and Breeds	Moderate	None noted.
White-crowned Sparrow	Generally Associated	Feeds and Breeds	Moderate	None noted.
Wild Turkey	Generally Associated	Feeds	Moderate	Low elevation sites only; likely uses this habitat more for cover than feeding.
Winter Wren	Generally Associated	Feeds and Breeds	Moderate	None noted.
Yellow-rumped Warbler	Generally Associated	Feeds	Moderate	None noted.
American Redstart	Present	Feeds and Breeds	Low	None noted.
American Tree Sparrow	Present	Feeds	Moderate	None noted.
Anna's Hummingbird	Present	Feeds and Breeds	Low	None noted.

Birds Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Ash-throated Flycatcher	Present	Feeds and Breeds	Low	Requires an oak component.
Blue Grouse	Present	Feeds and Breeds	Moderate	None noted.
Bohemian Waxwing	Present	Feeds	Moderate	Occurs in Westside habitats only during irruption years.
Canada Goose	Present	Feeds and Breeds	Moderate	None noted.
Chipping Sparrow	Present	Feeds	Low	None noted.
Common Redpoll	Present	Feeds	Moderate	Only in Skagit and Whatcom counties, Washington.
Double-crested Cormorant	Present	Feeds and Breeds	High	None noted.
House Finch	Present	Feeds and Breeds	Moderate	Uses this habitat where it is not too far from urban or agricultural areas.
Lewis's Woodpecker	Present	Feeds	Moderate	May use as wintering habitat in Oregon; historically occurred in this habitat in western Washington.
Northern Harrier	Present	Feeds and Breeds	High	None noted.
Northern Saw-whet Owl	Present	Feeds and Breeds	Moderate	None noted.
Red Crossbill	Present	Feeds and Breeds	Moderate	None noted.
Rough-legged Hawk	Present	Feeds	High	None noted.
Snowy Egret	Present	Feeds	Moderate	None noted.
Townsend's Solitaire	Present	Feeds	Moderate	None noted.
Veery	Present	Feeds and Breeds	High	None noted.
Western Scrub-Jay	Present	Feeds and Breeds	Moderate	None noted.
White-tailed Kite	Present	Feeds and Breeds	Moderate	None noted.
White-winged Crossbill	Present	Feeds	Low	None noted.

Mammals Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
American Beaver	Closely Associated	Feeds and Breeds	High	None noted.
Deer Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Dusky-footed Woodrat	Closely Associated	Feeds and Breeds	Moderate	None noted.
Fisher	Closely Associated	Feeds and Breeds	Moderate	None noted.
Fog Shrew	Closely Associated	Feeds and Breeds	High	None noted.
Long-tailed Vole	Closely Associated	Feeds and Breeds	High	None noted.
Mink	Closely Associated	Feeds and Breeds	Moderate	None noted.
Mountain Beaver	Closely Associated	Feeds and Breeds	High	None noted.
Muskrat	Closely Associated	Feeds and Breeds	Moderate	None noted.
Northern River Otter	Closely Associated	Feeds and Breeds	High	None noted.
Nutria	Closely Associated	Feeds and Breeds	Moderate	None noted.
Pacific Jumping Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Pacific Shrew	Closely Associated	Feeds and Breeds	High	None noted.
Pacific Water Shrew	Closely Associated	Feeds and Breeds	High	Closely tied to water.
Raccoon	Closely Associated	Feeds and Breeds	Moderate	None noted.
Southern Red-backed Vole	Closely Associated	Feeds and Breeds	High	None noted.
Water Shrew	Closely Associated	Feeds and Breeds	High	Lead a semi-aquatic life and require cold, clear water in small streams or ponds with abundant cover in the form of rocks, overhanging banks, etc.
Water Vole	Closely Associated	Feeds and Breeds	Low	None noted.
White-footed Vole	Closely Associated	Feeds and Breeds	Moderate	None noted.

Mammals Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Yuma Myotis	Closely Associated	Feeds and Breeds	High	More closely associated with water than other bat species. Uses caves, mines, loose bark and bark crevices typically close to water.
Big Brown Bat	Generally Associated	Feeds and Breeds	Moderate	Requires snags, caves, mines, rock crevices, or bridges for breeding and roosting.
Black Bear	Generally Associated	Feeds and Breeds	High	None noted.
Black-tailed Deer	Generally Associated	Feeds and Breeds	High	None noted.
Bobcat	Generally Associated	Feeds and Breeds	Moderate	None noted.
Broad-footed Mole	Generally Associated	Feeds and Breeds	Moderate	None noted.
Brush Rabbit	Generally Associated	Feeds and Breeds	Moderate	None noted.
California Myotis	Generally Associated	Feeds and Breeds	High	Uses rock crevices, hollow trees, mines or caves for breeding.
Coast Mole	Generally Associated	Feeds and Breeds	Moderate	None noted.
Columbian Mouse	Generally Associated	Feeds and Breeds	High	None noted.
Columbian White-tailed Deer	Generally Associated	Feeds and Breeds	High	None noted.
Common Porcupine	Generally Associated	Feeds and Breeds	Moderate	None noted.
Coyote	Generally Associated	Feeds and Breeds	High	None noted.
Creeping Vole	Generally Associated	Feeds and Breeds	High	None noted.
Eastern Cottontail	Generally Associated	Feeds and Breeds	Low	Likely uses this habitat where adjacent to urban or agricultural habitats.
Ermine	Generally Associated	Feeds and Breeds	Low	None noted.
Fringed Myotis	Generally Associated	Feeds and Breeds	Low	Requires caves, mines or rock crevices.
Gray Fox	Generally Associated	Feeds and Breeds	Low	None noted.
Hoary Bat	Generally Associated	Feeds	Low	Requires trees for roosting, but forages in openings and at edges of forests.

Mammals Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Keen's Myotis	Generally Associated	Feeds and Breeds	Low	Little studied; hard to distinguish from long-eared myotis. Likely requires tree cavites for breeding, caves for hibernacula.
Little Brown Myotis	Generally Associated	Feeds and Breeds	High	Uses caves, mines, or hollow trees, often near water.
Long-eared Myotis	Generally Associated	Feeds and Breeds	Moderate	Uses caves, mines, hollow trees, loose bark or rock crevices.
Long-legged Myotis	Generally Associated	Feeds and Breeds	Moderate	Uses caves or mines as hibernacula. Uses hollow trees, loose bark or rock crevices for maternity colonies.
Long-tailed Weasel	Generally Associated	Feeds and Breeds	Moderate	None noted.
Mountain Lion	Generally Associated	Feeds and Breeds	High	None noted.
Northern Flying Squirrel	Generally Associated	Feeds and Breeds	High	None noted.
Pallid Bat	Generally Associated	Feeds	Low	None noted.
Red Fox	Generally Associated	Feeds and Breeds	Low	Non-native Red fox.
Rocky Mountain Elk	Generally Associated	Feeds and Breeds	High	None noted.
Roosevelt Elk	Generally Associated	Feeds and Breeds	High	None noted.
Shrew-mole	Generally Associated	Feeds and Breeds	High	None noted.
Silver-haired Bat	Generally Associated	Feeds	Low	None noted.
Snowshoe Hare	Generally Associated	Feeds and Breeds	High	None noted.
Striped Skunk	Generally Associated	Feeds and Breeds	Moderate	None noted.
Townsend's Big-eared Bat	Generally Associated	Feeds	Moderate	None noted.
Townsend's Chipmunk	Generally Associated	Feeds and Breeds	High	None noted.
Townsend's Mole	Generally Associated	Feeds and Breeds	High	None noted.
Townsend's Vole	Generally Associated	Feeds and Breeds	High	None noted.

Mammals Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Trowbridge's Shrew	Generally Associated	Feeds and Breeds	High	None noted.
Virginia Opossum	Generally Associated	Feeds and Breeds	Low	None noted.
Western Red-backed Vole	Generally Associated	Feeds and Breeds	High	None noted.
Western Spotted Skunk	Generally Associated	Feeds and Breeds	Low	None noted.
American Marten	Present	Feeds and Breeds	Moderate	None noted.
Brazilian Free-tailed Bat	Present	Feeds	Moderate	None noted.
Bushy-tailed Woodrat	Present	Feeds and Breeds	Moderate	None noted.
Heather Vole	Present	Feeds and Breeds	Moderate	None noted.
Masked Shrew	Present	Feeds and Breeds	Moderate	None noted.
Montane Shrew	Present	Feeds and Breeds	Moderate	None noted.
Red Tree Vole	Present	Feeds and Breeds	Moderate	None noted.
Vagrant Shrew	Present	Feeds and Breeds	Moderate	None noted.

Reptiles Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Common Garter Snake	Closely Associated	Feeds and Breeds	High	None noted.
Western Pond Turtle	Closely Associated	Feeds and Breeds	High	None noted.
Northern Alligator Lizard	Generally Associated	Feeds and Breeds	High	None noted.
Northwestern Garter Snake	Generally Associated	Feeds and Breeds	High	None noted.
Pacific Coast Aquatic Garter Snake	Generally Associated	Feeds and Breeds	High	None noted.
Painted Turtle	Generally Associated	Feeds and Breeds	Moderate	None noted.
Red-eared Slider Turtle	Generally Associated	Feeds and Breeds	Moderate	None noted.

Reptiles Associated with Westside Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Rubber Boa	Generally Associated	Feeds and Breeds	High	Usually does not occur far from water.
Sharptail Snake	Generally Associated	Feeds and Breeds	Moderate	None noted.
Snapping Turtle	Generally Associated	Feeds and Breeds	Moderate	Avoids flowing water that lacks vegetation.
Western Rattlesnake	Generally Associated	Feeds and Breeds	High	None noted.
Western Terrestrial Garter Snake	Generally Associated	Feeds and Breeds	High	None noted.
California Mountain Kingsnake	Present	Feeds and Breeds	Moderate	None noted.
Common Kingsnake	Present	Feeds and Breeds	Low	None noted.
Ringneck Snake	Present	Feeds and Breeds	Moderate	None noted.
Southern Alligator Lizard	Present	Feeds and Breeds	Moderate	None noted.

Wildlife Species Found in Montane Coniferous Wetlands

Amphibians Associated with Montane Coniferous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Long-toed Salamander	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish are occur. Requires ponds, shallow lake edges, seasonal pools (like elk wallows) or slow streams for breeding.
Northwestern Salamander	Closely Associated	Feeds and Breeds	High	Requires ponds or stream backwaters for breeding.
Pacific Chorus (Tree) Frog	Closely Associated	Feeds and Breeds	High	Requires ponds, seasonal pools, temporary rain-filled depressions or slow streams for breeding.
Rough-skinned Newt	Closely Associated	Feeds and Breeds	High	Requires ponds or stream backwaters with abundant aquatic vegetation for breeding.
Western Toad	Closely Associated	Feeds and Breeds	High	None noted.
Cascades Frog	Generally Associated	Feeds and Breeds	High	Requires bogs or ponds with cold springs for breeding.
Columbia Spotted Frog	Generally Associated	Feeds and Breeds	Moderate	Rare or absent where predatory fish or bullfrogs occur. Requires shallow water in wet meadows or stream/pond edges with abundant aquatic vegetation for breeding.
Oregon Spotted Frog	Present	Feeds and Breeds	High	Rare or absent where predatory fish or bullfrogs occur. Requires shallow water in wet meadows or stream/pond edges with abundant aquatic vegetation for breeding.
Pacific Giant Salamander	Present	Feeds and Breeds	High	Requires small to mid-sized streams with a streambed of gravel, boulders and large logs for breeding.
Red-legged Frog	Present	Feeds and Breeds	High	Requires cool-water ponds, lake edges or slow streams for breeding.

Birds Associated with Montane Coniferous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Bufflehead	Closely Associated	Feeds and Breeds	Moderate	Nests in tree cavities.
Evening Grosbeak	Closely Associated	Feeds and Breeds	Moderate	None noted.
American Robin	Generally Associated	Feeds and Breeds	High	None noted.
Barrow's Goldeneye	Generally Associated	Feeds and Breeds	Moderate	Nests in tree cavities.
Black Swift	Generally Associated	Feeds	Low	Black swifts are long-distance foragers that may travel many miles from breeding sites and take advantage of flying insects caught in updrafts over just about any habitat.
Black-backed Woodpecker	Generally Associated	Feeds and Breeds	Moderate	Reach highest densities in recently burned forests or areas of bark beetle infestations.
Blue Grouse	Generally Associated	Feeds and Breeds	Moderate	None noted.
Bohemian Waxwing	Generally Associated	Feeds	Moderate	There are a few confirmed records of breeding. Nesting habitat usually is beaver ponds and bog areas.
Boreal Chickadee	Generally Associated	Feeds and Breeds	Low	None noted.
Brown Creeper	Generally Associated	Feeds and Breeds	Moderate	None noted.
Calliope Hummingbird	Generally Associated	Feeds and Breeds	Moderate	None noted.
Cassin's Finch	Generally Associated	Feeds and Breeds	High	None noted.
Cedar Waxwing	Generally Associated	Feeds and Breeds	Moderate	None noted.
Chestnut-backed Chickadee	Generally Associated	Feeds and Breeds	Moderate	None noted.
Common Nighthawk	Generally Associated	Feeds	Moderate	None noted.
Common Raven	Generally Associated	Feeds and Breeds	High	None noted.
Common Redpoll	Generally Associated	Feeds	Moderate	None noted.
Cooper's Hawk	Generally Associated	Feeds and Breeds	High	None noted.
Dark-eyed Junco	Generally Associated	Feeds and Breeds	High	None noted.

Birds Associated with Montane Coniferous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Dusky Flycatcher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Golden-crowned Kinglet	Generally Associated	Feeds and Breeds	High	None noted.
Gray Jay	Generally Associated	Feeds and Breeds	High	None noted.
Great Gray Owl	Generally Associated	Feeds and Breeds	High	None noted.
Hairy Woodpecker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Hermit Thrush	Generally Associated	Feeds and Breeds	High	None noted.
Hermit Warbler	Generally Associated	Feeds and Breeds	Moderate	None noted.
Macgillivray's Warbler	Generally Associated	Feeds and Breeds	High	None noted.
Mountain Chickadee	Generally Associated	Feeds and Breeds	Moderate	None noted.
Nashville Warbler	Generally Associated	Feeds and Breeds	Moderate	None noted.
Northern Flicker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Northern Goshawk	Generally Associated	Feeds and Breeds	High	None noted.
Northern Pygmy-owl	Generally Associated	Feeds and Breeds	Low	None noted.
Northern Saw-whet Owl	Generally Associated	Feeds and Breeds	Moderate	None noted.
Olive-sided Flycatcher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Pacific-slope Flycatcher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Peregrine Falcon	Generally Associated	Feeds	High	None noted.
Pileated Woodpecker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Pine Grosbeak	Generally Associated	Feeds and Breeds	Moderate	None noted.
Pine Siskin	Generally Associated	Feeds and Breeds	High	None noted.
Red Crossbill	Generally Associated	Feeds and Breeds	Moderate	None noted.

Birds Associated with Montane Coniferous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Red-breasted Nuthatch	Generally Associated	Feeds and Breeds	Moderate	None noted.
Red-breasted Sapsucker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Ruby-crowned Kinglet	Generally Associated	Feeds and Breeds	High	None noted.
Ruffed Grouse	Generally Associated	Feeds and Breeds	Moderate	None noted.
Rufous Hummingbird	Generally Associated	Feeds and Breeds	Moderate	None noted.
Song Sparrow	Generally Associated	Feeds and Breeds	Moderate	None noted.
Spruce Grouse	Generally Associated	Feeds and Breeds	High	Uses this habitat where adjacent to lodgepole alpine forest.
Steller's Jay	Generally Associated	Feeds and Breeds	Moderate	None noted.
Swainson's Thrush	Generally Associated	Feeds and Breeds	High	None noted.
Three-toed Woodpecker	Generally Associated	Feeds and Breeds	Moderate	Reach highest densities in recently burned forests or areas of bark beetle infestations.
Townsend's Warbler	Generally Associated	Feeds and Breeds	Moderate	None noted.
Tree Swallow	Generally Associated	Feeds and Breeds	Moderate	Requires snags not far from open water for nesting.
Varied Thrush	Generally Associated	Feeds and Breeds	Moderate	None noted.
Vaux's Swift	Generally Associated	Feeds and Breeds	Moderate	None noted.
Violet-green Swallow	Generally Associated	Feeds and Breeds	Moderate	None noted.
Warbling Vireo	Generally Associated	Feeds and Breeds	Low	None noted.
Western Tanager	Generally Associated	Feeds and Breeds	Moderate	None noted.
Williamson's Sapsucker	Generally Associated	Feeds and Breeds	Low	None noted.
Willow Flycatcher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Wilson's Warbler	Generally Associated	Feeds and Breeds	High	None noted.

Birds Associated with Montane Coniferous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Winter Wren	Generally Associated	Feeds and Breeds	Moderate	None noted.
Yellow-rumped Warbler	Generally Associated	Feeds and Breeds	Moderate	None noted.
American Crow	Present	Feeds and Breeds	High	None noted.
American Kestrel	Present	Feeds and Breeds	Moderate	None noted.
Barn Swallow	Present	Feeds and Breeds	Moderate	Can nest anywhere buildings, bridges, or overhanging cliffs occur in close proximity to water.
Brown-headed Cowbird	Present	Feeds and Breeds	Moderate	None noted.
Chipping Sparrow	Present	Feeds and Breeds	Low	None noted.
Clark's Nutcracker	Present	Feeds	Low	None noted.
European Starling	Present	Feeds and Breeds	Low	Requires snags or trees with cavities or buildings with crevices for nesting. Most likely to use this habitat where adjacent to agriculture or urban habitats.
Great Horned Owl	Present	Feeds and Breeds	High	None noted.
Merlin	Present	Feeds	Low	None noted.
Mountain Bluebird	Present	Feeds and Breeds	Moderate	None noted.
Northern Rough-winged Swallow	Present	Feeds	Moderate	Requires burrows in dirt banks, usually next to water, for nesting.
Turkey Vulture	Present	Feeds and Breeds	Low	Requires rocky outcrops, small caves, boulder piles, ledges on high cliffs or large hollow logs for nesting.
Western Screech-owl	Present	Feeds and Breeds	Moderate	None noted.
White-winged Crossbill	Present	Feeds and Breeds	Moderate	None noted.
Wood Duck	Present	Feeds and Breeds	Moderate	Nests in tree cavities.

Mammals Associated with Montane Coniferous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Big Brown Bat	Closely Associated	Feeds and Breeds	High	Requires snags, caves, mines, rock crevices, or bridges for breeding and roosting.
Deer Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Long-tailed Vole	Closely Associated	Feeds and Breeds	High	None noted.
Pacific Jumping Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Snowshoe Hare	Closely Associated	Feeds and Breeds	High	None noted.
Southern Red-backed Vole	Closely Associated	Feeds and Breeds	High	None noted.
Water Shrew	Closely Associated	Feeds and Breeds	High	Lead a semi-aquatic life and require cold, clear water in small streams or ponds with abundant cover in the form of rocks, overhanging banks, etc.
Water Vole	Closely Associated	Feeds and Breeds	Low	None noted.
Yuma Myotis	Closely Associated	Feeds and Breeds	High	More closely associated with water than other bat species. Uses caves, mines, loose bark and bark crevices typically close to water.
American Beaver	Generally Associated	Feeds and Breeds	High	None noted.
American Marten	Generally Associated	Feeds and Breeds	Moderate	None noted.
Black Bear	Generally Associated	Feeds and Breeds	High	None noted.
Black-tailed Deer	Generally Associated	Feeds and Breeds	High	None noted.
Bobcat	Generally Associated	Feeds	Moderate	None noted.
Bushy-tailed Woodrat	Generally Associated	Feeds and Breeds	Moderate	None noted.
California Myotis	Generally Associated	Feeds and Breeds	High	Uses rock crevices, hollow trees, mines or caves for breeding.
Columbian Ground Squirrel	Generally Associated	Feeds and Breeds	Moderate	None noted.
Columbian Mouse	Generally Associated	Feeds and Breeds	High	None noted.

Mammals Associated with Montane Coniferous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Common Porcupine	Generally Associated	Feeds and Breeds	Moderate	None noted.
Coyote	Generally Associated	Feeds and Breeds	High	None noted.
Creeping Vole	Generally Associated	Feeds and Breeds	High	None noted.
Fisher	Generally Associated	Feeds and Breeds	Low	None noted.
Golden-mantled Ground Squirrel	Generally Associated	Feeds and Breeds	Moderate	None noted.
Hoary Bat	Generally Associated	Feeds	Low	Requires trees for roosting, but forages in openings and at edges of forests.
Little Brown Myotis	Generally Associated	Feeds	High	Uses caves, mines, or hollow trees, often near water.
Long-eared Myotis	Generally Associated	Feeds and Breeds	Moderate	Uses caves, mines, hollow trees, loose bark or rock crevices.
Long-tailed Weasel	Generally Associated	Feeds and Breeds	Moderate	None noted.
Mink	Generally Associated	Feeds and Breeds	Moderate	None noted.
Montane Vole	Generally Associated	Feeds and Breeds	High	None noted.
Moose	Generally Associated	Feeds and Breeds	Moderate	None noted.
Mountain Caribou	Generally Associated	Feeds and Breeds	High	None noted.
Mountain Lion	Generally Associated	Feeds	High	None noted.
Mule Deer	Generally Associated	Feeds and Breeds	High	None noted.
Northern Bog Lemming	Generally Associated	Feeds and Breeds	Moderate	None noted.
Northern Flying Squirrel	Generally Associated	Feeds and Breeds	High	None noted.
Northern Pocket Gopher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Pacific Water Shrew	Generally Associated	Feeds and Breeds	High	Closely tied to water.
Rocky Mountain Elk	Generally Associated	Feeds and Breeds	High	None noted.

Mammals Associated with Montane Coniferous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Roosevelt Elk	Generally Associated	Feeds and Breeds	High	None noted.
Shrew-mole	Generally Associated	Feeds and Breeds	High	None noted.
Silver-haired Bat	Generally Associated	Feeds and Breeds	Moderate	Uses trees, bark crevices, and snags for summer roosts; if present in winter, may use caves, mines, or rock crevices for hibernacula.
Townsend's Big-eared Bat	Generally Associated	Feeds	Moderate	None noted.
Townsend's Chipmunk	Generally Associated	Feeds and Breeds	High	None noted.
Trowbridge's Shrew	Generally Associated	Feeds and Breeds	High	None noted.
Western Jumping Mouse	Generally Associated	Feeds and Breeds	Moderate	None noted.
Western Spotted Skunk	Generally Associated	Feeds and Breeds	Low	None noted.
Wolverine	Generally Associated	Feeds and Breeds	Low	None noted.
Coast Mole	Present	Feeds and Breeds	Moderate	None noted.
Ermine	Present	Feeds and Breeds	Low	None noted.
Fringed Myotis	Present	Feeds	Low	Requires caves, mines or rock crevices.
Grizzly Bear	Present	Feeds	Moderate	None noted.
Heather Vole	Present	Feeds and Breeds	Moderate	None noted.
Long-legged Myotis	Present	Feeds and Breeds	Moderate	Uses caves or mines as hibernacula. Uses hollow trees, loose bark or rock crevices for maternity colonies.
Lynx	Present	Feeds	Low	None noted.
Masked Shrew	Present	Feeds and Breeds	Moderate	None noted.
Montane Shrew	Present	Feeds and Breeds	Low	None noted.
Vagrant Shrew	Present	Feeds and Breeds	Moderate	None noted.

Reptiles Associated with Montane Coniferous Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Common Garter Snake	Closely Associated	Feeds and Breeds	Moderate	None noted.
Rubber Boa	Generally Associated	Feeds and Breeds	High	Usually does not occur far from water.

Wildlife Species Found in Eastside (Interior) Riparian -Wetlands

Amphibians Associated with Eastside (Interior) Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Bullfrog	Closely Associated	Feeds and Breeds	High	Requires warm-water ponds, marshes, or river/stream backwaters for breeding.
Columbia Spotted Frog	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish or bullfrogs occur. Requires shallow water in wet meadows or stream/pond edges with abundant aquatic vegetation for breeding.
Great Basin Spadefoot	Closely Associated	Feeds and Breeds	High	Requires ponds or temporary rain-filled depressions for breeding.
Long-toed Salamander	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish are occur. Requires ponds, shallow lake edges, seasonal pools (like elk wallows) or slow streams for breeding.
Northern Leopard Frog	Closely Associated	Feeds and Breeds	High	Requires ponds or lake edges with dense aquatic and emergent vegetation for breeding.
Pacific Chorus (Tree) Frog	Closely Associated	Feeds and Breeds	High	Requires ponds, seasonal pools, temporary rain-filled depressions or slow streams for breeding.
Tailed Frog	Closely Associated	Feeds and Breeds	Moderate	Requires clear, cold steep-gradient streams for breeding.
Tiger Salamander	Closely Associated	Feeds and Breeds	High	Rare or absent where predatory fish occur. Requires warm ponds or shallow lake edges for breeding.
Western Toad	Closely Associated	Feeds and Breeds	High	None noted.
Woodhouse's Toad	Closely Associated	Feeds and Breeds	High	Requires warm, shallow water in ponds, lakes, or slow streams for breeding.
Cascades Frog	Generally Associated	Feeds and Breeds	Moderate	Requires bogs or ponds with cold springs for breeding.
Northwestern Salamander	Present	Feeds and Breeds	High	Range extends only peripherally into the eastside Cascades in Washington only. Requires ponds or stream backwaters for breeding.
Red-legged Frog	Present	Feeds and Breeds	High	Range extends only peripherally into the eastside Cascades.

Amphibians Associated with Eastside (Interior) Riparian - Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Rough-skinned Newt	Present	Feeds and Breeds	High	Range doesn't extend very far east of Cascades. Needs ponds/backwaters & profuse aquatic vegetation breed.

Birds Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
American Black Duck	Closely Associated	Feeds and Breeds	Low	None noted.
American Dipper	Closely Associated	Feeds and Breeds	High	None noted.
American Redstart	Closely Associated	Feeds and Breeds	High	None noted.
Bank Swallow	Closely Associated	Feeds and Breeds	High	Requires burrows in dirt banks, usually next to water, for nesting.
Barn Swallow	Closely Associated	Feeds and Breeds	High	Can nest anywhere buildings, bridges, or overhanging cliffs occur in close proximity to water.
Belted Kingfisher	Closely Associated	Feeds and Breeds	High	None noted.
Black-billed Magpie	Closely Associated	Feeds and Breeds	High	None noted.
Black-crowned Night-heron	Closely Associated	Feeds and Breeds	High	Occur in wide bottomlands, not narrow canyons.
Blue Grouse	Closely Associated	Feeds and Breeds	High	None noted.
Bullock's Oriole	Closely Associated	Feeds and Breeds	Moderate	None noted.
Cedar Waxwing	Closely Associated	Feeds and Breeds	High	None noted.
Cliff Swallow	Closely Associated	Feeds and Breeds	Moderate	Can nest anywhere rimrock, overhanging cliffs, buildings or bridges occur in close proximity to water.
Common Merganser	Closely Associated	Feeds and Breeds	High	Nests in tree cavities near large lakes or rivers.
Common Yellowthroat	Closely Associated	Feeds and Breeds	High	None noted.
Cordilleran Flycatcher	Closely Associated	Feeds and Breeds	Moderate	None noted.
Double-crested Cormorant	Closely Associated	Feeds and Breeds	High	None noted.

Birds Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
European Starling	Closely Associated	Feeds and Breeds	High	Requires snags or trees with cavities or buildings with crevices for nesting. Most likely to use this habitat where adjacent to agriculture or urban habitats.
Fox Sparrow	Closely Associated	Feeds and Breeds	High	None noted.
Gray Catbird	Closely Associated	Feeds and Breeds	High	None noted.
Great Blue Heron	Closely Associated	Feeds and Breeds	High	None noted.
Great Egret	Closely Associated	Feeds and Breeds	High	More common in broad flood plains; does not occur in narrow riparian corridors as a breeder.
Harlequin Duck	Closely Associated	Feeds and Breeds	High	None noted.
Hooded Merganser	Closely Associated	Feeds and Breeds	Moderate	Nests in tree cavities.
Lazuli Bunting	Closely Associated	Feeds and Breeds	High	None noted.
Lincoln's Sparrow	Closely Associated	Feeds and Breeds	Moderate	None noted.
Long-eared Owl	Closely Associated	Feeds and Breeds	High	Typically nests in the abandoned nests of other corvids, raptors or squirrels.
Mallard	Closely Associated	Feeds and Breeds	High	None noted.
Mourning Dove	Closely Associated	Feeds and Breeds	High	None noted.
Northern Rough-winged Swallow	Closely Associated	Feeds and Breeds	High	Requires burrows in dirt banks, usually next to water, for nesting.
Northern Waterthrush	Closely Associated	Feeds and Breeds	High	None noted.
Pygmy Nuthatch	Closely Associated	Feeds and Breeds	Moderate	Uses this habitat where ponderosa pine occurs.
Red-eyed Vireo	Closely Associated	Feeds and Breeds	Moderate	Range of red-eyed vireo overlaps that of large black cottonwood groves.
Red-naped Sapsucker	Closely Associated	Feeds and Breeds	High	None noted.
Ring-necked Pheasant	Closely Associated	Feeds and Breeds	High	None noted.

Birds Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Ruffed Grouse	Closely Associated	Feeds and Breeds	High	None noted.
Sharp-tailed Grouse	Closely Associated	Feeds	High	In Oregon this was historically very important overwintering habitat.
Snowy Egret	Closely Associated	Feeds and Breeds	High	Requires tall shrubs or trees for nesting.
Solitary Sandpiper	Closely Associated	Feeds	Moderate	None noted.
Spotted Sandpiper	Closely Associated	Feeds and Breeds	Moderate	None noted.
Tree Swallow	Closely Associated	Feeds and Breeds	Moderate	Requires snags not far from open water for nesting.
Veery	Closely Associated	Feeds and Breeds	High	None noted.
Warbling Vireo	Closely Associated	Feeds and Breeds	High	None noted.
Western Screech-owl	Closely Associated	Feeds and Breeds	High	None noted.
Willow Flycatcher	Closely Associated	Feeds and Breeds	Moderate	None noted.
Wood Duck	Closely Associated	Feeds and Breeds	High	Nests in tree cavities.
Yellow Warbler	Closely Associated	Feeds and Breeds	High	None noted.
Yellow-billed Cuckoo	Closely Associated	Feeds and Breeds	Moderate	Not known from eastside Washington (even historically); in Oregon species may still occur in a few scattered locations.
Yellow-breasted Chat	Closely Associated	Feeds and Breeds	Moderate	None noted.
American Crow	Generally Associated	Feeds and Breeds	High	None noted.
American Goldfinch	Generally Associated	Feeds and Breeds	High	None noted.
American Kestrel	Generally Associated	Feeds and Breeds	High	None noted.
American Robin	Generally Associated	Feeds and Breeds	High	None noted.
American Tree Sparrow	Generally Associated	Feeds	Moderate	None noted.
Bald Eagle	Generally Associated	Feeds and Breeds	High	None noted.

Birds Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Barn Owl	Generally Associated	Feeds and Breeds	High	Requires cliffs, caves, rimrock, or tree cavities for nesting.
Black Swift	Generally Associated	Feeds and Breeds	Low	Requires suitable cliffs behind waterfalls for breeding.
Black-capped Chickadee	Generally Associated	Feeds and Breeds	Moderate	None noted.
Black-chinned Hummingbird	Generally Associated	Feeds and Breeds	Low	None noted.
Black-headed Grosbeak	Generally Associated	Feeds and Breeds	High	None noted.
Black-throated Gray Warbler	Generally Associated	Feeds and Breeds	Low	None noted.
Bobolink	Generally Associated	Feeds and Breeds	Moderate	None noted.
Bohemian Waxwing	Generally Associated	Feeds	Moderate	None noted.
Brewer's Blackbird	Generally Associated	Feeds and Breeds	Moderate	None noted.
Broad-tailed Hummingbird	Generally Associated	Feeds and Breeds	Low	High elevation, montane riparian. Breeding suspected but not confirmed. Birds have been found in eastside riparian aspen and willow habitats.
Brown Creeper	Generally Associated	Feeds and Breeds	Moderate	None noted.
Brown-headed Cowbird	Generally Associated	Feeds and Breeds	High	None noted.
Bufflehead	Generally Associated	Feeds and Breeds	Moderate	Nests in tree cavities.
Bushtit	Generally Associated	Feeds and Breeds	Moderate	None noted.
California Quail	Generally Associated	Feeds and Breeds	High	Uses this habitat where adjacent to more open habitats.
Calliope Hummingbird	Generally Associated	Feeds and Breeds	Moderate	None noted.
Canyon Wren	Generally Associated	Feeds and Breeds	Moderate	Requires rocky outcrops, cliffs for nesting.
Cassin's Finch	Generally Associated	Feeds and Breeds	High	None noted.
Cassin's Vireo	Generally Associated	Feeds and Breeds	Moderate	None noted.

Birds Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Cattle Egret	Generally Associated	Feeds and Breeds	High	Requires shrubs or trees for nesting.
Chipping Sparrow	Generally Associated	Feeds and Breeds	Moderate	None noted.
Common Nighthawk	Generally Associated	Feeds	Moderate	None noted.
Common Raven	Generally Associated	Feeds and Breeds	High	None noted.
Common Redpoll	Generally Associated	Feeds	Moderate	None noted.
Cooper's Hawk	Generally Associated	Feeds and Breeds	High	None noted.
Dark-eyed Junco	Generally Associated	Feeds and Breeds	High	None noted.
Downy Woodpecker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Dusky Flycatcher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Eastern Kingbird	Generally Associated	Feeds and Breeds	Moderate	Requires groves of hardwoods for breeding.
Evening Grosbeak	Generally Associated	Feeds and Breeds	Moderate	None noted.
Flammulated Owl	Generally Associated	Feeds and Breeds	Moderate	Must have ponderosa pine/aspen.
Golden Eagle	Generally Associated	Feeds and Breeds	High	Needs cliffs for nesting.
Golden-crowned Kinglet	Generally Associated	Feeds and Breeds	Moderate	None noted.
Golden-crowned Sparrow	Generally Associated	Feeds	Moderate	None noted.
Gray Jay	Generally Associated	Feeds and Breeds	Moderate	None noted.
Great Horned Owl	Generally Associated	Feeds and Breeds	High	None noted.
Greater Yellowlegs	Generally Associated	Feeds	Low	None noted.
Green-winged Teal	Generally Associated	Feeds	High	None noted.
Hairy Woodpecker	Generally Associated	Feeds and Breeds	Moderate	None noted.

Birds Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Hermit Thrush	Generally Associated	Feeds and Breeds	High	None noted.
House Wren	Generally Associated	Feeds and Breeds	Moderate	None noted.
Killdeer	Generally Associated	Feeds and Breeds	Moderate	None noted.
Least Flycatcher	Generally Associated	Feeds and Breeds	Low	Has bred regularly at Clyde Holiday State Wayside, Grant County, Oregon, and numerous singing males have been found in eastside hardwood riparian habitats in Washington.
Lesser Yellowlegs	Generally Associated	Feeds	Low	None noted.
Lewis's Woodpecker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Macgillivray's Warbler	Generally Associated	Feeds and Breeds	High	None noted.
Mountain Bluebird	Generally Associated	Feeds and Breeds	Moderate	None noted.
Mountain Chickadee	Generally Associated	Feeds and Breeds	Moderate	None noted.
Mountain Quail	Generally Associated	Feeds and Breeds	High	None noted.
Nashville Warbler	Generally Associated	Feeds and Breeds	High	None noted.
Northern Flicker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Northern Goshawk	Generally Associated	Feeds and Breeds	High	None noted.
Northern Pygmy-owl	Generally Associated	Feeds and Breeds	High	None noted.
Olive-sided Flycatcher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Orange-crowned Warbler	Generally Associated	Feeds and Breeds	High	None noted.
Osprey	Generally Associated	Feeds and Breeds	High	None noted.
Peregrine Falcon	Generally Associated	Feeds and Breeds	High	Needs cliffs for nesting.
Pied-billed Grebe	Generally Associated	Feeds and Breeds	High	None noted.

Birds Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Pileated Woodpecker	Generally Associated	Feeds and Breeds	Moderate	None noted.
Pine Siskin	Generally Associated	Feeds and Breeds	High	None noted.
Red-breasted Nuthatch	Generally Associated	Feeds and Breeds	Moderate	None noted.
Red-breasted Sapsucker	Generally Associated	Feeds and Breeds	Moderate	Only in south-central Oregon: may hybridize with Red-naped sapsucker in Eastside riparian.
Red-tailed Hawk	Generally Associated	Feeds and Breeds	High	None noted.
Red-winged Blackbird	Generally Associated	Feeds and Breeds	High	None noted.
Ring-necked Duck	Generally Associated	Feeds and Breeds	High	None noted.
Rufous Hummingbird	Generally Associated	Feeds and Breeds	Moderate	None noted.
Sandhill Crane	Generally Associated	Feeds and Breeds	High	Uses open riparian areas with only scattered willows or willow clumps.
Savannah Sparrow	Generally Associated	Feeds and Breeds	Moderate	None noted.
Say's Phoebe	Generally Associated	Feeds and Breeds	Moderate	Needs cliffs or rimrock for nesting.
Song Sparrow	Generally Associated	Feeds and Breeds	High	None noted.
Spotted Towhee	Generally Associated	Feeds and Breeds	Moderate	None noted.
Steller's Jay	Generally Associated	Feeds and Breeds	Moderate	None noted.
Swainson's Hawk	Generally Associated	Feeds and Breeds	High	None noted.
Swainson's Thrush	Generally Associated	Feeds and Breeds	High	None noted.
Townsend's Solitaire	Generally Associated	Feeds	Moderate	None noted.
Turkey Vulture	Generally Associated	Feeds and Breeds	High	Requires rocky outcrops, small caves, boulder piles, ledges on high cliffs or large hollow logs for nesting.
Violet-green Swallow	Generally Associated	Feeds and Breeds	Moderate	None noted.

Birds Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Western Bluebird	Generally Associated	Feeds and Breeds	High	None noted.
Western Tanager	Generally Associated	Feeds and Breeds	Moderate	None noted.
Western Wood-pewee	Generally Associated	Feeds and Breeds	Moderate	None noted.
White-breasted Nuthatch	Generally Associated	Feeds and Breeds	Moderate	Uses this habitat where ponderosa pine and hardwoods occur in the riparian zone.
White-crowned Sparrow	Generally Associated	Feeds and Breeds	High	None noted.
White-headed Woodpecker	Generally Associated	Feeds and Breeds	Low	Requires a ponderosa pine component.
White-throated Swift	Generally Associated	Feeds	Low	May use riparian areas as travel corridors.
Wild Turkey	Generally Associated	Feeds and Breeds	High	None noted.
Williamson's Sapsucker	Generally Associated	Feeds and Breeds	Low	None noted.
Wilson's Warbler	Generally Associated	Feeds and Breeds	High	None noted.
Winter Wren	Generally Associated	Feeds and Breeds	Moderate	None noted.
Yellow-rumped Warbler	Generally Associated	Feeds and Breeds	Moderate	None noted.
American Wigeon	Present	Feeds	Moderate	None noted.
Ash-throated Flycatcher	Present	Feeds and Breeds	Low	None noted.
Band-tailed Pigeon	Present	Feeds	Moderate	None noted.
Barred Owl	Present	Feeds and Breeds	Moderate	None noted.
Black-backed Woodpecker	Present	Feeds and Breeds	Moderate	None noted.
Canada Goose	Present	Feeds and Breeds	Moderate	None noted.
Chukar	Present	Feeds	Moderate	None noted.
Green-tailed Towhee	Present	Feeds and Breeds	Moderate	None noted.
House Finch	Present	Feeds and Breeds	Moderate	Uses this habitat where it is not too far from urban or agricultural areas.

Birds Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Lesser Goldfinch	Present	Feeds and Breeds	Moderate	None noted.
Merlin	Present	Feeds	Low	None noted.
Northern Harrier	Present	Feeds and Breeds	High	None noted.
Northern Saw-whet Owl	Present	Feeds and Breeds	Low	None noted.
Prairie Falcon	Present	Feeds and Breeds	High	Needs cliffs for nesting.
Red Crossbill	Present	Feeds	Low	None noted.
Rough-legged Hawk	Present	Feeds	High	None noted.
Ruby-crowned Kinglet	Present	Feeds and Breeds	Moderate	None noted.
Three-toed Woodpecker	Present	Feeds and Breeds	Moderate	None noted.
Townsend's Warbler	Present	Feeds and Breeds	Low	Heavy use during migration, and occasional breeding where conifers are present.
Vaux's Swift	Present	Feeds and Breeds	Low	None noted.

Mammals Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
American Beaver	Closely Associated	Feeds and Breeds	High	None noted.
Big Brown Bat	Closely Associated	Feeds and Breeds	High	Requires snags, caves, mines, rock crevices, or bridges for breeding and roosting.
Bushy-tailed Woodrat	Closely Associated	Feeds and Breeds	High	None noted.
Deer Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Long-legged Myotis	Closely Associated	Feeds and Breeds	Moderate	Uses caves or mines as hibernacula. Uses hollow trees, loose bark or rock crevices for maternity colonies.
Long-tailed Vole	Closely Associated	Feeds and Breeds	High	None noted.
Meadow Vole	Closely Associated	Feeds and Breeds	Low	None noted.
Mink	Closely Associated	Feeds and Breeds	Moderate	None noted.

Mammals Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Muskrat	Closely Associated	Feeds and Breeds	Moderate	None noted.
Northern River Otter	Closely Associated	Feeds and Breeds	High	None noted.
Pacific Jumping Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Pallid Bat	Closely Associated	Feeds and Breeds	Moderate	Requires rock cliffs, caves or mines for breeding.
Raccoon	Closely Associated	Feeds and Breeds	Moderate	None noted.
Snowshoe Hare	Closely Associated	Feeds and Breeds	High	None noted.
Southern Red-backed Vole	Closely Associated	Feeds and Breeds	High	None noted.
Water Shrew	Closely Associated	Feeds and Breeds	High	Lead a semi-aquatic life and require cold, clear water in small streams or ponds with abundant cover in the form of rocks, overhanging banks, etc.
Water Vole	Closely Associated	Feeds and Breeds	Low	None noted.
Western Harvest Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Western Jumping Mouse	Closely Associated	Feeds and Breeds	High	None noted.
Western Pipistrelle	Closely Associated	Feeds and Breeds	High	Requires cliffs, rimrock, caves or mines for breeding and roosting.
Western Small-footed Myotis	Closely Associated	Feeds and Breeds	Moderate	Requires cliffs, rimrock, boulders, or talus for breeding.
White-tailed Deer (Eastside)	Closely Associated	Feeds and Breeds	High	None noted.
Yuma Myotis	Closely Associated	Feeds and Breeds	High	More closely associated with water than other bat species. Uses caves, mines, loose bark and bark crevices typically close to water.
Black Bear	Generally Associated	Feeds and Breeds	High	None noted.
Black-tailed Deer	Generally Associated	Feeds and Breeds	High	None noted.
Bobcat	Generally Associated	Feeds and Breeds	Moderate	None noted.
Broad-footed Mole	Generally Associated	Feeds and Breeds	Moderate	None noted.

Mammals Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Brush Rabbit	Generally Associated	Feeds and Breeds	Moderate	None noted.
California Myotis	Generally Associated	Feeds and Breeds	High	Uses rock crevices, hollow trees, mines or caves for breeding.
Columbian Ground Squirrel	Generally Associated	Feeds and Breeds	Moderate	None noted.
Columbian Mouse	Generally Associated	Feeds and Breeds	Moderate	None noted.
Common Porcupine	Generally Associated	Feeds and Breeds	Moderate	None noted.
Coyote	Generally Associated	Feeds and Breeds	High	None noted.
Creeping Vole	Generally Associated	Feeds and Breeds	High	None noted.
Eastern Cottontail	Generally Associated	Feeds and Breeds	Low	Likely uses this habitat where adjacent to urban or agricultural habitats.
Eastern Fox Squirrel	Generally Associated	Feeds and Breeds	Moderate	None noted.
Ermine	Generally Associated	Feeds and Breeds	Low	None noted.
Feral Horse	Generally Associated	Feeds	Low	None noted.
Feral Pig	Generally Associated	Feeds and Breeds	Moderate	None noted.
Fisher	Generally Associated	Feeds and Breeds	Low	None noted.
Fringed Myotis	Generally Associated	Feeds and Breeds	Low	Requires caves, mines or rock crevices.
Hoary Bat	Generally Associated	Feeds	Moderate	Requires trees for roosting, but forages in openings and at edges of forests.
Little Brown Myotis	Generally Associated	Feeds and Breeds	High	Uses caves, mines, or hollow trees, often near water.
Long-eared Myotis	Generally Associated	Feeds and Breeds	Moderate	Uses caves, mines, hollow trees, loose bark or rock crevices.
Long-tailed Weasel	Generally Associated	Feeds and Breeds	Moderate	None noted.
Masked Shrew	Generally Associated	Feeds and Breeds	High	None noted.
Montane Vole	Generally Associated	Feeds and Breeds	High	None noted.

Mammals Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Moose	Generally Associated	Feeds and Breeds	High	None noted.
Mountain Caribou	Generally Associated	Feeds and Breeds	High	None noted.
Mountain Lion	Generally Associated	Feeds and Breeds	High	None noted.
Mule Deer	Generally Associated	Feeds and Breeds	High	None noted.
Northern Flying Squirrel	Generally Associated	Feeds and Breeds	High	None noted.
Northern Pocket Gopher	Generally Associated	Feeds and Breeds	Moderate	None noted.
Pacific Water Shrew	Generally Associated	Feeds and Breeds	Moderate	Closely tied to water.
Red Fox	Generally Associated	Feeds and Breeds	Low	Non-native Red fox.
Rocky Mountain Elk	Generally Associated	Feeds and Breeds	High	None noted.
Shrew-mole	Generally Associated	Feeds and Breeds	High	None noted.
Silver-haired Bat	Generally Associated	Feeds and Breeds	Moderate	Uses trees, bark crevices, and snags for summer roosts; if present in winter, may use caves, mines, or rock crevices for hibernacula.
Spotted Bat	Generally Associated	Feeds and Breeds	Moderate	Requires clliffs for breeding.
Striped Skunk	Generally Associated	Feeds and Breeds	Moderate	None noted.
Townsend's Big-eared Bat	Generally Associated	Feeds	Moderate	None noted.
Trowbridge's Shrew	Generally Associated	Feeds and Breeds	High	None noted.
Virginia Opossum	Generally Associated	Feeds and Breeds	Low	None noted.
Western Spotted Skunk	Generally Associated	Feeds and Breeds	Low	None noted.
Wild Burro	Generally Associated	Feeds	Low	None noted.
Yellow-bellied Marmot	Generally Associated	Feeds and Breeds	Moderate	Requires talus slopes, lava fields, rimrock, or boulder fields in close proximity to grassy openings or meadows.

Mammals Associated with Eastside (Interior) Riparian -Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Yellow-pine Chipmunk	Generally Associated	Feeds and Breeds	Moderate	None noted.
American Badger	Present	Feeds	Moderate	None noted.
American Marten	Present	Feeds and Breeds	Moderate	None noted.
Coast Mole	Present	Feeds and Breeds	Moderate	None noted.
Golden-mantled Ground Squirrel	Present	Feeds and Breeds	Moderate	None noted.
Grizzly Bear	Present	Feeds	Moderate	None noted.
Heather Vole	Present	Feeds and Breeds	Moderate	None noted.
Least Chipmunk	Present	Feeds and Breeds	Low	None noted.
Montane Shrew	Present	Feeds and Breeds	Moderate	None noted.
Preble's Shrew	Present	Feeds and Breeds	Low	None noted.
Pronghorn Antelope	Present	Feeds	Moderate	None noted.
Vagrant Shrew	Present	Feeds and Breeds	Moderate	None noted.
White-tailed Jackrabbit	Present	Feeds and Breeds	Moderate	None noted.

Reptiles Associated with Eastside (Interior) Riparian-Wetlands				
Species (alphabetically by common name within each association)	**Association**	**Activity**	**Confidence**	**Comments**
Common Garter Snake	Closely Associated	Feeds and Breeds	High	None noted.
Gopher Snake	Generally Associated	Feeds and Breeds	High	None noted.
Northern Alligator Lizard	Generally Associated	Feeds and Breeds	High	None noted.
Painted Turtle	Generally Associated	Feeds and Breeds	Moderate	None noted.
Racer	Generally Associated	Feeds and Breeds	High	None noted.
Rubber Boa	Generally Associated	Feeds and Breeds	High	Usually does not occur far from water.
Sharptail Snake	Generally Associated	Feeds and Breeds	Moderate	None noted.
Western Rattlesnake	Generally Associated	Feeds and Breeds	High	None noted.
Western Terrestrial Garter Snake	Generally Associated	Feeds and Breeds	High	None noted.
Southern Alligator Lizard	Present	Feeds and Breeds	Low	None noted.

FACET

Critical Areas Ordinance Update

Gap Analysis

CITY OF WALLA WALLA

JUNE 26, 2026

Prepared for:

City of Walla Walla
15 N. Third Avenue
Walla Walla, WA 99362

Facet Number:
2507.0393.00

FACET

Spokane Office
601 W Main Ave, Suite 617
Spokane, WA 99201
509.606.3600

The information contained in this report is based on the application of technical guidelines currently accepted as the best available science. All discussions, conclusions and recommendations reflect the best professional judgment of the author(s) and are based upon information available at the time the study was conducted. All work was completed within the constraints of budget, scope, and timing. The findings of this report are subject to verification and agreement by the appropriate local, state, and federal regulatory authorities. No other warranty, expressed or implied, is made.

Table of Contents

1. Introduction 1

1.1 Report Structure 1

2. General Provisions (WWMC 21.04.005-21.04.140) 2

2.1 Purpose (21.04.005) 3

2.2 Applicability (21.04.015) 3

2.3 Definitions (21.04.020) 4

2.4 Critical Area Maps (21.04.035) 6

2.5 Reasonable Use (21.04.090) 6

2.6 Mitigation Requirements (21.04.105) 7

2.7 Mitigation Plan Requirements (21.04.115) 7

2.8 Building setback (21.04.130) 8

3. Critical Aquifer Recharge Areas (WWMC 21.04.200-260) 8

3.1 Critical aquifer recharge areas—Designation (21.04.200) 8

3.2 Mapping of critical aquifer recharge areas (21.04.210) 9

3.3 Activities allowed in critical aquifer recharge areas (21.04.220) 9

3.4 Critical Area Report—Additional requirements for critical aquifer recharge areas (21.04.230) 9

3.5 Uses prohibited in critical aquifer recharge areas (21.04.260) 9

4. Wetlands (WWMC 21.04.300-350) 10

4.1 Mapping of wetlands (21.04.310) 11

4.2 Critical areas report – Additional requirements for wetland areas (21.04.320) 11

4.3 Performance standards – General requirements (21.04.340) 11

4.4 Performance standards – Wetland buffer decrease (21.04.344) 13

4.5 Performance standards – Buffer management plan (21.04.345) 17

4.6 Performance standards – Specific activities and uses (21.04.346) 17

4.7 Performance standards – Mitigation requirements (21.04.347) 17

5. Mapping of Frequently Flooded Areas (WWMC 21.04.400) 18

5.1 FFA Mapping-Commerce Guidelines (21.04.400-420) 18

5.1.1 Frequently Flooded Areas Designation (21.04.400 NEW) 18

5.1.2 Mapping of Frequently Flooded Areas (21.04.410 NEW #) 18

5.1.3 Frequently Flooded Areas Regulation (21.04.420 NEW) 18

6. Geologically Hazardous Areas (WWMC 21.04.500-21.04.560) 19

6.1 Geologically hazardous areas—Designation (21.04.500) 20

6.2 Mapping of geologically hazardous areas (21.04.510) 22

7. Fish and Wildlife Habitat Conservation Areas(WWMC 21.04.610) 22
7.1 Fish and Wildlife Habitat Conservation Areas – Designation (21.04.600) 23
7.2 Fish and Wildlife Habitat Conservation Areas – Mapping (21.04.610) 23
7.3 Critical area report – Additional requirements for habitat conservation areas (21.04.630) 24
7.4 Performance standards—Specific habitats. (21.04.650) 24
Other Stream Management Recommendations 25
7.5 Performance standards—Subdivisions (21.04.660) 27
7.6 Fish and wildlife habitat conservation areas – Piped streams (21.04.670) 27
8. References 28

Tables

Table 1. General Provisions review summary. 2
Table 2. Critical Aquifer Recharge Areas review summary. 8
Table 3. Wetlands review summary. 10
Table 4. Frequently Flooded Areas Review Summary. 18
Table 5. Geologically Hazardous Areas review summary 19
Table 6. Fish and Wildlife Habitat Conservation Areas review summary 22

Appendices

Appendix A-Guidance on Widths of Buffers (2018 and 2022)

Appendix B - Ratios for Compensatory Mitigation for Use with the Eastern Washington Wetland Rating System (2018 and 2022)

Appendix C – FEMA Flood Study Update Maps (2026)

1. INTRODUCTION

With the passage of the Growth Management Act (GMA), local jurisdictions throughout Washington State, including City of Walla Walla (City), were required to develop policies and regulations to designate and protect critical areas. The GMA and the Revised Code of Washington (RCW) 36.70A.030(11) define critical areas as wetlands, fish and wildlife habitat conservation areas, frequently flooded areas, critical aquifer recharge areas, and geologically hazardous areas. The GMA requires local jurisdictions to periodically review and evaluate their adopted policies and regulations regarding critical areas.

City of Walla Walla adopted the most recent critical areas ordinance (CAO) in 2019. According to the Washington Administrative Code (WAC) 365-195-915, critical area regulations must incorporate best available science (BAS), and any deviations from science-based recommendations must be identified, assessed, and explained. In addition, jurisdictions must give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries. A BAS review for this code update has been prepared as a separate document (Facet 2026).

City of Walla Walla's critical areas ordinance is codified in Chapter 21.04 of the City of Walla Walla's Municipal Code (WWMC). This gap analysis reviews the current critical areas regulations and evaluates gaps in consistency between them and BAS or the GMA. It also includes recommendations for improvements to general aspects of the CAO, such as clarity, consistency, and ease of use. The primary intention of this gap analysis is to help guide the update of the City's critical areas policies and regulations.

1.1 Report Structure

Sections 2 through 7 provide recommendations for updating the City's existing critical areas regulations. Section 2 addresses the general provisions applicable to all critical areas; Sections 3 through 7 address the different types of critical areas covered by the GMA, organized according to their organization in the current code. Each section contains a summary table of recommendations followed by a detailed analysis of the existing code, potential gaps, and recommendations.

2. GENERAL PROVISIONS (WWMC 21.04.005-21.04.140)

This section addresses provisions applicable to all types of critical areas as described in WWMC 21.04.005-21.04.140. Table 1 summarizes the recommended updates.

Table 1. General Provisions review summary.

Code Section	Title	Review Comment and Recommendations	Reason for Recommendation
21.04.005	Purpose	Add No Net Loss and special consideration for anadromous fish	Consistency
21.04.010	Authority	No comments or suggestions	
21.04.015	Applicability	Make Figure 1 more legible or remove it.	Legibility
21.04.020	Definitions	1. Add all critical area definitions consistent with the WAC. 2. Review critical area designations against definitions.	1. Clarity 2. Consistency
21.04.025	Severability	No comments or suggestions	
21.04.030	Jurisdiction – Critical areas	No comments or suggestions	
21.04.035	Critical area maps	Ensure maps are updated accordingly.	Clarity
21.04.040	Best available science	No comments or suggestions	
21.04.045	Administrative procedures	No comments or suggestions	
21.04.050	Fees	No comments or suggestions	
21.04.055	Administrative rules	No comments or suggestions	
21.04.060	Permit processing	No comments or suggestions	
21.04.065	Appeals	No comments or suggestions	
21.04.070	Interpretation	No comments or suggestions	
21.04.075	Relationship to other regulations	No comments or suggestions	
21.04.080	Multiple designations	No comments or suggestions	
21.04.085	Allowed activities	No comments or suggestions	
21.04.090	Reasonable use	1. Note: CAR by a qualified professional is required. 2. Consider adding details to clarify what constitutes reasonable use.	1. BAS 2. Consistency

Code Section	Title	Review Comment and Recommendations	Reason for Recommendation
21.04.095	Critical area reports – General requirements	No comments or suggestions	
21.04.100	Critical area reports – Modifications to requirements	No comments or suggestions	
21.04.105	Mitigation requirements	Review and update language for consistency with the 2008 Federal Mitigation Rule hierarchy	Administrative consistency
21.04.110	Mitigation sequencing	No comments or suggestions	
21.04.115	Mitigation plan requirements	Consider adding requirements for timing, legal protections, and use of native plant species	BAS, clarity
21.04.120	Bonds to ensure mitigation, maintenance and monitoring	No comments or suggestions	
21.04.125	Notice on title	No comments or suggestions	
21.04.130	Building setbacks	Review width requirement	BAS
21.04.135	Critical area inspections	No comments or suggestions	
21.04.140	Unauthorized critical area alterations and enforcement	No comments or suggestions	

2.1 Purpose (21.04.005)

WCC 21.04.005.E: We recommend incorporating the following statements to align with WAC 365-190-080: "to protect all functions and values of critical areas to ensure no net loss of ecological functions and values," and "to give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries."

2.2 Applicability (21.04.015)

Figure 1 under WWMC 21.04.015.C is low resolution and difficult to read. Update for better legibility or remove from code.

2.3 Definitions (21.04.020)

We recommend aligning the critical area definitions more closely with WAC 365-190-030 to ensure consistency with state standards. Definitions of critical areas should reflect those provided in the WAC, and all applicable critical area definitions should be provided within the definitions section for clarity and consistency. Additional designation criteria is provided in each critical area code section. Designation information may be incorporated into definitions as appropriate.

Best available science (BAS)

Consider removing text, "'Citations of Recommended Sources of Best Available Science for Designating and Protecting Critical Areas' published by the state Office of Community Development." The broader definition of BAS in the WAC allows use of current information that meets BAS standards.

Critical Aquifer Recharge Areas

Recommend updating to align with WAC 365-190-100, which is more detailed than WAC 365-190-030(2).

Erosion hazard areas

Recommend adding general statement from WAC to WWMC definition as shown in underlined text below.

WAC definition: *"Erosion hazard areas" are those areas containing soils which, according to the United States Department of Agriculture Natural Resources Conservation Service Soil Survey Program, may experience significant erosion. Erosion hazard areas also include coastal erosion-prone areas and channel migration zones.*

WWMC definition: "*Erosion hazard areas*" *— means at least those areas identified by the United States Department of Agriculture National Resources Conservation Service as ~~having a~~ prone to significant erosion, including severe rill and inter-rill erosion hazard.*

Frequently flooded areas

WWMC 21.04.020 does not currently include a definition for Frequently Flooded Areas. It is recommended that this term be defined consistent with WAC 365-190-030(8) and incorporated into the definitions section for clarity and regulatory consistency.

WAC definition: "*Frequently flooded areas*" *are lands in the flood plain subject to at least a one percent or greater chance of flooding in any given year, or within areas subject to flooding due to high groundwater. These areas include, but are not limited to, streams, rivers, lakes, coastal areas, wetlands, and areas where high groundwater forms ponds on the ground surface.*

Geologically hazardous areas

The City's definition of geologically hazardous areas is consistent with the WAC. Development types could be added to match the WAC if preferred.

WAC definition: "*Geologically hazardous areas*" *are areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to siting commercial, residential, or industrial development consistent with public health or safety concerns.*

WWMC definition: "*Geologically hazardous areas*" *— means areas that may not be suited to development consistent with public health, safety or environmental standards because of their susceptibility to erosion, sliding, earthquake, or other geological events as designated by WAC 365-190-030(9). Types of geologically hazardous areas include: erosion, landslide, seismic, mine, and volcanic hazards.*

Groundwater

A portion of the groundwater definition in the WAC 173-100-040 is missing. Recommend adding.

Landslide hazard areas

WAC 365-190-120(6) provides greater detail than the currently referenced definition under WAC 365-190-030(10). Recommend updating to provide more detail.

Water Typing System

Since water types F, Np and Ns are no used to assign stream buffer widths, they are not referenced in WWC 21.04.650 and do not need to be defined.

Wetland Category

Update to reference the current 2014 Ecology Wetland Rating System for Eastern Washington.

Wetlands

Recommend removing delineation methodology from the wetland definition as shown in the strike-through below.

WAC definition: "*Wetland*" *or* "*wetlands*" *means areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway.*

However, wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate conversion of wetlands, if permitted by the County or City.

WWMC definition: "*Wetlands" — means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands. ~~For identifying and delineating a wetland, local government shall use the approved federal delineation manual and regional supplement, as amended.~~*

2.4 Critical Area Maps (21.04.035)

WWMC states critical area maps "*will be updated as inventories are completed in compliance with the requirements of the Growth Management Act, and additional maps may be added as appropriate.*" However, the City's critical area maps are not readily accessible through its online resources.

We recommend that the City update all critical area maps with any new data available and that these maps be made easily accessible through the City's website to improve transparency and usability.

2.5 Allowed activities (21.04.085)

For clarity, recommend stating in introductory paragraph that allowed activities are still subject to underlaying permit or approval and must be consistent with this chapter. Any new critical area impacts/modification is subject to mitigation sequencing requirements.

City staff noted that property fencing is a recurring issue not adequately addressed in the current code. Recommend adding language to the allowed activities section to provide direction on fencing used in landscaping, farming, and property line marking capacities.

2.6 Reasonable Use (21.04.090)

We recommend noting a critical areas report prepared by a qualified professional must be provided to support the Director's review of reasonable use exception criteria.

Consider adding additional criteria to standardize reasonable use reviews, such as square footage limits and/or neighborhood analyses. This can help standardize the review process for both city staff and applicants.

2.7 Mitigation Requirements (21.04.105)

Review this code section regarding mitigation banking against the 2008 Federal Mitigation Rule hierarch (Ecology publication #21-06-003 excerpt below for reference). Cities commonly prefer to keep mitigation within city limits. However, when state and federal permits apply, the city may add code language to allow the federally required mitigation approach. Recommend incorporating language to allow off-site mitigation when it is required by other agencies, state or federal, and is demonstrated by support watershed health.

Federal Mitigation Rule hierarchy

The 2008 Federal Mitigation Rule (33 CFR Part 332.3[b] and 40 CFR Part 230.93[b]) lists the preference of mitigation options in the following order.

1. Mitigation bank credits
2. In-lieu fee program credits
3. Permittee-responsible mitigation under a watershed approach
4. Permittee-responsible mitigation through on-site and in-kind mitigation
5. Permittee-responsible mitigation through off-site and/or out-of-kind mitigation

2.8 Mitigation Plan Requirements (21.04.115)

This code section could add additional mitigation plan and plan sheet requirements from Ecology's sample wetland regulations (Ecology publication 22-06-014, Appendix A). Since these requirements apply to all critical areas, only general requirements would be applicable. This may include requirements to:

1) Describe the proposed timing of impact and mitigation activities, and

2) Proof the mitigation area and any associated buffers are protected by a legal mechanism such as a critical areas tract, conservation easement, and/or Notice on Title.

It is considered best management practice for restoration activities to use native plant species appropriate to the site for revegetation of disturbed or degraded areas. Incorporating locally adapted native plant species also supports resilience to climate change by improving the ability of wetlands to withstand environmental stressors. While it is likely the policy is being applied in practice, the current mitigation requirements do not explicitly mandate the use of native species. The City may choose to incorporate this requirement into code to ensure consistency and strengthen long-term ecological outcomes.

2.9 Building setback (21.04.130)

Currently, a five-foot building setback is required from the edge of all critical area buffers. The intent of the setback is to allow maintenance of a structure without encroaching into protected critical area buffers. The City may consider increasing the standard building setback to fifteen feet and allowing reduction down to five feet when the applicant demonstrates long-term building maintenance can be achieved without encroaching upon the critical area buffer. The City may choose to set a higher standard building setback value and allow reductions through the critical areas report process.

3. CRITICAL AQUIFER RECHARGE AREAS (WWMC 21.04.200-260)

Table 2. Critical Aquifer Recharge Areas review summary.

Code Section	Title	Review Comment and Recommendations	Reason for Recommendation
21.04.200	Critical aquifer recharge areas – Designation	Update to match Ecology guidance	Clarity
21.04.210	Mapping of critical aquifer recharge areas	Update *Critical Area Map 1: CARA* reference	Clarity
21.04.220	Activities allowed in critical aquifer recharge areas	Add specifications to reduce impacts	Clarification
21.04.230	Critical area report – Additional requirements for critical aquifer recharge areas.	Add mitigation plan / measures to critical area report requirements	BAS
21.04.240	Performance standards – General requirements	No comments or suggestions	
21.04.250	Performance standards – Specific uses	No comments or suggestions	
21.04.260	Uses prohibited in critical aquifer recharge areas	Consider adding a table with additional details	Clarification

3.1 Critical aquifer recharge areas—Designation (21.04.200)

The Washington State Department of Ecology (Ecology) has revised the Critical Aquifer Recharge Area Guidance. The current guidance is *2021 Critical Aquifer Recharge Areas: Guidance Document* (Pub 05-10-028).[1] We recommend adding "current or as revised" when referring to this document.

[1] 2021 Critical Aquifer Recharge Areas: Guidance Document

Also update CARA map reference for consistency with WWMC 21.04.210.

3.2 Mapping of critical aquifer recharge areas (21.04.210)

The map referenced by name in the code (WWMC 21.04.210.A), *Critical Area Map 1: Critical aquifer recharge areas*, was not readily found. Recommend revising the language to more generally reference publicly available CARA maps. Retain provision B (WWMC 21.04.210.B), stating that public CARA maps are advisory, as-is.

3.3 Activities allowed in critical aquifer recharge areas (21.04.220)

Recommend the City add a reference to RCW 90.48 (Water Pollution Control) to ensure consistency with applicable state requirements.

Additionally, the City may impose conditions of approval, as necessary, to prevent groundwater degradation. Such conditions should be based on established prevention, control, and treatment methods, including BAS. Where applicable, all proposals must also comply with water source protection requirements and guidance provided by the Federal Environmental Protection Agency, the Washington State Department of Ecology, the Washington State Department of Health, and the Walla Walla County Health Department. Groundwater quantity and quality protection standards could be located under the performance standards subsection (WWMC 21.04.240).

3.4 Critical Area Report—Additional requirements for critical aquifer recharge areas (21.04.230)

Documentation showing best management practices (BMPs) are implemented or a mitigation plan may be required to address groundwater impacts identified in the hydrogeologic site evaluation, including monitoring, process controls, remediation, and discussion of alternatives. Appropriate BMPs and mitigation measures should be applied. Process needs to ensure that soil analysis for infiltration BMPs is in accordance with (Storm Water Management Model (SWMM) measures to prevent delivery of contaminants to groundwater.

3.5 Uses prohibited in critical aquifer recharge areas (21.04.260)

Currently this code section is similar to Walla Walla County 'Uses prohibited in critical aquifer recharge areas' code. Consider adding 'dry wells on sites used for vehicle repair and servicing or dry cleaners' as stated in Walla Walla County code WWCMC 18.08.260). Recommend retaining general provision 'F' to cover other impactful land uses not listed.

Alternatively, the City could add a table to list prohibited uses by CARA classification. For example, a hazardous liquid transmission pipeline may be prohibited in a Class 1 (1- and 5-Year Wellhead Protection Area) but allowed in Class 2 and 3 CARA when state and federal standards are met.

4. WETLANDS (WWMC 21.04.300-350)

Table 3. Wetlands review summary.

Code Section	Title	Review Comment and Recommendations	Reason for Recommendation
21.04.300	Wetlands critical areas – Designation	Minor descriptive edit recommended to simplify	Clarity
21.04.310	Mapping of wetland areas	Update *Critical Area Map 2: Wetlands* reference	Clarity
21.04.320	Critical area report – Additional requirements for wetland areas	Check study area width against final wetland buffer widths; update as needed to capture widest buffer.	BAS
21.04.330	Activities allowed in wetlands.	No comments or suggestions	
21.04.340	Performance standards – General requirements	1. Consider adding further detail on disconnected buffers. 2. Add vegetation standards criteria 3. Add GPS option 4. Add small wetland exemption	1. Clarity 2. BAS / clarity 3. BAS / clarity 4. BAS
21.04.341	Signs and fencing of wetlands.	No comments or suggestions	
21.04.342	Performance standards – Wetland buffer averaging	No comments or suggestions	
21.04.343	Performance standards – Wetland buffer increase	No comments or suggestions	
21.04.344	Performance standards – Wetland buffer decrease.	Deletion recommended	BAS
21.04.345	Performance standards – Buffer management plan.	Review for redundancy with general mitigation requirements	Clarity
21.04.346	Performance standards – Specific activities and uses.	1. Passive recreation – consider adding ADA allowance. 2. Stormwater facilities – discourage single-point discharge	1. Administration 2. BAS

Code Section	Title	Review Comment and Recommendations	Reason for Recommendation
21.04.347	Performance standards – Mitigation requirements	Review simplified table (Ecology 2022 recommendations)	BAS / Administration
21.04.348	Performance standards – Wetland mitigation plan	No comments or suggestions	
21.04.350	Wetland mitigation banks	No comments or suggestions	

4.1 Wetland critical areas – Designation (21.04.300)

Generally, the designation and rating descriptions align with best practices and Ecology guidance. Recommend simplifying the 'Category I Wetland' description to align with the level of detail provided in the other category descriptions.

4.2 Mapping of wetlands (21.04.310)

The map referenced by name in the code (WWMC 21.04.310.A), *Critical Area Map 2: Wetlands*, was not readily found. Recommend revising the language to more generally reference publicly available wetland maps. Retain provision B (WWMC 21.04.310.B), stating that public wetland maps are advisory, as-is.

4.3 Critical areas report – Additional requirements for wetland areas (21.04.320)

Since the widest wetland buffer under current City code is 250-feet, recommend updating the distance stated under WWMC 21.04.320.B.3 from 200-feet to 250-feet.

4.4 Performance standards – General requirements (21.04.340)

Disconnected buffers (WWMC 21.04.340.C.2)

Additional detail on what constitutes a significant development is provided in Ecology's Sample Wetland Regulations (Publication # 22-06-014, Appendix A). This information could be added for clarity. An excerpt from Ecology's sample wetland regulations is below:

> *Functionally Disconnected Buffer Area. Buffers may exclude areas that are functionally and effectively disconnected from the wetland by an existing public or private road or legally established development, as determined by the [Administrator]. Functionally and effectively disconnected means that the road or other significant development blocks the protective measures provided by a buffer.*

Significant developments shall include built public infrastructure such as roads and railroads, and private developments such as homes or commercial structures. The [Administrator] shall evaluate whether the interruption will affect the entirety of the buffer. Individual structures may not fully interrupt buffer function. In such cases, the allowable buffer exclusion should be limited in scope to just the portion of the buffer that is affected. Where questions exist regarding whether a development functionally disconnects the buffer, or the extent of that impact, the [Administrator] may require a critical area report to analyze and document the buffer functionality.

Examples of how this guidance has been incorporated into wetland buffer regulations are provided below.

Walla Walla County, in addition to incorporating Ecology's sample regulation language above for specific uses and activities under WWCMC 18.08.345.H, states the following under performance standard - general requirements (WWCMC 18.08.340.C.2):

Buffers shall not include areas that are functionally and effectively disconnected from the wetland by a road or other substantially developed surface of sufficient width and with use characteristics such that buffer functions are not provided.

Skagit County draft code update, words this disconnected buffer provision as follows (SCC 14.24.230.6).

(6) Where a legally established and constructed public roadway, private roads, and legally established development as determined by the Director functionally disconnects a wetland buffer as demonstrated in a critical area report, the Director may approve a modification of the standard buffer width to the edge of the development, provided:

(a) The isolated part of the buffer does not provide additional protection of the wetland; and

(b) The isolated part of the buffer provides insignificant biological, geological, or hydrological buffer functions relating to the wetland; and

(c) If the resulting buffer distance is less than 75% of the standard or optional buffer for the applicable wetland category, no further reduction will be allowed.

(d) The legally established development includes hard surfaces a minimum of 20 feet wide that completely isolates the project area from the critical area.

Standard buffer widths (WWMC 21.04.340.C.3)

City code currently requires applicants to restore or rehabilitate disturbed vegetation within the buffer with native plant communities. The City may include an option to apply a wider buffer if vegetation conditions are not brought up to standards. Additionally, the City may consider adding a clear description of what a native plant community represents, such as density or coverage requirements.

Measurement of Wetland buffers (WWMC 21.04.340.C.4)

Consider adding Ecology recommended language to allow GPS-mapping (Publication # 22-06-014, Appendix A).

> *Wetland delineations will be documented on a ground-verified map using either professional surveying methods or an equivalent professional method using GPS with sub-meter accuracy.*

Table 4: Recommended buffer widths

The current City-required buffers are based on Ecology's 2018 buffer guidance (Appendix 8-C) and are consistent with BAS.

Although Ecology's 2018 guidance is part of the BAS-based guidance available, Ecology updated buffer recommendations in 2022 to include additional clarity surrounding buffer table options. The underlying science behind buffer width recommendations in the 2018 and 2022 publications remains the same. Ecology's 2022 buffer recommendations outlines a preferred option (Publication # 22-06-014, Appendix D, Option 1) that includes consideration of a habitat corridor for wetlands with moderate to high habitat scores. This option also requires minimization measures to be applied, or buffer width increased. See Appendix A of this report for both the 2018 and 2022 Ecology wetland buffer guidance.

Small wetlands exemption (*Not Applicable)*

The small wetlands exemption in 2022 Ecology sample (Ecology Publication #22-06-014, Appendix A) does not apply to ecoregions that use the Arid West Regional Supplement (US Army Corps 2008). Ecology guidance states that wetlands in the arid west perform functions at an 'outsized role due to their rarity in the landscape.' Therefore, this is not applicable to small wetlands in the City of Walla Walla.

4.5 Performance standards – Wetland buffer decrease (21.04.344)

Ecology guidance no longer supports outright wetland buffer reductions. Other regulatory mechanisms, such as reasonable use exceptions or function buffer interruptions, may be used to apply lower buffers. If the City continues to apply Ecology's 2018 wetland buffer guidance, then buffer reductions would be limited to guidance on reducing the intensity of impacts from proposed land uses. See Ecology Publication #05-06-008, July 2018 revision excerpt below (8C.2.4).

8C.2.4 Special Conditions for a Possible Reduction in Buffer Widths

8C.2.4.1 Condition 1: Reduction in Buffer Width Based on Reducing the Intensity of Impacts from Proposed Land Uses

The buffer widths recommended for proposed land uses with high-intensity impacts to wetlands can be reduced to those recommended for moderate-intensity impacts under the following conditions:

- For wetlands that score moderate or high for habitat (6 points or more for the habitat functions), the width of the buffer can be reduced if both of the following criteria are met:

  1) A relatively undisturbed, vegetated corridor at least 100-feet wide is protected between the wetland and any other Priority Habitats as defined by the Washington State Department of Fish and Wildlife. The latest definitions of priority habitats and their locations are available on the WDFW web site at: http://wdfw.wa.gov/hab/phshabs.htm)

     The corridor must be protected for the entire distance between the wetland and the Priority Habitat by some type of legal protection such as a conservation easement.

  2) Measures to minimize the impacts of different land uses on wetlands, such as the examples summarized in Table 8C-8, are applied.

- For wetlands that score less than 6 points for habitat, the buffer width can be reduced to that required for moderate land-use impacts by applying measures to minimize the impacts of the proposed land uses (see examples in Table 8C-8).

Table 8C-8. Examples of measures to minimize impacts to wetlands from proposed change in land use that have high impacts. (This is not a complete list of measures.)

Examples of Disturbance	Activities and Uses that Cause Disturbances	Examples of Measures to Minimize Impacts
Lights	• Parking lots • Warehouses • Manufacturing • Residential	• Direct lights away from wetland
Noise	• Manufacturing • Residential	• Locate activity that generates noise away from wetland
Toxic runoff*	• Parking lots • Roads • Manufacturing • Residential areas • Application of agricultural pesticides • Landscaping	• Route all new, untreated runoff away from wetland while ensuring wetland is not dewatered • Establish covenants limiting use of pesticides within 150 ft of wetland • Apply integrated pest management
Stormwater runoff	• Parking lots • Roads • Manufacturing • Residential areas • Commercial • Landscaping	• Retrofit stormwater detention and treatment for roads and existing adjacent development • Prevent channelized flow from lawns that directly enters the buffer
Change in water regime	• Impermeable surfaces • Lawns • Tilling	• Infiltrate or treat, detain, and disperse into buffer new runoff from impervious surfaces and new lawns
Pets and human disturbance	• Residential areas	• Use privacy fencing; plant dense vegetation to delineate buffer edge and to discourage disturbance using vegetation appropriate for the ecoregion; place wetland and its buffer in a separate tract
Dust	• Tilled fields	• Use best management practices to control dust
* These examples are not necessarily adequate for minimizing toxic runoff if threatened or endangered species are present at the site.		

8C.2.4.2 Condition 2: Reductions in Buffer Widths Where Existing Roads or Structures Lie Within the Buffer

Where a legally established, non-conforming use of the buffer exists (e.g., a road or structure that lies within the width of buffer recommended for that wetland), proposed actions in the buffer may be permitted as long as they do not increase the degree of non-conformity. This means no increase in the impacts to the wetland from activities in the buffer.

For example, if a land use with high impacts (e.g., building an urban road) is being proposed next to a Category II wetland with a moderate level of function for habitat, a 150-foot buffer would be needed to protect functions (see Table 8C-6). If, however, an existing urban road is already present and only 50 feet from the edge of the Category II wetland, the additional 100 feet of buffer may not be needed if the road is being widened. A vegetated buffer on the other side of the road would not help buffer the existing impacts to the wetland from the road. If the existing road is resurfaced or widened (e.g., to add a sidewalk) along the upland edge, without any further roadside development that would increase the degree of non-conformity, the additional buffer is not necessary. The associated increase in impervious surface from widening a road, however, may necessitate mitigation for impacts from stormwater.

If, however, the proposal is to build a new development (e.g., shopping center) along the upland side of the road, the impacts to the wetland and its functions may increase. This would increase the degree of non-conformity. The project proponent would need to provide the additional 100 feet of buffer extending beyond the road or apply buffer averaging (see Section 8C.2.6).

8C.2.4.3 Condition 3: Reduction in Buffer Widths Through an Individual Rural Stewardship Plan

A Rural Stewardship Plan (RSP) is the product of a collaborative effort between rural property owners and a local government to tailor a management plan specific for a rural parcel of land. The goal of the RSP is better management of wetlands than what would be achieved through strict adherence to regulations. In exchange, the landowner gains flexibility in the widths of buffers required, in clearing limits, and in other requirements found in the regulations. For example, dense development in rural residential areas can be treated as having a low level of impact when the development of the site is managed through a locally approved RSP. The voluntary agreement includes provisions for restoration, maintenance, and long-term monitoring and specifies the widths of buffers needed to protect each wetland within the RSP.

4.6 Performance standards – Buffer management plan (21.04.345)

Review and consider if this is beneficial or redundant with mitigation requirements under WWMC 21.04.105 – 115. For example, maintaining dense native plant cover, keeping invasive plant cover low, and requiring five years of monitoring and maintenance are covered in the general mitigation code sections. Mitigation plans are required to propose mitigation consistent with BAS and include a planting plan with species and density (WWMC 21.04.115). WWMC 21.04.105.F states mitigation monitoring shall be required for five years and a monitoring program is required under WWMC 21.04.115.D.

One unique detail under WWMC 21.04.345 is the reference to 'Table 8, Walla Walla County Conservation District native riparian vegetation planting guidelines'. That document was not located in brief online search. Recommend a more general reference to incorporating BAS since specific resources can change over time.

4.7 Performance standards – Specific activities and uses (21.04.346)

Passive recreation (21.04.346.B.1) limits trails to a five-foot width. Consider adding an allowance for wider trails when necessary for ADA compliance.

Stormwater facilities (21.04.346.C) may also note that a single-discharge point should be avoided. Dispersed discharges allow the buffer to provide infiltration and water quality functions over the distance remaining.

4.8 Performance standards – Mitigation requirements (21.04.347)

Table 5: Mitigation ratios for Eastern Washington is from the 2018 Ecology guidance. The 2022 Ecology guidance (Publication # 22-06-014, Appendix E) offers a simplified version of this table. Review and consider adopting (Appendix B of this report). Please note, both 2018 and 2022 options are both considered BAS.

4.9 Performance standards – Wetland mitigation plan (21.04.348)

Recommend additional text to reference Ecology's requirement to select wetland mitigation sites using a watershed approach (Publication #10-06-007). This would align City requirements with state and federal mitigation requirements.

5. MAPPING OF FREQUENTLY FLOODED AREAS (WWMC 21.04.400)

Table 4. Frequently Flooded Areas Review Summary.

Code Section	Title	Review Comment and Recommendations	Reason for Recommendation
21.04.400 *(new)*	Frequently flooded areas – designation	Add critical area designation	Compliance
21.04.~~400~~10	Mapping of Frequently Flooded Areas	Update map reference	Clarity
21.04.420 *(new)*	Frequently flooded areas- regulation	Add regulation	Compliance

The City may choose to make the updates suggested below or remove this content from Chapter 21.04 and reference Chapter 21.10. This would simplify the code.

5.1 FFA Mapping-Commerce Guidelines (21.04.400-420)

5.1.1 Frequently Flooded Areas Designation (21.04.400 NEW)

It is recommended to designate frequently flooded areas are designated in the critical area ordinance to ensure compliance with state regulations. [WAC 365-190-110]

5.1.2 Mapping of Frequently Flooded Areas (21.04.410 NEW #)

The map referenced by name in the code (WWMC 21.04.400.A), *Critical Area Map 3: Frequently Flooded Areas*, was not readily found. Recommend revising the language to more generally reference publicly available FFA maps. Retain provision B (WWMC 21.04.410.B), stating that public flood hazard maps are advisory, as-is.

5.1.3 Frequently Flooded Areas Regulation (21.04.420 NEW)

Title 15 (Buildings and Construction) and Chapter 21.10 (Floodplain Management) of the City of Walla Walla Code regulate proposed activities adjacent to or within frequently flooded areas. If allowed, any structure permitted in these flood areas, it is subject to the flood-proofing regulations provided in Title 15 and Chapter 21.10.

Many other communities in Washington take a similar approach and regulate areas of special flood hazards using National Flood Insurance Program standards, deeming this sufficient for their frequently flooded areas codes (Commerce 2023). Commerce notes that this approach can meet the minimum requirements without exceptional circumstances. However, Commerce also notes that FEMA maps do

not address all community flood risk and that the frequently flooded area designation should be based on BAS. Commerce, therefore, encourages local governments to consider additional flood risks in their communities and address related regulatory issues in their frequently flooded areas. Ecology invites local governments to exceed FEMA minimum requirements for floodplain management (Ecology n.d.).

FEMA recently completed a flood study updated for Walla Walla County. This includes risk assessment mapping. Those updated maps are included in Appendix C of this report for City reference.

6. GEOLOGICALLY HAZARDOUS AREAS (WWMC 21.04.500-21.04.560)

Table 5. Geologically Hazardous Areas review summary.

Code Section	Title	Review Comment and Recommendations	Reason for Recommendation
21.04.500	Geologically hazardous areas – Designation	Review definitions	Consistency with WAC
21.04.510	Mapping of geologically hazardous areas	Update *Critical Area Map 4: Geologic Hazard Areas* reference	Clarity
21.04.520	Activities allowed in geologically hazardous areas.	No comments or suggestions	
21.04.530	Critical area report – Additional requirements for geologically hazardous areas.	No comments or suggestions	
21.04.540	Critical area report – Additional requirements for specific geologically hazardous areas	No comments or suggestions	
21.04.550	Performance standards – General Requirements	No comments or suggestions	
21.04.560	Performance standards – Specific hazards	No comments or suggestions	

6.1 Geologically hazardous areas—Designation (21.04.500)

The Walla Walla Municipal Code does not mirror the Washington Administrative Code designations verbatim; however, it generally aligns with the intent and underlying definitions, and in some cases provides greater specificity and detail.

We recommend conducting a comprehensive review of the WAC definitions for all hazard areas to determine whether revisions to the WWMC definitions and/or designations are warranted to ensure consistency and regulatory clarity. WAC 365-190-120 defines Geologically Hazardous Areas as follows:

(1) Geologically hazardous areas include areas susceptible to erosion, sliding, earthquake, or other geological events. They pose a threat to the health and safety of citizens when incompatible commercial, residential, or industrial development is sited in areas of significant hazard.

(2) Some geological hazards can be reduced or mitigated by engineering, design, or modified construction or mining practices so that risks to public health and safety are minimized. When technology cannot reduce risks to acceptable levels, building in geologically hazardous areas must be avoided. The distinction between avoidance and compensatory mitigation should be considered by counties and cities that do not currently classify geological hazards, as they develop their classification scheme.

(3) Areas that are susceptible to one or more of the following types of hazards shall be classified as a geologically hazardous area:

(a) Erosion hazard;

(b) Landslide hazard;

(c) Seismic hazard; or

(d) Areas subject to other geological events such as coal mine hazards and volcanic hazards including: Mass wasting, debris flows, rock falls, and differential settlement.

(4) Counties and cities should assess the risks and classify geologically hazardous areas as either:

(a) Known or suspected risk;

(b) No known risk; or

(c) Risk unknown - data are not available to determine the presence or absence of risk.

(5) Erosion hazard areas include areas likely to become unstable, such as bluffs, steep slopes, and areas with unconsolidated soils. Erosion hazard areas may also include coastal erosion areas: This information can be found in the Washington state coastal atlas available from the department of ecology. Counties and cities may consult with the United States Department of Agriculture Natural Resources Conservation Service for data to help identify erosion hazard areas.

(6) Landslide hazard areas include areas subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They include any areas susceptible to landslide because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other factors, and include, at a minimum, the following:

(a) Areas of historic failures, such as:

(i) Those areas delineated by the United States Department of Agriculture Natural Resources Conservation Service as having a significant limitation for building site development;

(ii) Those coastal areas mapped as class u (unstable), uos (unstable old slides), and urs (unstable recent slides) in the department of ecology Washington coastal atlas; or

(iii) Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the United States Geological Survey or Washington department of natural resources.

(b) Areas with all three of the following characteristics:

(i) Slopes steeper than 15 percent;

(ii) Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and

(iii) Springs or groundwater seepage.

(c) Areas that have shown movement during the holocene epoch (from 10,000 years ago to the present) or which are underlain or covered by mass wastage debris of this epoch;

(d) Slopes that are parallel or subparallel to planes of weakness (such as bedding planes, joint systems, and fault planes) in subsurface materials;

(e) Slopes having gradients steeper than 80 percent subject to rockfall during seismic shaking;

(f) Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action, including stream channel migration zones;

(g) Areas that show evidence of, or are at risk from snow avalanches;

(h) Areas located in a canyon or on an active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding; and

(i) Any area with a slope of 40 percent or steeper and with a vertical relief of 10 or more feet except areas composed of bedrock. A slope is delineated by establishing its toe and top and measured by averaging the inclination over at least 10 feet of vertical relief.

(7) Seismic hazard areas must include areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement or subsidence, soil liquefaction, surface faulting, or tsunamis. Settlement and soil liquefaction conditions occur in areas underlain by cohesionless soils of low density, typically in association with a shallow groundwater table. One indicator of potential for future earthquake damage is a record of earthquake damage in the past. Ground shaking is the primary cause of earthquake damage in Washington, and ground settlement may occur with shaking. The strength of ground shaking is primarily affected by:

(a) The magnitude of an earthquake;

(b) The distance from the source of an earthquake;

(c) The type or thickness of geologic materials at the surface; and

(d) The type of subsurface geologic structure.

(8) Other geological hazard areas:

(a) Volcanic hazard areas must include areas subject to pyroclastic flows, lava flows, debris avalanche, or inundation by debris flows, lahars, mudflows, or related flooding resulting from volcanic activity.

(b) Mine hazard areas are those areas underlain by, adjacent to, or affected by mine workings such as audits, gangways, tunnels, drifts, or air shafts. Factors which should be considered include: Proximity to development, depth from ground surface to the mine working, and geologic material.

6.2 Mapping of geologically hazardous areas (21.04.510)

The map referenced by name in the code (WWMC 21.04.510.A), *Critical Area Map 4: Geologically hazardous areas*, was not readily found. Recommend revising the language to more generally reference publicly available geologically hazardous areas maps. Retain provision B (WWMC 21.04.510.B), stating that public geologic hazard area maps are advisory, as-is.

7. FISH AND WILDLIFE HABITAT CONSERVATION AREAS (WWMC 21.04.600 - 671)

Table 6. Fish and Wildlife Habitat Conservation Areas review summary.

21.04.600	Fish and wildlife habitat conservation areas – Designation	Consider adding reference to the 2023 WDFW PHS List.	
21.04.600	Fish and wildlife habitat conservation areas – Designation	Add reference to the 2023 WDFW PHS List	BAS
21.04.610	Fish and wildlife habitat conservation areas – Mapping	Update the map reference	Clarity
21.04.620	Fish and wildlife habitat conservation areas – Water bodies – Allowed uses	No comments or suggestions	
21.04.630	Critical area report – Additional requirements for habitat conservation areas	Increase FWHCA documentation in vicinity of subject property.	BAS
21.04.640	Performance standards – General requirements	No comments or suggestions	

21.04.600	Fish and wildlife habitat conservation areas – Designation	Consider adding reference to the 2023 WDFW PHS List.	
21.04.650	Performance standards – Specific habitats	1. Recommend adding shrubsteppe to the priority habitats listed. 2. Review stream protections against current WDFW recommendations. 3. Clean up table to remove extraneous information and undefined terms.	1. BAS 2. BAS 3. Clarity
21.04.660	Performance standards – Subdivisions	Consider adding habitat corridor review requirements	BAS
21.04.670	Fish and wildlife habitat conservation areas – Piped streams	Consider adding incentives to daylight stream segments	BAS
21.04.671	Fish and wildlife habitat conservation areas – Mitigation standards	No comments or suggestions	
21.04.700	Landfill vicinity development standards	No comments or suggestions	

7.1 Fish and Wildlife Habitat Conservation Areas – Designation (21.04.600)

The Fish and Wildlife Habitat Conservation Areas (FWHCA) designation criteria can be improved by referencing WDFW Priority Habitat and Species (PHS) list current or as amended. This approach ensures CAO designations remain current with evolving state wildlife data without requiring formal ordinance amendment each time the PHS list is updated.

7.2 Fish and Wildlife Habitat Conservation Areas – Mapping (21.04.610)

The map referenced by name in the code (WWMC 21.04.610.A), *Critical Area Map 5: Fish and Wildlife Habitat Conservation Areas'*, was not readily found. Recommend revising the language to more generally reference publicly available FWHCA maps. Retain provision B (WWMC 21.04.610.B), stating that public FWHCA maps are advisory, as-is.

7.3 Critical area report – Additional requirements for habitat conservation areas (21.04.630)

21.04.630.B.2 limits documentation of priority habitats and species to within 200 feet of the project area. However, some species are impacted at a distance of more than 200 feet. We recommend increasing this screening area to be more protective and allow full consideration of WDFW management recommendations. The City may establish appropriate screening area on a site-specific basis considering conditions that constitute a significant disturbance, like urban land use.

7.4 Performance standards—Specific habitats. (21.04.650)

Shrubsteppe Habitat

Recommend adding shrubsteppe habitat to this code section. Shrubsteppe is a priority habitat on the WDFW PHS List. WDFW PHS on the web maps several shrubsteppe habitat patches within the City. This habitat also supports other listed species, like Ferruginous hawk.

Riparian habitat areas – BAS summary

Review WDFW BAS synthesis (Rentz et al. 2020) and recommendations for riparian protections summarized in the *Draft Best Available Science Review, Critical Areas Ordinance Update, Walla Walla County,* Section 6.4 (Facet 2026). Current WDFW riparian protection recommendations are based on soil type and dominant site potential tree height (SPTH) after 200 years of growth. Under this SPTH approach, WDFW no longer recommends using a stream classification system based on fish use. All streams are recognized as performing important functions, and the $SPTH_{200}$ model seeks to achieve full ecological function.

However, the City of Walla Walla contains no forested ecosystems and is all mapped by WDFW as a dryland ecosystem. In dryland ecosystems, WDFW recommends first identifying the full extent of the riparian vegetative community. Then overlaying a minimum 100-foot riparian buffer. The wider of the two riparian protection areas would apply on a site-specific basis; this is referred to as the zone of influence. It is commonly applied in non-forested environments like shrubsteppe. Width may alternatively be based on desired pollutant removal efficacy. As stated in WDFW Riparian Ecosystems: Volume 1 (bold emphasis added)(Quinn, Wilhere and Krueger 2020):

> *In dryland ecoregions, the width of the riparian ecosystem is based on the ecological function that creates the widest zone of influence. At most sites, this will be either the wood (large and small) or pollutant removal functions.* ***For grass, herb, shrub, and small tree vegetation types, the zone of influence based on wood, which depends on vegetation height, will be narrower than the zone of influence based on pollutant removal.*** *Therefore,* ***if pollutants, including sediments due to ground disturbance, are a concern at a particular site, then riparian ecosystem width should be based on the desired removal efficacy for pollutants created at that site.*** *If, for instance, surface run-off containing excess nitrogen is a concern and a 95% removal is desired, then the zone of influence is 170 ft (52 m) wide, measured from the*

active channel, see Table 5.4. If pollutant removal is not a concern, then riparian ecosystem width should be based on site-potential vegetation height (i.e., trees or shrubs), which should provide maximum wood and shade for aquatic habitats.

Given this information, the riparian protection widths WDFW recommends for Walla Walla range from 100-feet to 170-feet as measured from the ordinary high water mark or channel migration zone, whichever is greater.

A 100-foot-wide buffer is estimated to achieve 95 percent pollution removal and approximately 85 percent surface nitrogen (Rentz, et al. 2020). RMZ buffer recommendations presume the area is densely vegetated with native plants. WDFW recognizes that this increases existing non-conformity and recommends addressing that through non-conforming use regulations. In summary, a minimum buffer width of 100 feet for all streams aligns with BAS if SPTH/dryland ecosystem widths are not used for RMZ determinations.

The City must review the BAS-based recommendations and determine the best regulatory approach for the City of Walla Walla. We recommend reviewing water-quality buffer functions alongside stormwater management regulations. In general, urban settings are limited by surrounding land uses; review of buffer widths should be paired with consideration of requirements to enhance ecological functions. Currently, regulatory buffers range from 35 to 100 feet, depending on stream type. Most streams in the City currently require a 35-foot buffer. The current approach does not meet the minimum recommendations of the WDFW guidance.

Other Stream Management Recommendations

The following WDFW riparian management recommendations for urban areas should also be considered for implementation (Rentz et al. 2020):

- maintaining and improving functions through regulatory and voluntary means,
- identifying and prioritizing restoration,
- maintaining and improving riparian connections, and
- applying stormwater management.

We recommend reviewing WDFW PHS guidelines to determine appropriate protection measures for streams in Walla Walla and to update buffer width requirements. A minimum 100-foot buffer is recommended for water quality. If the City wants to incorporate nonscientific information as the basis for departing from BAS-recommendations, then the city must comply with WAC 365-195-915 below (bold emphasis added).

WAC 365-195-915. Criteria for including the best available science in developing policies and development regulations.

(1) To demonstrate that the best available science has been included in the development of climate resiliency and critical areas policies and regulations, counties and cities should address each of the following on the record:

(a) The specific policies and development regulations adopted to protect the functions and values of the critical areas at issue.

(b) The relevant sources of best available scientific information included in the decision-making.

(c) ***Any nonscientific information—including legal, social, cultural, economic, and political information—used as a basis for climate resiliency and critical area policies and regulations that depart from recommendations derived from the best available science. A county or city departing from science-based recommendations should:***

(i) Identify the information in the record that supports its decision to depart from science-based recommendations;

(ii) Explain its rationale for departing from science-based recommendations; and

(iii) Identify potential risks to climate resiliency, the functions and values of the critical area or areas at issue, and any additional measures chosen to limit such risks. State Environmental Policy Act (SEPA) review often provides an opportunity to establish and publish the record of this assessment.

(2) Counties and cities should include the best available science in determining whether to grant applications for administrative variances and exemptions from generally applicable provisions in policies and development regulations adopted to protect the functions and values of critical areas. Counties and cities should adopt procedures and criteria to ensure that the best available science is included in every review of an application for an administrative variance or exemption.

7.4.1 Riparian habitat areas (21.04.650.D.2)

To align with BAS, recommend adding channel migration zone or ordinary high water mark, whichever is greater to width measurements provision (b).

Recommend deleting repetitive language from (c). Overlapping critical area buffers are already addressed in (3) below. Also suggest adding language to (c) to clarify when and how buffers are modified to account for existing development that functionally interrupt buffers.

7.4.2 Buffer widths (21.04.650, Table 6)

Recommend applying 100-foot buffer to all streams to align with WDFW dryland ecosystem model as described in the riparian habitat areas – BAS summary above.

Remove waterway category column since it is not used anywhere else in the code and is not defined.

Remove existing conditions/targeted functions from table. This information is not used to determine buffer widths and information may be out-of-date. For example, the methodology for measuring the 'existing riparian average' is not clear and all those widths are less than required buffers. The CREP minimum can be retained as a footnote or moved to a separate code provision. Lastly, stormwater management is regulated under Title 13 – Water and Sewers. Stormwater management can also be noted in the stream buffer regulations under measures recommended for protection.

7.4.3 Buffer modification options (21.04.650.D.4 – 6)

Review buffer modification options in detail once updates to stream/riparian buffers are established. Buffer decreases below the 100-foot minimum recommended for water quality would need to demonstrate water quality is maintained. If buffer averaging is retained, water quality protection should be demonstrated. The City's stormwater design standards can be added to the buffer averaging criteria.

Standard riparian/buffer width recommendation presume a native plant community is present. Therefore, buffer reduction with enhancement is not supported by BAS. Recommend deleting 21.04.650.D.6.

7.5 Performance standards—Subdivisions (21.04.660)

Subdivisions of land may impact wildlife movement and corridors. To aid consideration of habitat corridor impacts during project permitting, the City may add language to protect wildlife corridors, supported by BAS and qualified professional reports.

7.6 Fish and wildlife habitat conservation areas – Piped streams (21.04.670)

Walla Walla may consider adding provisions which provide incentives for daylighting streams as a strategy to promote instream habitat restoration. This would support WDFW's recommendations to identify and prioritize restoration and improve riparian connections.

8. REFERENCES

Ecology (Washington State Department of Ecology). 2022. "Wetland guidance for critical areas ordinance (CAO) updates, Western and Eastern Washington." *Publication No. 22-06-014. Washington State Department of Ecology, Olympia.* https://apps.ecology.wa.gov/publications/documents/2206014.pdf

Ecology (Washington State Department of Ecology). n.d. "Frequently flooded areas: Critical Areas Ordinance." Washington State Department of Ecology. Available at: https://ecology.wa.gov/regulations-permits/guidance-technical-assistance/guidance-for-floodplains-critical-areas-ordinanc

Ecology (Washington State Department of Ecology), USACE (U.S. Army Corps of Engineers) Seattle District, and U.S. EPA (U.S. Environmental Protection Agency) Region 10. 2021. "Wetland Mitigation in Washington State Part 1: Agency Policies and Guidance (Version 2)." *Washington State Department of Ecology Publication #21-06-003.* https://apps.ecology.wa.gov/publications/documents/2106003.pdf.

Facet. 2026. "Critical Areas Ordinance Update Best Available Science Review." Prepared for City of Walla Walla.

Hruby, T. and A. Yahnke. 2014. "Washington State Wetland Rating System for Eastern Washington: 2014." *Publication No. 14-06-030. Washington State Department of Ecology, Olympia.*

Quinn, T., G.F. Wilhere, and K.L. Krueger, technical editors. 2020. "Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications." Habitat Program, Washington Department of Fish and Wildlife, Olympia. https://wdfw.wa.gov/sites/default/files/publications/01987/wdfw01987.pdf

Rentz, T., A. Windrope, K. Folkerts, and J. Azerrad. 2020. "Riparian Ecosystems, Volume 2: Management Recommendations." Habitat Program, Washington Department of Fish and Wildlife, Olympia. https://wdfw.wa.gov/sites/default/files/publications/01988/wdfw01988.pdf

APPENDIX A. Guidance on Widths of Buffers (2018 and 2022)

Appendix 8-C

Guidance on Widths of Buffers and Ratios for Compensatory Mitigation for Use with the Western Washington Wetland Rating System

8C.1 Introduction

This appendix provides guidance on widths of buffers, ratios for compensatory mitigation, and other measures for protecting wetlands that are linked to the *Washington State Wetland Rating System for Western Washington: 2014 Update,* Department of Ecology Publication #14-06-029 (October 2014). Refer to Appendix 8-D for guidance for eastern Washington. Appendices 8-C through 8-F have been formatted similar to the main text of this volume (i.e., with a numbering system) to help with organization.

The tables below list the recommended widths of buffers for various alternatives, examples of measures to minimize impacts, and ratios for compensatory mitigation.

- **Table 8C-1.** Width of buffers needed to protect wetlands in western Washington if impacts from land use and wetland functions are NOT incorporated (Buffer Alternative 1). [Page 4]
- **Table 8C-2.** Width of buffers based on wetland category and modified by the intensity of the impacts from changes in proposed land use (Buffer Alternative 2). [Page 5]
- **Table 8C-3.** Types of land uses that can result in high, moderate, and low levels of impacts to adjacent wetlands (used in Buffer Alternatives 2 and 3). [Page 5]
- **Table 8C-4.** Width of buffers needed to protect Category IV wetlands in western Washington (Buffer Alternative 3). [Page 6]
- **Table 8C-5.** Width of buffers needed to protect Category III wetlands in western Washington (Buffer Alternative 3). [Page 6]
- **Table 8C-6**. Width of buffers needed to protect Category II wetlands in western Washington (Buffer Alternative 3). [Page 7]
- **Table 8C-7.** Width of buffers needed to protect Category I wetlands in western Washington (Buffer Alternative 3). [Page 8]
- **Table 8C-8.** Examples of measures to minimize impacts to wetlands from different types of activities. [Page 10]

- **Table 8C-9.** Comparison of recommended buffer widths for high intensity land uses between Alternative 3 (step-wise scale) and Alternative 3A (graduated scale) based on score for habitat functions [Page 14].
- **Table 8C-10.** Comparison of recommended widths for buffers between Alternative 3 and Alternative 3A for proposed land uses with high impacts with mitigation for impacts. [Page 14]
- **Table 8C-11.** Mitigation ratios for projects in western Washington. [Page 20]

The guidance in this appendix can be used in developing regulations such as critical areas ordinances for protecting and managing the functions and values of wetlands. The recommendations are based on the analysis of the current scientific literature found in Volume 1. The detailed rationale for the recommendations is provided in Appendices 8-E and 8-F.

The recommendations on buffer widths and mitigation ratios are general, and there may be some wetlands for which these recommendations are either too restrictive or not protective enough. The recommendations are based on the assumption that a wetland will be protected only at the scale of the site itself. They do not reflect buffers and ratios that might result from regulations that are developed based on a larger landscape-scale approach.

8C.2 Widths of Buffers

Requiring buffers of a specific width has been one of the primary methods by which local jurisdictions in Washington have protected the functions and values of wetlands. Generally, buffers are the uplands adjacent to an aquatic resource that can, through various physical, chemical, and biological processes, reduce impacts to wetlands from adjacent land uses. The physical characteristics of buffers (e.g., slope, soils, vegetation, and width) determine how well buffers reduce the adverse impacts of human development. These characteristics are discussed in detail in Chapter 5, Volume 1.

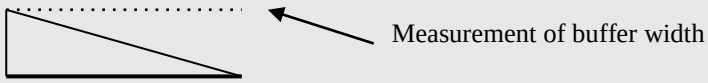
In addition to reducing the impacts of adjacent land uses, buffers also protect and maintain a wide variety of functions and values provided by wetlands. For example, buffers can provide the terrestrial habitats needed by many species of wildlife that use wetlands to meet some of their needs.

The review of the scientific literature has shown, however, that buffers alone cannot adequately protect all functions that a wetland performs. Additional guidance is, therefore, provided on other ways in which wetlands can be managed and regulated to provide some of the necessary protection that buffers alone do not provide. The following guidance for protecting the functions and values of wetlands is based on their category as determined through the rating system for western Washington.

Basic assumptions for using the guidance on widths for buffers

Recommendations for widths of buffers assume that:

- The wetland has been categorized using the *Washington State Wetland Rating System for Western Washington: 2014 Update*, Department of Ecology Publication #14-06-029, October 2014.
- The buffer is vegetated with native plant communities that are appropriate for the *ecoregion* or with a plant community that provides similar functions. Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. The U.S. Environmental Protection Agency maintains updated maps of 7ecoregions that are available at http://www.epa.gov/naaujydh/pages/models/ecoregions.htm . Ecoregions currently mapped for Washington are: Coast Range, Puget Lowland, Cascades, Eastern Cascades Slopes and Foothills, North Cascades, Columbia Plateau, Blue Mountains, and Northern Rockies.
- If the vegetation in the buffer is disturbed (grazed, mowed, etc.), proponents planning changes to land use that will increase impacts to wetlands need to rehabilitate the buffer with native plant communities that are appropriate for the ecoregion, or with a plant community that provides similar functions.
- The width of the buffer is measured along the horizontal plane (see drawing below):



- The buffer will remain relatively undisturbed in the future within the width specified.

Three alternatives for protecting the functions of wetlands using buffers are described in the following sections:

- **Buffer Alternative 1.** Width based only on wetland category.
- **Buffer Alternative 2.** Width based on wetland category and the intensity of impacts from proposed changes in land use.
- **Buffer Alternative 3.** Width based on wetland category, intensity of impacts, and wetland functions or special characteristics. This alternative has two options for determining the widths of buffers when they are based on the score for habitat. Alternative 3 provides three buffer widths based on habitat scores, while Alternative 3A provides a graduated scale of widths for buffers based on habitat scores.

The buffer widths recommended for each alternative were based on the review of scientific information in Volume 1. The guidance in this appendix synthesizes the information about the types and sizes of buffers needed to protect the functions and special characteristics of wetlands.

Appendices 8-C and 8-D do not provide the metric equivalents for buffer widths even though most of the research on buffers uses the metric scale. This decision was made because most local governments use the English Customary measures. For example, a buffer width is set at 50 feet rather than 15 meters.

8C.2.1 Buffer Alternative 1: Width Based Only on Wetland Category

This alternative, in which the width of buffers is based only on the category of the wetland, is the simplest (Table 8C-1). The width recommended for each category of wetland in Alternative 1 is the widest recommended for that category in both Alternatives 2 and 3 (discussed below). Alternative 1 provides the least flexibility because many different types of wetlands and types of human impacts are combined. For example, not all wetlands that fall into Category I or II need a 300-foot buffer. If no distinctions are made between the wetlands that fall into Category I or II, all wetlands that fall into these categories have to be protected with a 300-foot buffer so adequate protection is provided for those wetlands that do need a buffer this wide. Also, the widths recommended for this alternative are those needed to protect the wetland from proposed land uses that have the greatest impacts since no distinctions between impacts are made.

Table 8C-1. Width of buffers needed to protect wetlands in western Washington if impacts from land use and wetland functions are NOT incorporated (Buffer Alternative 1).

Category of Wetland	Widths of Buffers
IV	50 ft
III	150 ft
II	300 ft
I	300 ft

8C.2.2 Buffer Alternative 2: Width Based on Wetland Category and Modified by the Intensity of the Impacts from Proposed Land Use

The second alternative increases the regulatory flexibility by including the concept that not all proposed changes in land uses have the same level of impact (Table 8C-2). For example, one new residence being built on 5 acres of land near a wetland is expected to have a smaller impact than 20 houses built on the same 5 acres. Three categories of impacts from proposed land uses are outlined: land uses that can create high impacts, moderate impacts, and low impacts to wetlands. Different land uses that can cause these levels of impacts are listed in Table 8C-3.

Table 8C-2. Width of buffers needed to protect wetlands in western Washington considering impacts of proposed land uses (Buffer Alternative 2)**.**

Category of Wetland	Land Use with Low Impact *	Land Use with Moderate Impact *	Land Use with High Impact*
IV	25 ft	40 ft	50 ft
III	75 ft	110 ft	150 ft
II	150 ft	225 ft	300 ft
I	150 ft	225 ft	300 ft
* See Table 8C-3 below for types of land uses that can result in low, moderate, and high impacts to wetlands.			

Table 8C-3. Types of proposed land use that can result in high, moderate, and low levels of impacts to adjacent wetlands.

Level of Impact from Proposed Change in Land Use	Types of Land Use Based on Common Zoning Designations *
High	• Commercial • Urban • Industrial • Institutional • Retail sales • Residential (more than 1 unit/acre) • Conversion to high-intensity agriculture (dairies, nurseries, greenhouses, growing and harvesting crops requiring annual tilling and raising and maintaining animals, etc.) • High-intensity recreation (golf courses, ball fields, etc.) • Hobby farms
Moderate	• Residential (1 unit/acre or less) • Moderate-intensity open space (parks with biking, jogging, etc.) • Conversion to moderate-intensity agriculture (orchards, hay fields, etc.) • Paved trails • Building of logging roads • Utility corridor or right-of-way shared by several utilities and including access/maintenance road
Low	• Forestry (cutting of trees only) • Low-intensity open space (hiking, bird-watching, preservation of natural resources, etc.) • Unpaved trails • Utility corridor without a maintenance road and little or no vegetation management.
* Local governments are encouraged to create land-use designations for zoning that are consistent with these examples.	

8C.2.3 Buffer Alternative 3: Width Based on Wetland Category, Intensity of Impacts, Wetland Functions, or Special Characteristics

The third alternative provides the most flexibility by basing the widths of buffers on three factors: the wetland category, the intensity of the impacts (as used in Alternative 2), and the functions or special characteristics of the wetland that need to be protected as determined through the rating system. The recommended widths for buffers are shown in Tables 8C-4 to 8C-7. Using this alternative, a wetland may fall into more than one category in the table. For example, an interdunal wetland may be rated a Category III wetland because it is an isolated interdunal wetland, but it may be rated a Category II wetland based on its score for functions.

If a wetland meets more than one of the characteristics listed in Tables 8C-4 to 8C-7, the buffer recommended to protect the wetland is the widest one. For example, if a Category I wetland (Table 8C-7) scores 8 points for habitat and 7 points for water quality functions, a 300-foot buffer is needed for land uses with high impacts because the widths needed to protect habitat are wider than those needed for the other functions.

Table 8C-4. Width of buffers needed to protect Category IV wetlands in western Washington (Buffer Alternative 3 for wetlands scoring less than 16 points for all functions).

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use	Other Measures Recommended for Protection
Score for all 3 basic functions is less than 16 points	Low - 25 ft Moderate – 40 ft High – 50 ft	No recommendations at this time[1]

[1] No information on other measures for protection was available at the time this document was written. The Washington State Department of Ecology will continue to collect new information for future updates to this document.

Table 8C-5. Width of buffers needed to protect Category III wetlands in western Washington (Buffer Alternative 3 for wetlands scoring 16 - 19 points for all functions).

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use	Other Measures Recommended for Protection
Moderate level of function for habitat (score for habitat 6 - 7 points)* *If wetland scores 8-9 habitat points, use Table 8C-6 for Category II buffers	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time
Score for habitat 3-5 points	Low - 40 ft Moderate – 60 ft High – 80 ft	No recommendations at this time

[1]

Table 8C-6. Width of buffers needed to protect Category II wetlands in western Washington (Buffer Alternative 3 for wetlands scoring 20 - 22 points for all functions or having the "Special Characteristics" identified in the rating system).

Wetland Characteristics	**Buffer Widths by Impact of Proposed Land Use** (Apply most protective if more than one criterion is met.)	**Other Measures Recommended for Protection**
High level of function for habitat (score for habitat 8 - 9 points)	Low - 150 ft Moderate – 225 ft High – 300 ft	Maintain connections to other habitat areas
Moderate level of function for habitat (score for habitat 6 - 7 points)	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[2]
High level of function for water quality improvement and low for habitat (score for water quality 8 - 9 points; habitat less than 6 points)	Low - 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Estuarine	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[2]
Interdunal	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[2]
Not meeting above characteristics	Low - 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time[2]

[2] See footnote on the previous page.

Table 8C-7. Width of buffers needed to protect Category I wetlands in western Washington (Buffer Alternative 3 for wetlands scoring 23 points or more for all functions or having the "Special Characteristics" identified in the rating system).

Wetland Characteristics	**Buffer Widths by Impact of Proposed Land Use** (Apply most protective if more than one criterion is met)	**Other Measures Recommended for Protection**
Wetlands Of High Conservation Value	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries No septic systems within 300 ft of wetland Restore degraded parts of buffer
Bogs	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries Restore degraded parts of buffer
Forested	Buffer width to be based on score for habitat functions or water quality functions	If forested wetland scores high for habitat, need to maintain connections to other habitat areas Restore degraded parts of buffer
Estuarine	Low - 100 ft Moderate – 150 ft High – 200 ft	No recommendations at this time[3]
Wetlands in Coastal Lagoons	Low - 100 ft Moderate – 150 ft High – 200 ft	No recommendations at this time[3]
High level of function for habitat (score for habitat 8 - 9 points)	Low – 150 ft Moderate – 225 ft High – 300 ft	Maintain connections to other habitat areas Restore degraded parts of buffer
Interdunal wetland with high level of function for habitat (score for habitat 8 - 9 points).	Low – 150 ft Moderate – 225 ft High – 300 ft	Maintain connections to other habitat areas Restore degraded parts of buffer
Moderate level of function for habitat (score for habitat 6 - 7 points)	Low – 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[3]
High level of function for water quality improvement (8 – 9 points) and low for habitat (less than 6 points)	Low – 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Not meeting any of the above characteristics	Low – 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time[3]

[3] See footnote on page 6.

8C.2.4 Special Conditions for a Possible Reduction in Buffer Widths

8C.2.4.1 Condition 1: Reduction in Buffer Width Based on Reducing the Intensity of Impacts from Proposed Land Uses

The buffer widths recommended for proposed land uses with high-intensity impacts to wetlands can be reduced to those recommended for moderate-intensity impacts under the following conditions:

- For wetlands that score moderate or high for habitat (6 points or more for the habitat functions), the width of the buffer can be reduced if both of the following criteria are met:

    1) A relatively undisturbed, vegetated corridor at least 100-feet wide is protected between the wetland and any other Priority Habitats as defined by the Washington State Department of Fish and Wildlife. The latest definitions of priority habitats and their locations are available on the WDFW web site at: http://wdfw.wa.gov/hab/phshabs.htm)

        The corridor must be protected for the entire distance between the wetland and the Priority Habitat by some type of legal protection such as a conservation easement.

    2) Measures to minimize the impacts of different land uses on wetlands, such as the examples summarized in Table 8C-8, are applied.

- For wetlands that score less than 6 points for habitat, the buffer width can be reduced to that required for moderate land-use impacts by applying measures to minimize the impacts of the proposed land uses (see examples in Table 8C-8).

Table 8C-8. Examples of measures to minimize impacts to wetlands from proposed change in land use that have high impacts. (This is not a complete list of measures.)

Examples of Disturbance	Activities and Uses that Cause Disturbances	Examples of Measures to Minimize Impacts
Lights	• Parking lots • Warehouses • Manufacturing • Residential	• Direct lights away from wetland
Noise	• Manufacturing • Residential	• Locate activity that generates noise away from wetland
Toxic runoff*	• Parking lots • Roads • Manufacturing • Residential areas • Application of agricultural pesticides • Landscaping	• Route all new, untreated runoff away from wetland while ensuring wetland is not dewatered • Establish covenants limiting use of pesticides within 150 ft of wetland • Apply integrated pest management
Stormwater runoff	• Parking lots • Roads • Manufacturing • Residential areas • Commercial • Landscaping	• Retrofit stormwater detention and treatment for roads and existing adjacent development • Prevent channelized flow from lawns that directly enters the buffer
Change in water regime	• Impermeable surfaces • Lawns • Tilling	• Infiltrate or treat, detain, and disperse into buffer new runoff from impervious surfaces and new lawns
Pets and human disturbance	• Residential areas	• Use privacy fencing; plant dense vegetation to delineate buffer edge and to discourage disturbance using vegetation appropriate for the ecoregion; place wetland and its buffer in a separate tract
Dust	• Tilled fields	• Use best management practices to control dust
* These examples are not necessarily adequate for minimizing toxic runoff if threatened or endangered species are present at the site.		

8C.2.4.2 Condition 2: Reductions in Buffer Widths Where Existing Roads or Structures Lie Within the Buffer

Where a legally established, non-conforming use of the buffer exists (e.g., a road or structure that lies within the width of buffer recommended for that wetland), proposed actions in the buffer may be permitted as long as they do not increase the degree of non-conformity. This means no increase in the impacts to the wetland from activities in the buffer.

For example, if a land use with high impacts (e.g., building an urban road) is being proposed next to a Category II wetland with a moderate level of function for habitat, a 150-foot buffer would be needed to protect functions (see Table 8C-6). If, however, an existing urban road is already present and only 50 feet from the edge of the Category II wetland, the additional 100 feet of buffer may not be needed if the road is being widened. A vegetated buffer on the other side of the road would not help buffer the existing impacts to the wetland from the road. If the existing road is resurfaced or widened (e.g., to add a sidewalk) along the upland edge, without any further roadside development that would increase the degree of non-conformity, the additional buffer is not necessary. The associated increase in impervious surface from widening a road, however, may necessitate mitigation for impacts from stormwater.

If, however, the proposal is to build a new development (e.g., shopping center) along the upland side of the road, the impacts to the wetland and its functions may increase. This would increase the degree of non-conformity. The project proponent would need to provide the additional 100 feet of buffer extending beyond the road or apply buffer averaging (see Section 8C.2.6).

8C.2.4.3 Condition 3: Reduction in Buffer Widths Through an Individual Rural Stewardship Plan

A Rural Stewardship Plan (RSP) is the product of a collaborative effort between rural property owners and a local government to tailor a management plan specific for a rural parcel of land. The goal of the RSP is better management of wetlands than what would be achieved through strict adherence to regulations. In exchange, the landowner gains flexibility in the widths of buffers required, in clearing limits, and in other requirements found in the regulations. For example, dense development in rural residential areas can be treated as having a low level of impact when the development of the site is managed through a locally approved RSP. The voluntary agreement includes provisions for restoration, maintenance, and long-term monitoring and specifies the widths of buffers needed to protect each wetland within the RSP.

8C.2.5 Conditions for Increasing the Width of, or Enhancing, the Buffer

8C.2.5.1 Condition 1: Buffer is Not Vegetated with Plants Appropriate for the Region

The recommended widths for buffers are based on the assumption that the buffer is vegetated with a native plant community appropriate for the ecoregion or with one that performs similar functions. If the existing buffer is unvegetated, sparsely vegetated, or vegetated with invasive species that do not perform needed functions, the buffer should either be planted to create the appropriate plant community or the buffer should be widened to ensure that adequate functions of the buffer are provided. Generally, improving the vegetation will be more effective than widening the buffer.

8C.2.5.2 Condition 2: Buffer Has a Steep Slope

The review of the literature (Volume 1) indicates that the effectiveness of buffers at removing pollutants before they enter a wetland decreases as the slope increases. If a buffer is to be based on the score for its ability to improve water quality (see Tables 8C-4 through 8C-7) rather than habitat or other criteria, then the buffer should be increased by 50% if the slope is greater than 30% (a 3-foot rise for every 10 feet of horizontal distance).

8C.2.5.3 Condition 3: Buffer Is Used by Species Sensitive to Disturbance

If the wetland provides habitat for a species that is particularly sensitive to disturbance (such as a threatened or endangered species), the width of the buffer should be increased to provide adequate protection for the species based on its particular, life-history needs. Some buffer requirements for priority species are available on the Washington State Department of Fish and Wildlife web page (http://wdfw.wa.gov/hab/phsrecs.htm). The list of priority species for vertebrates is at http://wdfw.wa.gov/hab/phsvert.htm; for invertebrates it is at http://wdfw.wa.gov/hab/phsinvrt.htm. Information on the buffer widths needed by some threatened, endangered, and sensitive species of wildlife is provided in Appendix 8-H.

8C.2.6 Buffer Averaging

The widths of buffers may be averaged if this will improve the protection of wetland functions, or if it is the only way to allow for reasonable use of a parcel. There is no scientific information available to determine if averaging the widths of buffers actually protects functions of wetlands. The authors have concluded that averaging could be allowed in the following situations:

Averaging may not be used in conjunction with any of the other provisions for reductions in buffers (listed above).

- Averaging to **improve wetland protection** may be permitted when **all** of the following conditions are met:
  - The wetland has significant differences in characteristics that affect its habitat functions, such as a wetland with a forested component adjacent to a degraded emergent component or a "dual-rated" wetland with a Category I area adjacent to a lower rated area
  - The buffer is increased adjacent to the higher-functioning area of habitat or more sensitive portion of the wetland and decreased adjacent to the lower-functioning or less sensitive portion
  - The total area of the buffer after averaging is equal to the area required without averaging
  - The buffer at its narrowest point is never less than 3/4 of the required width
- Averaging to **allow reasonable use** of a parcel may be permitted when **all** of the following are met:
  - There are no feasible alternatives to the site design that could be accomplished without buffer averaging
  - The averaged buffer will not result in degradation of the wetland's functions and values as demonstrated by a report from a qualified wetland professional (see Appendix 8-G for a definition of a qualified wetland professional)
  - The total buffer area after averaging is equal to the area required without averaging
  - The buffer at its narrowest point is never less than 3/4 of the required width

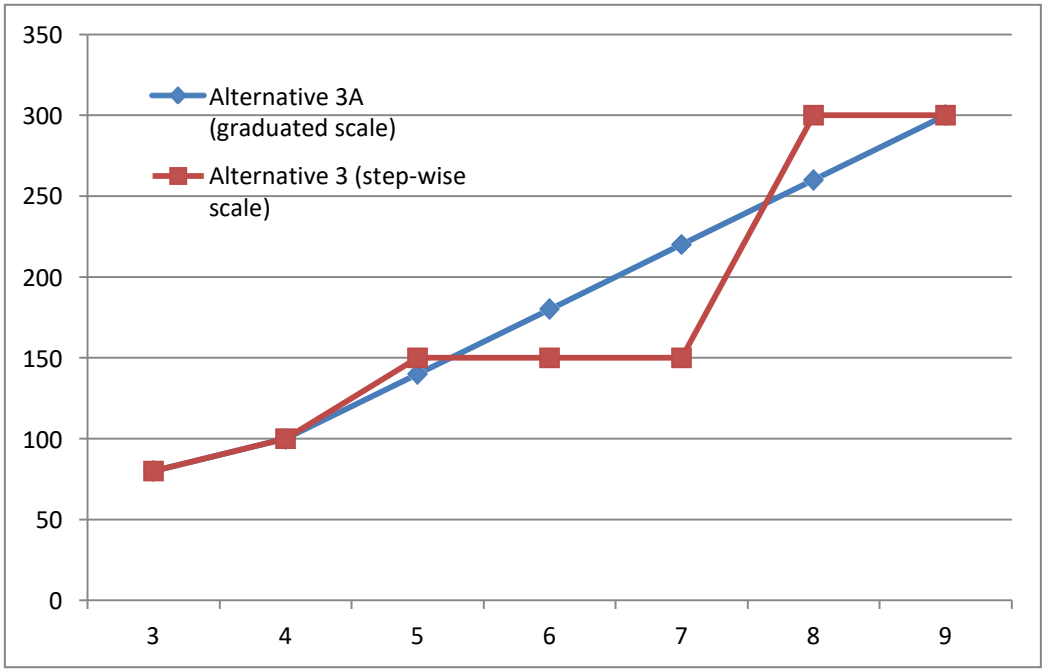
8C.2.7 Modifying Buffer Widths in Alternative 3 Using a Graduated Scale for the Habitat Functions (Alternative 3A)

Alternative 3 contains recommendations for protecting the habitat functions of wetlands using only three groupings of scores (3-4, 5-7, 8-9). As a result, a one-point difference between 4 and 5 and between 7 and 8 can result in a 50-foot increase in the width of a buffer around a wetland. The habitat scores were divided into three groups to simplify the regulations based on this guidance.

Such a large increase in width with a one-point increase in the habitat score may be contentious. A jurisdiction may wish to reduce the increments in the widths for buffers by developing a more graduated (but inherently more complicated) scale based on the scores for habitat. Table 8C-9 provides one example of a graduated scale for widths of buffers where the width increases for every one point increase in the habitat score.

Table 8C-9. Comparison of widths for buffers in Alternatives 3 (step-wise scale) and 3A (graduated scale) for proposed land uses with high impacts based on the score for habitat functions in western Washington

Points for Habitat from Wetland Rating Form	3	4	5	6	7	8	9
Alternative 3	80	100	150	150	150	300	300
Alternative 3A	80	100	140	180	220	260	300



Other scales are possible as long as they keep within the limits established from the scientific information currently available: wetlands with scores for habitat that are higher than 7 points need buffers that are at least 300 feet wide; wetlands with a score of 5-7 points need buffers of at least 150 feet; and wetlands with a score 3-4 points need buffers that are at least 80 feet wide.

These buffer widths can be further reduced by 25 percent if a proposed project with high impacts implements the mitigation measures such as those described in Table 8C-8. The measures are part of "Condition 1" in Section 8C.2.4 (Special Conditions for a Possible Reduction in Buffer Widths). The buffer widths under Buffer Alternatives 3 and 3A, and the corresponding 25 percent reduction (per buffer reduction condition 1) are shown in Table 8C-10.

Table 8C-10. Comparison of widths for buffers in Alternatives 3 (step-wise scale) and 3A (graduated scale) for proposed land uses with high impacts based on the score for habitat functions in western Washington if the impacts are mitigated.

Points for Habitat from Wetland Rating Form	3	4	5	6	7	8	9
Alternative 3 (with impact-reducing measures)	60	75	110	110	110	225	225
Alternative 3A (with impact-reducing measures	60	75	105	135	165	195	225

Alternatives 3 and 3A represent two separate approaches for determining widths of buffers for wetlands scoring between 5 and 8 points for the habitat functions. Local governments should select one of the two approaches and should not hybridize the approaches or adopt both at the same time.

Appendix D. Buffer Approaches for Eastern Washington

Option 1

Table 1. Wetland buffer width requirements, in feet, if Table 2 is implemented and a habitat corridor is provided

Category of wetland	Habitat Score 3-5 points (corridor not required)	Habitat Score 6-7 points	Habitat Score 8-9 points	Buffer width based on special characteristics
Category I & II: Based on rating of wetland functions (and not listed below)	75	110	150	NA
Category I & II: Forested	75	110	150	NA
Category I: Bogs, calcareous fens, and Wetlands of High Conservation Value	NA	NA	NA	190
Category I: Alkali	NA	NA	NA	150
Category II: Vernal pool	NA	NA	NA	150
Category III	60	110	150	NA
Category IV	40	40	40	NA

Impact minimization measures

Developments that produce the listed disturbances and are requesting a buffer reduction are required to address the disturbance through the use of applicable minimization measures.

This is not a complete list of measures, nor is every example measure required. Though not every measure is required, all effort should be made to implement as many measures as possible. Regulatory staff should determine, in coordination with the applicant, which measures are applicable and practicable.

Table 2. Impact minimization measures

Examples of disturbance	Activities and uses that cause disturbances	Examples of measures to minimize impacts
Lights	• Parking lots • Commercial/Industrial • Residential • Recreation (e.g., athletic fields) • Agricultural buildings	• Direct lights away from wetland • Only use lighting where necessary for public safety and keep lights off when not needed • Use motion-activated lights • Use full cut-off filters to cover light bulbs and direct light only where needed • Limit use of blue-white colored lights in favor of red-amber hues • Use lower-intensity LED lighting • Dim light to the lowest acceptable intensity
Noise	• Commercial • Industrial • Recreation (e.g., athletic fields, bleachers, etc.) • Residential • Agriculture	• Locate activity that generates noise away from wetland • Construct a fence to reduce noise impacts on adjacent wetland and buffer • Plant a strip of dense shrub vegetation adjacent to wetland buffer
Toxic runoff	• Parking lots • Roads • Commercial/industrial • Residential areas • Application of pesticides • Landscaping • Agriculture	• Route all new, untreated runoff away from wetland while ensuring wetland is not dewatered • Establish covenants limiting use of pesticides within 150 ft. of wetland • Apply integrated pest management (Note: These examples are not necessarily adequate for minimizing toxic runoff if threatened or endangered species are present at the site.)

Examples of disturbance	Activities and uses that cause disturbances	Examples of measures to minimize impacts
Stormwater runoff	• Parking lots • Roads • Residential areas • Commercial/industrial • Recreation • Landscaping/lawns • Other impermeable surfaces, compacted soil, etc.	• Retrofit stormwater detention and treatment for roads and existing adjacent development • Prevent channelized or sheet flow from lawns that directly enters the buffer • Infiltrate or treat, detain, and disperse new runoff from impervious surfaces and lawns
Pets and human disturbance	• Residential areas • Recreation	• Use privacy fencing • Plant dense native vegetation to delineate buffer edge and to discourage disturbance • Place wetland and its buffer in a separate tract • Place signs around the wetland buffer every 50-200 ft., and for subdivisions place signs at the back of each residential lot • When platting new subdivisions, locate greenbelts, stormwater facilities, or other lower-intensity land uses adjacent to wetland buffers
Dust	• Tilled fields • Roads	• Use best management practices to control dust

Table 3. Wetland buffer width requirements, in feet, for applicants not providing a habitat corridor or implementing measures in Table 2

Category of wetland	Habitat score 3-5 points	Habitat score 6-7 points	Habitat score 8-9 points	Buffer width based on special characteristics
Category I & II: Based on rating of wetland functions (and not listed below)	100	150	200	NA
Category I & II: Forested	100	150	200	NA
Category I: Bogs, calcareous fens, and Wetlands of High Conservation Value	NA	NA	NA	250
Category I: Alkali	NA	NA	NA	200
Category II: Vernal pool	NA	NA	NA	200
Category III	80	150	200	NA
Category IV	50	50	50	NA

Conditions for implementing Tables 1, 2, and 3

1. Wetlands that score 6 points or more for habitat function: the buffers in Table 1 can be used only if all of the following criteria are met:

a. A relatively undisturbed, vegetated corridor at least 100 feet wide is protected between the wetland and:

i. A legally protected, relatively undisturbed and vegetated area (e.g., Priority Habitats, compensatory mitigation sites, wildlife areas/refuges, national, county, and state parks where they have management plans with identified areas designated as Natural, Natural Forest, or Natural Area Preserve, or

ii. An area that is the site of a Watershed Project identified within, and fully consistent with, a Watershed Plan as defined by RCW 89-08-460, or

iii. An area where development is prohibited according to the provisions of the local shoreline master program, or

iV. An area with equivalent habitat quality that has conservation status in perpetuity, in consultation with WDFW.

b. The corridor is permanently protected for the entire distance between the wetland and the shoreline or legally protected area by a conservation easement, deed restriction, or other legal means.

c. Presence or absence of the shoreline or Priority Habitat must be confirmed by a qualified biologist or shoreline Administrator.

d. The measures in Table 2 are implemented, as applicable, to minimize the impacts of the adjacent land uses.

2. For wetlands that score 5 or fewer habitat points, only the measures in Table 2 are required for the use of the buffers in Table 1.

3. If an applicant does not apply the mitigation measures in Table 2 or is unable to provide a protected corridor, then the buffers in Table 3 shall be used.

4. The buffer widths in Tables 1 and 3 assume that the buffer is vegetated with a native plant community appropriate for the ecoregion. If the existing buffer is un-vegetated, sparsely vegetated, or vegetated with invasive species that do not perform needed functions, the buffer must either be planted to create the appropriate native plant community or be widened to ensure that the buffer provides adequate functions to protect the wetland.

Note: An expanded table with graduated buffer widths based on habitat score is also outlined in the July 2018 Appendix 8-D[77] of *Wetlands in Washington State, Volume 2*. This is an approach that assigns unique buffer widths to each habitat score in seven increments. It is a gradual increase in buffer width with each point. Compared to Option 1, this avoids a marked increase in buffer width resulting from an increase of one point in the habitat score.

Option 2

Table 1. Width of buffers, in feet, needed to protect wetlands from impacts of proposed land uses (used with Table 2)

Category of wetland	Land use with low impact*	Land use with moderate impact*	Land use with high impact*
I	125	190	250
II	100	150	200
III	75	110	150
IV	25	40	50

*See Table 2 below for types of land uses that can result in low, moderate, and high impacts to wetlands

Table 2. Levels of impacts from proposed land use types

[Local governments are encouraged to ensure the uses in this table match the uses specified in their development and land use regulations and are consistent with the principles in this example.]

Level of impact from proposed land use	Types of land use
High	• Commercial • Urban • Industrial • Institutional • Mixed-use developments • Residential (more than 1 unit/acre) • Roads: federal and state highways, including on-ramps and exits, state routes, and other roads associated with high-impact land uses • Railroads • Agriculture with high-intensity activities (dairies, nurseries, greenhouses, growing and harvesting crops requiring annual tilling, raising and maintaining animals, etc.)

[77] https://apps.ecology.wa.gov/publications/parts/0506008part4.pdf

Level of impact from proposed land use	Types of land use
	• Open/recreational space with high-intensity uses (golf courses, ball fields, etc.) • Solar farms (utility scale)
Moderate	• Residential (1 unit/acre or less) • Roads: Forest Service roads and roads associated with moderate-impact land uses • Open/recreational space with moderate-intensity uses (parks with paved trails or playgrounds, biking, jogging, etc.) • Agriculture with moderate-intensity uses (orchards, hay fields, light or rotational grazing, etc.) • Utility corridor or right-of-way used by one or more utilities and including access/maintenance • Wind farm
Low	• Natural resource lands (forestry/silviculture–cutting of trees only, not land clearing and removing stumps) • Open/recreational space with low-intensity uses (unpaved trails, hiking, birdwatching, etc.) • Utility corridor without a maintenance road and little or no vegetation management • Cell tower

Option 3

Table 1. Wetland buffer width requirements, in feet, based solely on wetland category

Category of wetland	Buffer width
I	250
II	200
III	150
IV	50

APPENDIX B. Ratios for Compensatory Mitigation for Use with the Eastern Washington Wetland Rating System (2018 and 2022)

8C.3 Ratios for Compensatory Mitigation

When the acreage required for compensatory mitigation is divided by the acreage of impact, the result is a number known variously as a *replacement*, *compensation*, or *mitigation* ratio. Compensatory mitigation ratios are used to help ensure that compensatory mitigation actions are adequate to offset unavoidable wetland impacts by requiring a greater amount of mitigation area than the area of impact. Requiring greater mitigation area helps compensate for the risk that a mitigation action will fail and for the time lag that occurs between the wetland impact and achieving a fully functioning mitigation site.

8C.3.1 Definitions of Types of Compensatory Mitigation

The ratios presented are based on the type of compensatory mitigation proposed (e.g., restoration, creation, and enhancement). In its *Regulatory Guidance Letter 02-02*, the U.S. Army Corps of Engineers provided definitions for these types of compensatory mitigation. For consistency, the authors of this document use the same definitions which are provided below.

Restoration: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into:

- **Re-establishment.** The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a **former** wetland. Re-establishment results in a gain in wetland acres (and functions). Activities could include removing fill material, plugging ditches, or breaking drain tiles.
- **Rehabilitation.** The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic functions of a **degraded** wetland. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres. Activities could involve breaching a dike to reconnect wetlands to a floodplain or return tidal influence to a wetland.

Creation (Establishment): The manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland or deepwater site where a wetland did not previously exist. Establishment results in a gain in wetland acres. Activities typically involve excavation of upland soils to elevations that will produce a wetland hydroperiod, create hydric soils, and support the growth of hydrophytic plant species.

Enhancement: The manipulation of the physical, chemical, or biological characteristics of a wetland site to heighten, intensify, or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for specified purposes such as water quality improvement, flood water retention, or wildlife

habitat. Enhancement results in a change in some wetland functions and can lead to a decline in other wetland functions, but does not result in a gain in wetland acres. Activities typically consist of planting vegetation, controlling non-native or invasive species, modifying site elevations or the proportion of open water to influence hydroperiods, or some combination of these activities.

Protection/Maintenance (Preservation): Removing a threat to, or preventing the decline of, wetland conditions by an action in or near a wetland. This includes the purchase of land or easements, repairing water control structures or fences, or structural protection such as repairing a barrier island. This term also includes activities commonly associated with the term *preservation*. Preservation does not result in a gain of wetland acres, may result in a gain in functions, and will be used only in exceptional circumstances.

Distinction between rehabilitation and enhancement

The distinction between rehabilitation and enhancement as defined above is not clear-cut and can be hard to understand. Actions that rehabilitate or enhance wetlands span a continuum of activities that cannot be defined by specific criteria.

Rehabilitation ⟷ *Enhancement*

In general, rehabilitation involves actions that are more sustainable and that reinstate environmental processes, both at the site and landscape scale (e.g., reinstating hydrologic processes in a diked floodplain by breaching the dikes). Rehabilitation actions often focus on restoring environmental processes that have been disturbed or altered by previous or ongoing, human activity. Ecology further defines *rehabilitation* as:

- Actions that restore the original hydrogeomorphic (HGM) class, or subclass, to a wetland whose current HGM class, or subclass, has been changed by human activities
- Actions that restore the water regime that was present and maintained the wetland before human activities changed it

Any other actions taken in existing wetlands would be considered *enhancement.* Enhancement typically involves actions that provide gains in only one or a few functions and can lead to a decline in other functions. Enhancement actions often focus on structural or superficial improvements to a site and generally do not address larger-scale environmental processes.

For example, a wetland that was once a forested, riverine wetland was changed to a depressional, emergent wetland by the construction of a dike and through grazing. Rehabilitating the wetland would involve breaching the dike so the wetland becomes a riverine wetland again, discontinuing the grazing, and reforesting the area. Discontinuing the grazing and reforesting the wetland without re-establishing the links to the riverine system would be considered enhancement.

Basic assumptions for using the guidance on ratios

- The ratios are for a compensatory mitigation project that is concurrent with impacts to wetlands. If impacts are to be mitigated by using an approved and established mitigation bank, the rules and ratios applicable to the bank should be used.
- The ratios are based on the assumption that the category (based on the rating system for western Washington) and hydrogeomorphic (HGM) class or subclass of the wetland proposed as compensation are the same as the category and HGM class or subclass of the affected wetland (e.g., impacts to a Category II riverine wetland are compensated by creating, restoring, or enhancing a Category II riverine wetland).
- Ratios for projects in which the category and HGM class or subclass of wetlands proposed as compensation is not the same as that of the wetland affected will be determined on a case-by-case basis using the recommended ratios as a starting point. The ratios could be higher in such cases.
- The ratio for using rehabilitation as compensation is 2 times that for using re-establishment or creation (R/C) (2 acres of rehabilitation are equivalent to 1 acre of R/C). The ratio for using enhancement as compensation is 4 times that for using R/C (4 acres of enhancement are equivalent to 1 acre of R/C).
- Re-establishment or creation can be used in combination with rehabilitation or enhancement. For example, 1 acre of impact to a Category III wetland would require 2 acres of R/C. If an applicant provides 1 acre of R/C (i.e., replacing the lost acreage at a 1:1 ratio), the remaining 1 acre of R/C necessary to compensate for the impact could be substituted with 2 acres of rehabilitation or 4 acres of enhancement.
- Generally the use of enhancement alone as compensation is discouraged. Using enhancement in combination with the replacement of wetland area at a minimum of 1:1 through re-establishment or creation is preferred.

These ratios were developed to provide a starting point for further discussions with each proponent of compensatory mitigation. They are based on the observations of the success and risk of compensatory mitigation, as reviewed in Volume 1, and do not represent the specific risk or opportunities of any individual project.

As noted above, the ratios for compensatory mitigation are based on the assumption that the category and hydrogeomorphic (HGM) class or subclass of the affected wetland and the mitigation wetland are the same. The ratios may be adjusted either up or down if the category or HGM class or subclass of the wetland proposed for compensation is different. For example, ratios may be lower if impacts to a Category IV wetland are to be mitigated by creating a Category II wetland. The same is true for impacts to wetlands that currently would be considered *atypical* (see definition below).

Also, compensatory mitigation should not result in the creation, restoration, or enhancement of an atypical wetland. An atypical wetland is defined as a wetland whose

design does not match the type of wetland that would be found in the geomorphic setting of the proposed site (i.e., the water source(s) and hydroperiod proposed for the mitigation site are not typical for the geomorphic setting). In addition, any designs that provide exaggerated morphology or require a berm or other engineered structures to hold back water would be considered atypical. For example, excavating a permanently inundated pond in an existing seasonally saturated or inundated wetland is one example of an enhancement project that could result in an atypical wetland. Another example would be excavating depressions in an existing wetland on a slope that required the construction of berms to impound water.

On a case-by-case basis, it is possible to use the scores from the Washington State wetland rating system to compare functions between the mitigation wetland and the impacted wetland. This information may also be used to adjust replacement ratios. Scores from the methods for assessing wetland functions (Hruby et al. 1999) provide another option to establish whether the functions lost will be replaced if both the affected wetland and the wetland used for compensation are of the same HGM class and subclass.

Mitigation ratios for projects in western Washington are shown in Table 8C-11. Refer to the text box on the basic assumptions on the previous page before reading the table. As mentioned previously, these ratios were developed to provide a starting point for further discussions with each proponent of compensatory mitigation. They only factor in the observations of mitigation success and risk at a programmatic level, and do not represent the specific risk or opportunity of any individual project.

Table 8C-11. Mitigation ratios for projects in western Washington.

Category and Type of Wetland Impacts	Re-establishment or Creation	Rehabilitation Only[4]	Re-establishment or Creation (R/C) and Rehabilitation (RH)[4]	Re-establishment or Creation (R/C) and Enhancement (E)[4]	Enhancement Only[4]
All Category IV	1.5:1	3:1	1:1 R/C and 1:1RH	1:1 R/C and 2:1 E	6:1
All Category III	2:1	4:1	1:1 R/C and 2:1 RH	1:1 R/C and 4:1 E	8:1
Category II Estuarine	Case-by-case	4:1 Rehabilitation of an estuarine	Case-by-case	Case-by-case	Case-by-case
Category II Interdunal	2:1 Compensation has to be interdunal wetland	4:1 Compensation has to be interdunal wetland	1:1 R/C and 2:1 RH Compensation has to be interdunal wetland	Not considered an option[5]	Not considered an option[5]
All other Category II	3:1	6:1	1:1 R/C and 4:1 RH	1:1 R/C and 8:1 E	12:1
Category I Forested	6:1	12:1	1:1 R/C and 10:1 RH	1:1 R/C and 20:1 E	24:1
Category I based on score for functions	4:1	8:1	1:1 R/C and 6:1 RH	1:1 R/C and 12:1 E	16:1
Category I Natural Heritage site	Not considered possible[6]	6:1 Rehabilitation of a Natural Heritage site	R/C Not considered possible[6]	R/C Not considered possible[6]	Case-by-case
Category I Coastal Lagoon	Not considered possible[6]	6:1 Rehabilitation of a coastal lagoon	R/C not considered possible[6]	R/C not considered possible[6]	Case-by-case
Category I Bog	Not considered possible[6]	6:1 Rehabilitation of a bog	R/C Not considered possible[6]	R/C Not considered possible[6]	Case-by-case
Category I Estuarine	Case-by-case	6:1 Rehabilitation of an estuarine	Case-by-case	Case-by-case	Case-by-case
NOTE: Preservation is discussed in the following section.					

[4] These ratios are based on the assumption that the rehabilitation or enhancement actions implemented represent the average degree of improvement possible for the site. Proposals to implement more effective rehabilitation or enhancement actions may result in a lower ratio, while less effective actions may result in a higher ratio. The distinction between rehabilitation and enhancement is not clear-cut. Instead, rehabilitation and enhancement actions span a continuum. Proposals that fall within the gray area between rehabilitation and enhancement will result in a ratio that lies between the ratios for rehabilitation and the ratios for enhancement.

[5] Due to the dynamic nature of interdunal systems, enhancement is not considered an ecologically appropriate action.

[6] Natural Heritage sites, coastal lagoons, and bogs are considered irreplaceable wetlands because they perform some special functions that cannot be replaced through compensatory mitigation. Impacts to such wetlands would therefore result in a net loss of some functions no matter what kind of compensation is proposed.

8C.3.2 Conditions for Increasing or Reducing Replacement Ratios

Increases in replacement ratios are appropriate under the following circumstances:

- Success of the proposed restoration or creation is uncertain
- A long time will elapse between impact and establishment of wetland functions at the mitigation site
- Proposed mitigation will result in a lower category wetland or reduced functions relative to the wetland being impacted
- The impact was unauthorized

Reductions in replacement ratios are appropriate under the following circumstances:

- Documentation by a qualified wetland specialist (see Appendix 8-H) demonstrates that the proposed mitigation actions have a very high likelihood of success based on prior experience
- Documentation by a qualified wetland specialist demonstrates that the proposed actions for compensation will provide functions and values that are significantly greater than the wetland being affected
- The proposed actions for compensation are conducted in advance of the impact and are shown to be successful
- In wetlands where several HGM classes are found within one delineated boundary, the areas of the wetlands within each HGM class can be scored and rated separately and the ratios adjusted accordingly, if **all of the following** apply:
  - The wetland does not meet any of the criteria for wetlands with "Special Characteristics" as defined in the rating system
  - The rating and score for the entire wetland is provided along with the scores and ratings for each area with a different HGM class.
  - Impacts to the wetland are all within an area that has a different HGM class from the one used to establish the initial category
  - The proponents provide adequate hydrologic and geomorphic data to establish that the boundary between HGM classes lies at least 50 feet outside of the footprint of the impacts

8C.3.3 Replacement Ratios for Preservation

In some cases, preservation of existing wetlands may be acceptable as compensation for wetland losses. Acceptable sites for preservation include those that:

- Are important due to their landscape position
- Are rare or limited wetland types
- Provide high levels of functions

Ratios for preservation in combination with other forms of mitigation generally range from 10:1 to 20:1, as determined on a case-by-case basis, depending on the quality of the wetlands being impacted and the quality of the wetlands being preserved. Ratios for preservation as the sole means of mitigation generally start at 20:1. Specific ratios will depend upon the significance of the preservation project and the quality of the wetland resources lost.

See Chapter 8 (Section 8.3.7.2) and Appendix 8-B for more information on preservation and the criteria for its use as compensation.

8C.3.4 Replacement Ratios for Temporal Impacts and Conversions

When impacts to wetlands are not permanent, local governments often require some compensation for the temporal loss of wetland functions. *Temporal impacts* refer to impacts to those functions that will eventually be replaced but cannot achieve similar functionality in a short time. For example, clearing forested wetland vegetation for pipeline construction could result in the temporal loss of functions, such as song bird habitat provided by the tree canopy. It may take over 20 years to re-establish the level of function lost as a result of clearing the trees. Although the wetlands will be re-vegetated and over time it is anticipated that their previous level of functioning will be re-established, a temporal loss of functions will occur. There is also some risk of failure associated with the impacts or alterations, especially when soil is compacted by equipment, deep excavation is required, and pipeline trenches alter the water regime at the site.

Therefore, in addition to restoring the affected wetland to its previous condition, local governments should consider requiring compensation to account for the risk and temporal loss of wetland functions. Generally, the ratios for temporal impacts to forested and scrub-shrub wetlands are one-quarter of the recommended ratios for permanent impacts (refer to Table 8C-11), provided that the following measures are satisfied:

- An explanation of how hydric soil, especially deep organic soil, is stored and handled in the areas where the soil profile will be severely disturbed for a fairly significant depth or time

- Surface and groundwater flow patterns are maintained or can be restored immediately following construction
- A 10-year monitoring and maintenance plan is developed and implemented for the restored forest and scrub-shrub wetlands
- Disturbed buffers are re-vegetated and monitored
- Where appropriate, the hydroseed mix to be applied on re-establishment areas is identified

When impacts are to a native emergent community and there is a potential risk that its re-establishment will be unsuccessful, compensation for temporal loss and the potential risk should be required in addition to restoring the affected wetland and monitoring the site. If the impacts are to wetlands dominated by non-native vegetation (e.g., blackberry, reed canarygrass, or pasture grasses), restoration of the affected wetland with native species and monitoring after construction is generally all that is required.

Loss of functions due to the permanent conversion of wetlands from one type to another also requires compensation. When wetlands are not completely lost but are converted to another type, such as a forested wetland converted to an emergent or shrub wetland (e.g., for a utility right-of-way), some functions are lost or reduced.

The ratios for conversion of wetlands from one type to another will vary based on the degree of the alteration, but they are generally one-half of the recommended ratios for permanent impacts (refer to Table 8C-11).

Refer to Appendix 8-F for the rationale for the ratios provided in this appendix.

Specific guidance has been developed for conversions of wetlands to cranberry bogs. Please refer to the 1998 *Guidelines for Implementation of Compensatory Mitigation Requirements for Conversion of Wetlands to Cranberry Bogs* for information on ratios associated with this activity (Washington State Department of Ecology, U.S. Environmental Protection Agency Region 10, U.S. Army Corps of Engineers Seattle District, and U.S. Fish and Wildlife Service. 1998. Special Public Notice: http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/ACF101C.pdf).

Appendix E. Mitigation Ratio Tables

Compensation ratios for permanent impacts (western and eastern Washington)

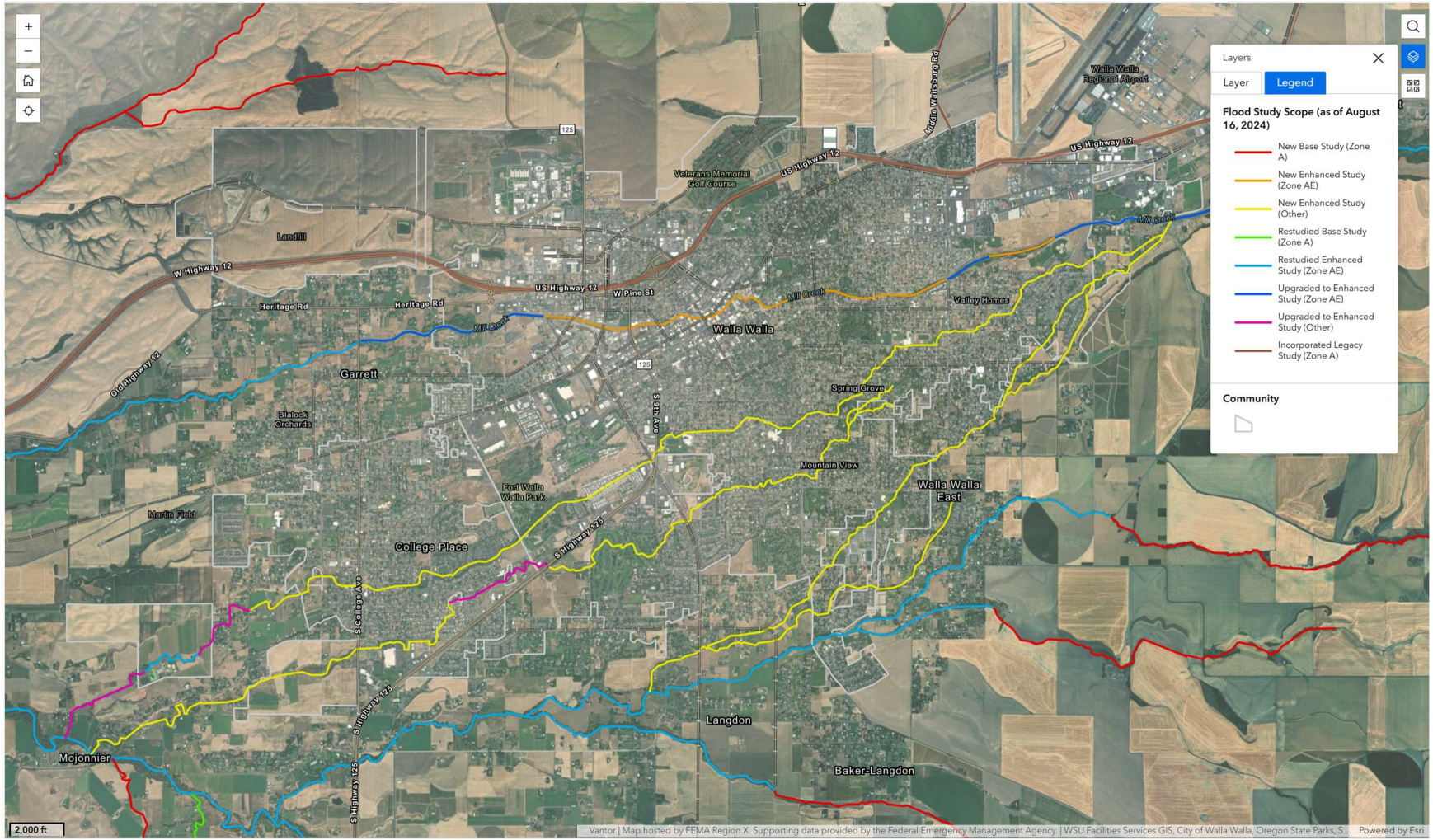
Table 1

Category of impacted wetland (based on score for function)	Re-establishment or creation	Rehabilitation	Preservation	Enhancement
Category I	4:1	8:1	16:1	16:1
Category II	3:1	6:1	12:1	12:1
Category III	2:1	4:1	8:1	8:1
Category IV	1.5:1	3:1	6:1	6:1

Notes:

- Ratios for rehabilitation, preservation, and enhancement may be reduced when combined with 1:1 replacement through re-establishment or creation. See Table 6B-2 in *Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance –Version 2* (Ecology et al., 2021 or as revised).
- All proposed preservation sites need to meet the preservation criteria listed in Chapter 070.3.E of Appendix A, Sample Wetland Regulations.
- The ratios provide in Table 1 are for permanent, direct impacts to wetlands. For recommended ratios for other types of impacts (e.g., long-term temporary, conversions), see Chapters 6B4.4 through 6B4.8 of *Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance –Version 2* (Ecology et al., 2021 or as revised).
- The category of impacted wetland is based on scores for functions. Compensation ratios in this table generally do not apply when impacts involve a wetland whose category is based on special characteristics. Compensation ratios for impacts to wetlands with special characteristics are provided in Table 2 below. Specific tables are provided for western and eastern Washington.

APPENDIX C. FEMA Flood Study Update Maps (2026)



FEMA Risk Map [Scope (Flood) | Walla Walla County, Washington - Risk MAP Portfolio]

Federal Emergency Management Agency

Washington, D.C. 20472

JUL 21 2006

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

The Honorable David G. Carey
Chairman, Walla Walla County
Board of Commissioners
P.O. Box 1506
Walla Walla, WA 99362

IN REPLY REFER TO:
Case No.: 05-10-0491P
Community Name: Walla Walla County, WA
Community No.: 530194
Effective Date of This Revision: NOV 23 2006

Dear Mr. Carey:

The Flood Insurance Study report and Flood Insurance Rate Map for your community have been revised by this Letter of Map Revision (LOMR). Please use the enclosed annotated map panel(s) revised by this LOMR for floodplain management purposes and for all flood insurance policies and renewals issued in your community.

Additional documents are enclosed which provide information regarding this LOMR. Please see the List of Enclosures below to determine which documents are included. Other attachments specific to this request may be included as referenced in the Determination Document. If you have any questions regarding floodplain management regulations for your community or the National Flood Insurance Program (NFIP) in general, please contact the Consultation Coordination Officer for your community. If you have any technical questions regarding this LOMR, please contact the Director, Federal Insurance and Mitigation Division of the Department of Homeland Security's Federal Emergency Management Agency (FEMA) in Bothell, Washington, at (425) 487-4682, or the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP). Additional information about the NFIP is available on our website at http://www.fema.gov/nfip.

Sincerely,

Kevin C Long

Kevin C. Long, CFM, Project Engineer
Engineering Management Section
Mitigation Division

For: Doug Bellomo, P.E., Acting Chief
Engineering Management Section
Mitigation Division

List of Enclosures:
Letter of Map Revision Determination Document
Annotated Flood Insurance Rate Map
Annotated Flood Insurance Study Report

cc: Ms. Connie Krueger
Planning Director
County Planning Office
Walla Walla County

[redacted]
Senior Civil/Environmental Engineer
USKH, Inc.

 | Issue Date: JUL 21 2006 | Effective Date: NOV 23 2006 | Case No.: 05-10-0491P | LOMR-APP

Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION DETERMINATION DOCUMENT

COMMUNITY AND REVISION INFORMATION		PROJECT DESCRIPTION	BASIS OF REQUEST
COMMUNITY	Walla Walla County Washington (Unincorporated Areas)	NO PROJECT	FLOODWAY HYDRAULIC ANALYSIS NEW TOPOGRAPHIC DATA
	COMMUNITY NO.: 530194		
IDENTIFIER	Triple Creek Meadows	APPROXIMATE LATITUDE & LONGITUDE: 46.038, -118.317 SOURCE: USGS QUADRANGLE DATUM: NAD 83	

ANNOTATED MAPPING ENCLOSURES			ANNOTATED STUDY ENCLOSURES
TYPE: FIRM*	NO.: 530194 0445 B	DATE: December 1, 1983	DATE OF EFFECTIVE FLOOD INSURANCE STUDY: January 18, 2002 PROFILES: 56P and 61P FLOODWAY DATA TABLE: 3
TYPE: FBFM**	NO.: 530194 0445	DATE: December 1, 1983	

Enclosures reflect changes to flooding sources affected by this revision.
* FIRM - Flood Insurance Rate Map; ** FBFM - Flood Boundary and Floodway Map; *** FHBM - Flood Hazard Boundary Map

FLOODING SOURCE(S) & REVISED REACH(ES) See Page 2 for Additional Flooding Sources

Reser Creek – from the confluence with Russell Creek to approximately 650 feet upstream

SUMMARY OF REVISIONS

Flooding Source	Effective Flooding	Revised Flooding	Increases	Decreases
Reser Creek	Zone A2	Zone A2	YES	YES
	Zone B	Zone B	YES	YES
	Floodway	Floodway	YES	YES
	BFEs*	BFEs	NONE	YES

* BFEs - Base Flood Elevations

DETERMINATION

This document provides the determination from the Department of Homeland Security's Federal Emergency Management Agency (FEMA) regarding a request for a Letter of Map Revision (LOMR) for the area described above. Using the information submitted, we have determined that a revision to the flood hazards depicted in the Flood Insurance Study (FIS) report and/or National Flood Insurance Program (NFIP) map is warranted. This document revises the effective NFIP map, as indicated in the attached documentation. Please use the enclosed annotated map panels revised by this LOMR for floodplain management purposes and for all flood insurance policies and renewals in your community.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional Information about the NFIP is available on our website at http://www.fema.gov/nfip.

Kevin C Long

Kevin C. Long, CFM, Project Engineer
Engineering Management Section
Mitigation Division

106979 10.3.1.05100491 102-I-A-C

Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)

COMMUNITY INFORMATION (CONTINUED)

OTHER FLOODING SOURCES AFFECTED BY THIS REVISION

FLOODING SOURCE(S) & REVISED REACH(ES)

Russell Creek – from approximately 100 feet downstream to approximately 2,460 feet upstream of Powerline Road

SUMMARY OF REVISIONS

Flooding Source	Effective Flooding	Revised Flooding	Increases	Decreases
Russell Creek	Zone A5	Zone A5	YES	YES
	Zone B	Zone B	YES	YES
	Floodway	Floodway	YES	YES
	BFEs*	BFEs	YES	YES

* BFEs - Base Flood Elevations

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional Information about the NFIP is available on our website at http://www.fema.gov/nfip.

Kevin C Long

Kevin C. Long, CFM, Project Engineer
Engineering Management Section
Mitigation Division

Federal Emergency Management Agency
Washington, D.C. 20472

LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)

COMMUNITY INFORMATION

APPLICABLE NFIP REGULATIONS/COMMUNITY OBLIGATION

We have made this determination pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (P.L. 93-234) and in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, P.L. 90-448), 42 U.S.C. 4001-4128, and 44 CFR Part 65. Pursuant to Section 1361 of the National Flood Insurance Act of 1968, as amended, communities participating in the NFIP are required to adopt and enforce floodplain management regulations that meet or exceed NFIP criteria. These criteria, including adoption of the FIS report and FIRM, and the modifications made by this LOMR, are the minimum requirements for continued NFIP participation and do not supersede more stringent State/Commonwealth or local requirements to which the regulations apply.

We provide the floodway designation to your community as a tool to regulate floodplain development. Therefore, the floodway revision we have described in this letter, while acceptable to us, must also be acceptable to your community and adopted by appropriate community action, as specified in Paragraph 60.3(d) of the NFIP regulations.

COMMUNITY REMINDERS

We based this determination on the 1-percent-annual-chance flood discharges computed in the FIS for your community without considering subsequent changes in watershed characteristics that could increase flood discharges. Future development of projects upstream could cause increased flood discharges, which could cause increased flood hazards. A comprehensive restudy of your community's flood hazards would consider the cumulative effects of development on flood discharges subsequent to the publication of the FIS report for your community and could, therefore, establish greater flood hazards in this area.

Your community must regulate all proposed floodplain development and ensure that permits required by Federal and/or State/Commonwealth law have been obtained. State/Commonwealth or community officials, based on knowledge of local conditions and in the interest of safety, may set higher standards for construction or may limit development in floodplain areas. If your State/Commonwealth or community has adopted more restrictive or comprehensive floodplain management criteria, those criteria take precedence over the minimum NFIP requirements.

We will not print and distribute this LOMR to primary users, such as local insurance agents or mortgage lenders; instead, the community will serve as a repository for the new data. We encourage you to disseminate the information in this LOMR by preparing a news release for publication in your community's newspaper that describes the revision and explains how your community will provide the data and help interpret the NFIP maps. In that way, interested persons, such as property owners, insurance agents, and mortgage lenders, can benefit from the information.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional Information about the NFIP is available on our website at http://www.fema.gov/nfip.

Kevin C Long

Kevin C. Long, CFM, Project Engineer
Engineering Management Section
Mitigation Division

Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)

We have designated a Consultation Coordination Officer (CCO) to assist your community. The CCO will be the primary liaison between your community and FEMA. For information regarding your CCO, please contact:

Mr. Carl L. Cook, Jr.
Director, Federal Insurance and Mitigation Division
Federal Emergency Management Agency, Region X
Federal Regional Center
130 228th Street Southwest
Bothell, WA 98021-9796
(425) 487-4682

STATUS OF THE COMMUNITY NFIP MAPS

We will not physically revise and republish the FIRM and FIS report for your community to reflect the modifications made by this LOMR at this time. When changes to the previously cited FIRM panel(s) and FIS report warrant physical revision and republication in the future, we will incorporate the modifications made by this LOMR at that time.

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional Information about the NFIP is available on our website at http://www.fema.gov/nfip.

Kevin C Long

Kevin C. Long, CFM, Project Engineer
Engineering Management Section
Mitigation Division

Federal Emergency Management Agency

Washington, D.C. 20472

LETTER OF MAP REVISION
DETERMINATION DOCUMENT (CONTINUED)

PUBLIC NOTIFICATION OF REVISION

PUBLIC NOTIFICATION

FLOODING SOURCE	LOCATION OF REFERENCED ELEVATION	BFE (FEET NGVD)		MAP PANEL NUMBER(S)
		EFFECTIVE	REVISED	
Reser Creek	Just upstream of confluence with Russell Creek	938	937	0445 B
	Approximately 400 feet upstream of confluence with Russell Creek	941	940	0445 B
Russell Creek	Just upstream of Powerline Road	927	928	0445 B
	Approximately 2,600 feet upstream of Powerline Road	941	940	0445 B

Within 90 days of the second publication in the local newspaper, a citizen may request that we reconsider this determination. Any request for reconsideration must be based on scientific or technical data. Therefore, this letter will be effective only after the 90-day appeal period has elapsed and we have resolved any appeals that we receive during this appeal period. Until this LOMR is effective, the revised BFEs presented in this LOMR may be changed.

A notice of changes will be published in the *Federal Register*. This information also will be published in your local newspaper on or about the dates listed below.

LOCAL NEWSPAPER Name: *Waitsburg Times*
Dates: 08/17/2006 08/24/2006

This determination is based on the flood data presently available. The enclosed documents provide additional information regarding this determination. If you have any questions about this document, please contact the FEMA Map Assistance Center toll free at 1-877-336-2627 (1-877-FEMA MAP) or by letter addressed to the LOMR Depot, 3601 Eisenhower Avenue, Alexandria, VA 22304. Additional Information about the NFIP is available on our website at http://www.fema.gov/nfip.

Kevin C Long

Kevin C. Long, CFM, Project Engineer
Engineering Management Section
Mitigation Division

CHANGES ARE MADE IN DETERMINATIONS OF BASE FLOOD ELEVATIONS FOR THE UNINCORPORATED AREAS OF WALLA WALLA COUNTY, WASHINGTON, UNDER THE NATIONAL FLOOD INSURANCE PROGRAM

On December 1, 1983, the Department of Homeland Security's Federal Emergency Management Agency identified Special Flood Hazard Areas (SFHAs) in the unincorporated areas of Walla Walla County, Washington, through issuance of a Flood Insurance Rate Map (FIRM). The Mitigation Division has determined that modification of the elevations of the flood having a 1-percent chance of being equaled or exceeded in any given year (base flood) for certain locations in this community is appropriate. The modified Base Flood Elevations (BFEs) revise the FIRM for the community.

The changes are being made pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (Public Law 93-234) and are in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, Public Law 90-448), 42 U.S.C. 4001-4128, and 44 CFR Part 65.

A hydraulic analysis was performed to incorporate improved topographic data along Reser and Russell Creeks and has resulted in a revised delineation of the regulatory floodways and increases and decreases in SFHA width for both Reser and Russell Creeks, increased and decreased BFEs for Russell Creek, and decreased BFEs for Reser Creek. The table below indicates existing and modified BFEs for selected locations along the affected lengths of the flooding source(s) cited above.

Location	Existing BFE (feet)*	Modified BFE (feet)*
Reser Creek:		
Just upstream of confluence with Russell Creek	938	937
Approximately 400 feet upstream of confluence with Russell Creek	941	940
Russell Creek:		
Just upstream of Powerline Road	927	928
Approximately 2,100 feet upstream of Powerline Road	941	940

*National Geodetic Vertical Datum, rounded to nearest whole foot

Under the above-mentioned Acts of 1968 and 1973, the Mitigation Division must develop criteria for floodplain management. To participate in the National Flood Insurance Program (NFIP), the community must use the modified BFEs to administer the floodplain management measures of the NFIP. These modified BFEs will also be used to calculate the appropriate flood insurance premium rates for new buildings and their contents and for the second layer of insurance on existing buildings and contents.

Upon the second publication of notice of these changes in this newspaper, any person has 90 days in which he or she can request, through the Chief Executive Officer of the community, that the Mitigation Division reconsider the determination. Any request for reconsideration must be based on knowledge of changed conditions or new scientific or technical data. All interested parties are on notice that until the 90-day period elapses, the Mitigation Division's determination to modify the BFEs may itself be changed.

Any person having knowledge or wishing to comment on these changes should immediately notify:

The Honorable David G. Carey
Chairman, Walla Walla County
Board of Commissioners
P.O. Box 1506
Walla Walla, WA 99362

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Reser Creek								
A	637	250	477	3.2	942.6	942.6	943.3	0.7
B	1,145	150	264	5.3	947.7	947.7	948.1	0.4
C	1,375	200	285	5.3	952.6	952.6	953.0	0.4
D	1,845	254	285	5.3	957.3	957.3	957.3	0.0
E	2,115	450	396	3.8	961.7	961.7	961.7	0.0
F	2,315	200	350	4.3	962.4	962.4	962.4	0.0
G	2,945	200	243	6.2	966.9	966.9	967.3	0.4
H	3,760	310	459	3.3	976.0	976.0	976.0	0.0
I	4,610	125	240	6.3	982.6	982.6	982.7	0.1
J	5,445	73	176	8.6	998.1	998.1	998.2	0.1

REVISED DATA

[1] Feet Above Mouth

REVISED TO REFLECT LOMR EFFECTIVE NOV 23 2006

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

WALLA WALLA COUNTY, WA
(UNINCORPORATED AREAS)

FLOODWAY DATA

RESER CREEK

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Russell Creek								
A	200	250	477	5.0	862.3	862.3	862.5	0.2
B	880	500	1,436	1.7	872.0	872.0	872.1	0.1
C	1,920	70	205	11.7	878.6	878.6	878.6	0.0
D	2,200	210	398	6.0	882.7	882.7	882.7	0.0
E	3,200	150	346	6.9	889.9	889.9	890.1	0.2
F	3,295	600	860	2.8	893.2	893.2	893.2	0.0
G	4,505	661	465	5.2	903.9	903.9	904.0	0.1
H	5,150	240	414	5.8	912.1	912.1	912.5	0.4
I	5,280	550	633	3.8	915.4	915.4	915.5	0.1
J	6,665	241	343	7.0	924.6	924.6	924.6	0.0
K	7,037	542	2,239	1.1	928.2	928.2	929.1	0.9
L	8,135	154	346	6.9	934.1	934.1	934.2	0.1
M	9,227	240	259	7.4	942.6[2]	942.2	942.2	0.0
N	11,245	46	139	13.8	961.6	961.6	961.6	0.0
O	12,350	50	239	8.0	974.2	974.2	974.2	0.0
P	13,240	35	151	12.7	980.8	980.8	980.8	0.0
Q	14,535	25	92	11.1	990.7	990.7	990.7	0.0
R	15,815	31	162	6.3	1,001.2	1,001.2	1,001.2	0.0
S	15,975	76	434	2.4	1,003.9	1,003.9	1,003.9	0.0
T	16,870	31	99	10.3	1,008.2	1,008.2	1,008.2	0.0
U	17,585	33	125	8.2	1,017.7	1,017.7	1,017.7	0.0
V	17,720	231	713	2.7	1,032.4	1,032.4	1,032.4	0.0
W	18,830	26	143	13.4	1,042.6	1,042.6	1,042.6	0.0
X	19,890	570	471	4.1	1,053.9	1,053.9	1,054.8	0.9
Y	20,960	781	225	8.5	1,063.3	1,063.3	1,063.3	0.0

REVISED DATA

[1]Feet Above Mouth
[2]Controlled by Reser Creek

REVISED TO REFLECT LOMR
EFFECTIVE NOV 23 2006

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

WALLA WALLA COUNTY, WA
(UNINCORPORATED AREAS)

FLOODWAY DATA

RUSSELL CREEK

ELEVATION IN FEET (NGVD 29)

890 900 910 920 930 940 950 960 970

4800 5600 6400 7200 8000 8800 9600 10,000

STREAM DISTANCE IN FEET ABOVE MOUTH

BURLINGTON NORTHERN RAILROAD

REVISED REACH

POWERLINE ROAD

CONFLUENCE WITH RESER CREEK

STATION 9,227=
STATION 9,315

H I J K L M

LEGEND

- 0.2% ANNUAL CHANCE FLOOD
- 1% ANNUAL CHANCE FLOOD
- 2% ANNUAL CHANCE FLOOD
- 10% ANNUAL CHANCE FLOOD
- STREAM BED
- CROSS SECTION LOCATION

56P

FEDERAL EMERGENCY MANAGEMENT AGENCY

WALLA WALLA COUNTY, WA
(UNINCORPORATED AREAS)

FLOOD PROFILES

RUSSELL CREEK

REVISED TO
REFLECT LOMR
EFFECTIVE NOV 23 2006

ELEVATION IN FEET (NGVD 29)

930 940 950 960 970 980

-400 0 400 800 1200 1600 2000 2400 2800 3200 3600 4000 4400 4800

940 950 960 970 980 990 1000

CONFLUENCE WITH RUSSELL CREEK

REVISED REACH

KENDALL ROAD

SOUTH WILBER STREET

A B C D E F G H I

LEGEND

- 0.2% ANNUAL CHANCE FLOOD
- 1% ANNUAL CHANCE FLOOD
- 2% ANNUAL CHANCE FLOOD
- 10% ANNUAL CHANCE FLOOD
- STREAM BED
- CROSS SECTION LOCATION

STREAM DISTANCE IN FEET ABOVE MOUTH

61P

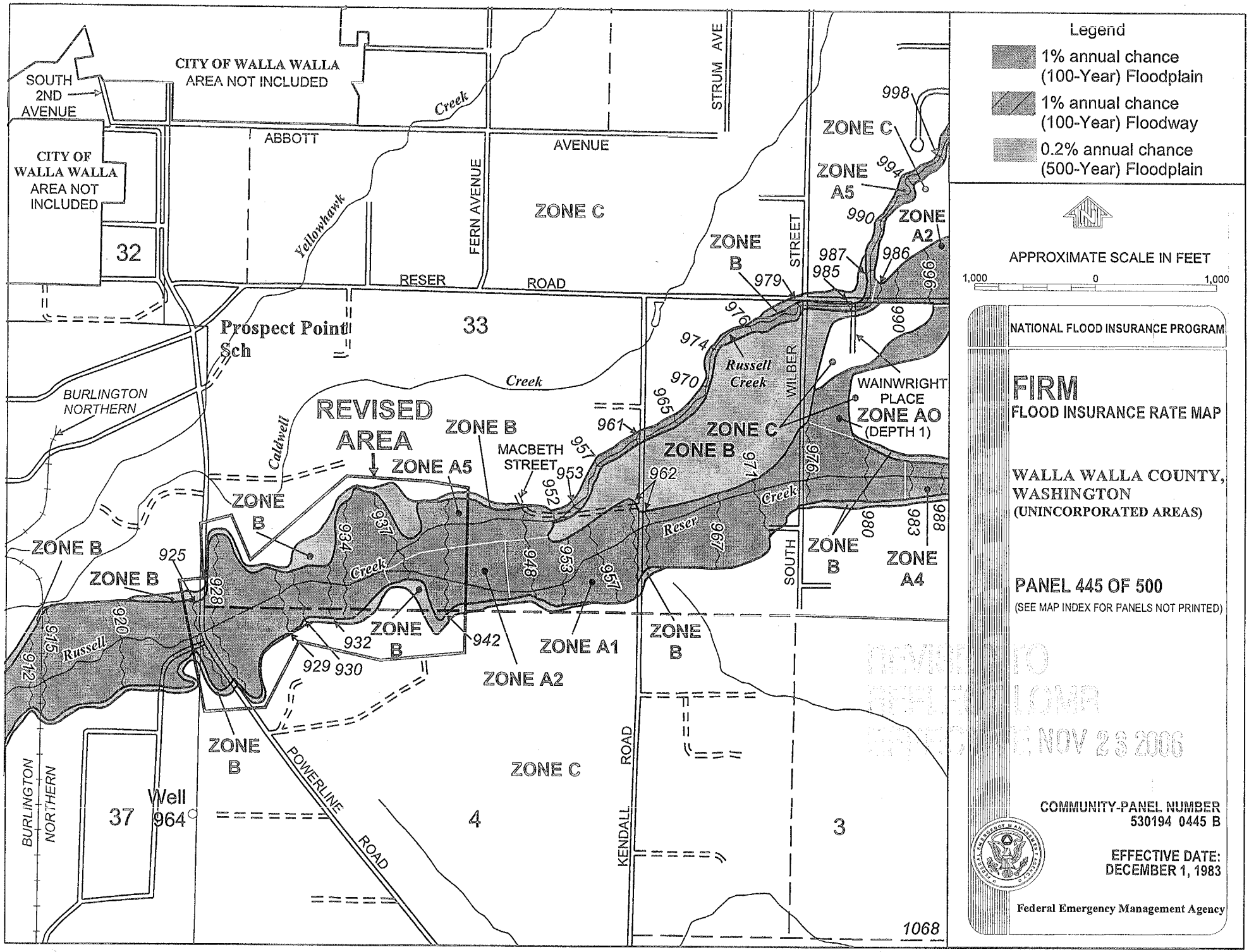
FEDERAL EMERGENCY MANAGEMENT AGENCY

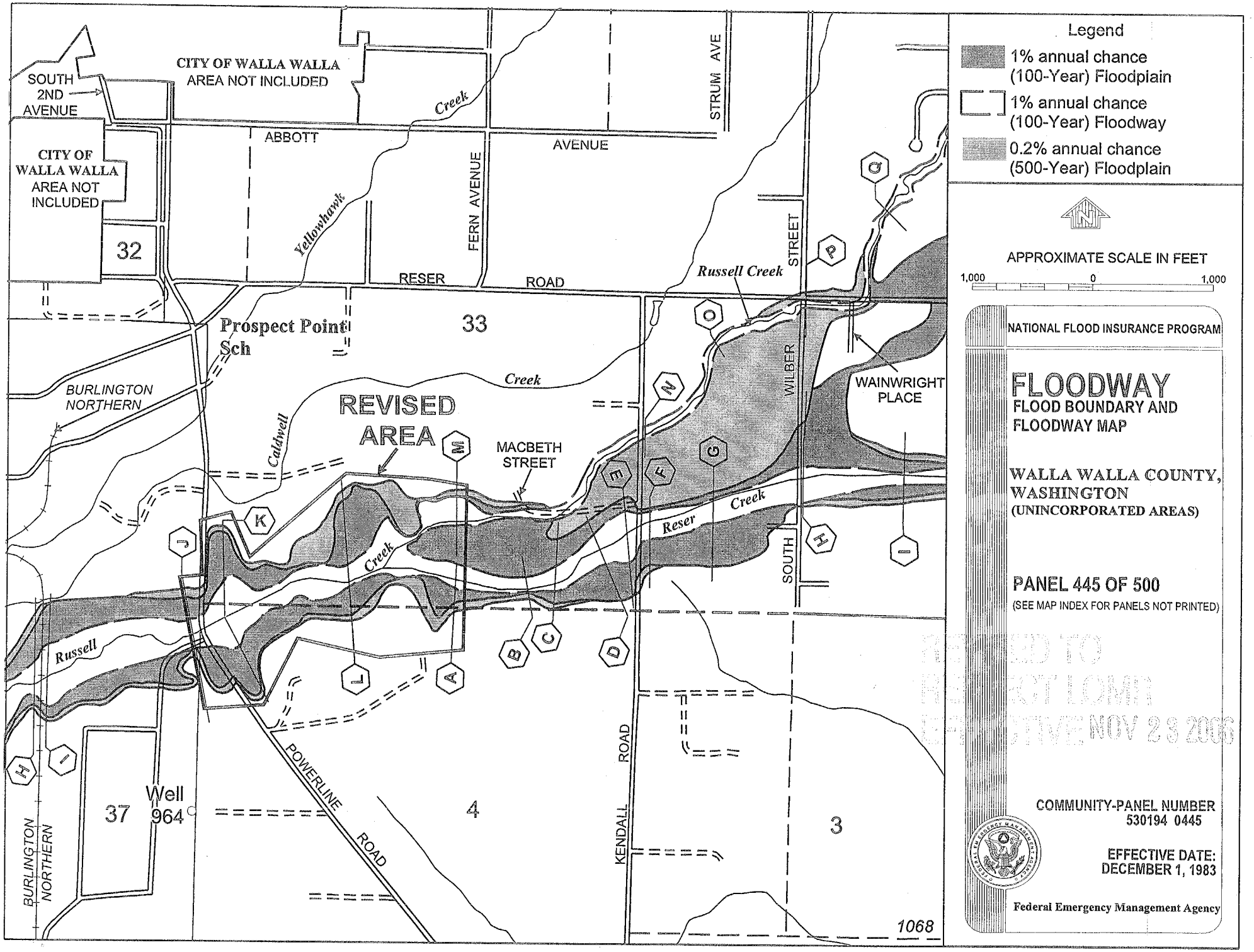
WALLA WALLA COUNTY, WA
(UNINCORPORATED AREAS)

FLOOD PROFILES

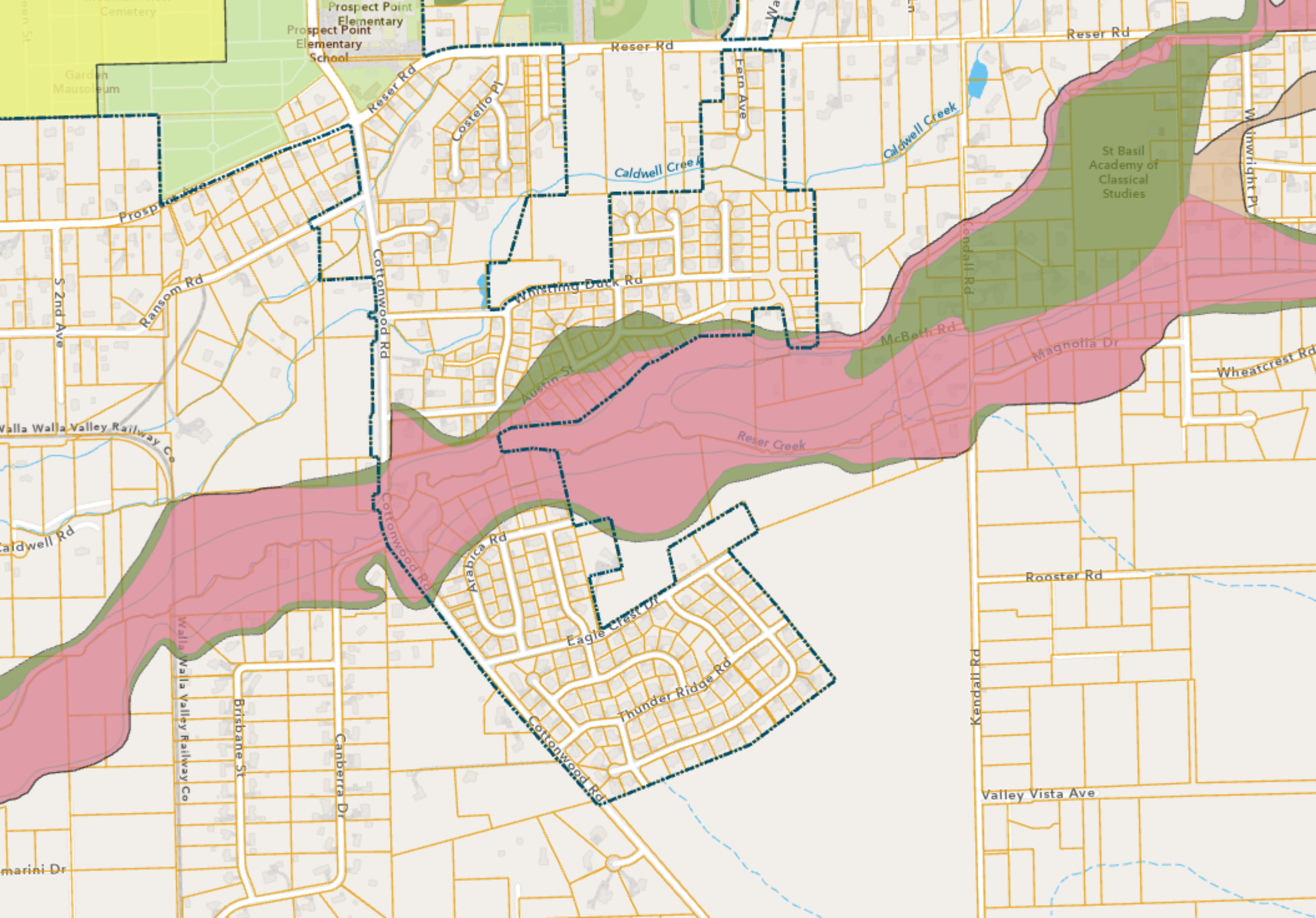
RESER CREEK

REVISED TO REFLECT LOMR EFFECTIVE NOV 23 2006


CITY OF WALLA WALLA
AREA NOT INCLUDED
SOUTH 2ND AVENUE
CITY OF WALLA WALLA AREA NOT INCLUDED
ABBOTT
AVENUE
STRUM AVE
Yellowhawk Creek
FERN AVENUE
RESER ROAD
ZONE C
32
33
Prospect Point Sch
BURLINGTON NORTHERN
Caldwell Creek
REVISED AREA
ZONE A5
ZONE B
MACBETH STREET
ZONE C
ZONE B
Russell Creek
WILBER STREET
WAINWRIGHT PLACE
ZONE AO
(DEPTH 1)
Reser Creek
SOUTH
ZONE A4
ZONE A2
ZONE A1
Russell
POWERLINE ROAD
KENDALL ROAD
Well 964
37
4
3
1068
998
994
990
987
986
985
979
976
974
970
966
961
957
953
952
962
971
976
980
983
986
967
934
931
928
925
948
953
957
942
932
929
930
920
915
912
Legend
1% annual chance (100-Year) Floodplain
1% annual chance (100-Year) Floodway
0.2% annual chance (500-Year) Floodplain
APPROXIMATE SCALE IN FEET
1,000 0 1,000
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
WALLA WALLA COUNTY, WASHINGTON
(UNINCORPORATED AREAS)
PANEL 445 OF 500
(SEE MAP INDEX FOR PANELS NOT PRINTED)
COMMUNITY-PANEL NUMBER
530194 0445 B
EFFECTIVE DATE:
DECEMBER 1, 1983
Federal Emergency Management Agency



REVISED TO REFLECT LOMR EFFECTIVE: NOV 23 2006


Prospect Point Elementary
Prospect Point Elementary School
Reser Rd
Costello Pl
Fern Ave
Caldwell Creek
St Basil Academy of Classical Studies
Prospect Ave
S 2nd Ave
Ransom Rd
Cottonwood Rd
Whistling Duck Rd
Kendall Rd
McBeth Rd
Magnolia Dr
Wheatcrest Rd
Austin St
Reser Creek
Walla Walla Valley Railway Co
Caldwell Rd
Arabica Rd
Eagle Crest Dr
Thunder Ridge Rd
Rooster Rd
Brisbane St
Canberra Dr
Valley Vista Ave

Wetlands in Washington State

Volume 2: Guidance for Protecting and Managing Wetlands



Final

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Washington Department of FISH and WILDLIFE



Funding for this project was funded in part through a grant from the United States Environmental Protection Agency (EPA Region 10 and EPA Headquarters Grant #'s CD-970018-01 and CD-970585-01, Joan Cabreza, grant officer). The views herein are those of the authors and do not necessarily reflect the views of EPA.

If you have special accommodation needs or require this publication in an alternate format, please contact Tim Schlender at 360-407-6096 (Voice) or TTY (for the speech or hearing impaired) at 711 or 800-833-6388.

Published by the Department of Ecology's Shorelands and Environmental Assistance Program, P.O. Box 47600, Olympia, WA 98504-7600. For more information contact Teri Granger at 360-407-6857, e-mail: tgra461@ecy.wa.gov

Wetlands in Washington State

Volume 2: Guidance for Protecting and Managing Wetlands

FINAL
April 2005
Ecology Publication #05-06-008

Written by (alphabetical): Teri Granger[1], Tom Hruby Ph.D.[1], Andy McMillan[1], Douglas Peters[2], Jane Rubey[1], Dyanne Sheldon[3], Stephen Stanley[1], Erik Stockdale[1]

1. Washington State Department of Ecology
2. Washington Department of Community, Trade, and Economic Development
3. Sheldon and Associates

Printed on recycled paper

This document is available on the Department of Ecology web site at
http://www.ecy.wa.gov/biblio/0506008.html.

For a CD or printed copy of this report, contact:

Department of Ecology Publications Distribution Office
Address: PO Box 47600, Olympia WA 98504-7600
E-mail: jewi461@ecy.wa.gov
Phone: (360) 407-7472

Refer to Publication #05-06-008

For the *Responses to Comments* on the draft of this volume refer to Publication #05-06-009.

For the Draft *Wetlands in Washington State – Volume 2: Guidance for Protecting and Managing Wetlands*, refer to Publication #04-06-024.

For Volume 1 of this two-volume series, *Wetlands in Washington State – Volume 1: A Synthesis of the Science* refer to Publication #05-06-006.

Preferred citation:

Granger, T., T. Hruby, A. McMillan, D. Peters, J. Rubey, D. Sheldon, S. Stanley, E. Stockdale. April 2005. Wetlands in Washington State - Volume 2: Guidance for Protecting and Managing Wetlands. Washington State Department of Ecology. Publication #05-06-008. Olympia, WA.

Table of Contents

LIST OF TABLES ..... **viii**

LIST OF FIGURES ..... **ix**

ACKNOWLEDGEMENTS ..... **xi**

CHAPTER 1 INTRODUCTION TO VOLUME 2 ..... **1-1**

1.1 OVERVIEW OF VOLUMES 1 AND 2 ..... **1-1**
1.2 PURPOSE AND GOALS OF VOLUME 2 ..... **1-2**
1.3 SCOPE OF VOLUME 2 ..... **1-5**
1.4 DEVELOPING VOLUME 2 ..... **1-6**
1.5 HOW VOLUME 2 IS ORGANIZED **1-7**
1.6 HOW TO USE VOLUME 2 ..... **1-7**
1.7 USING SCIENCE TO PROTECT AND MANAGE WETLANDS **1-8**
1.7.1 Ecological Principles to Consider 1-9
1.7.2 Interpreting the Science 1-10
1.8 SCIENCE AND RISK MANAGEMENT **1-11**

CHAPTER 2 THE GROWTH MANAGEMENT ACT AND PROTECTION OF CRITICAL AREAS **2-1**

2.1 INTRODUCTION **2-1**
2.2 AN OVERVIEW OF THE GMA **2-1**
2.3 A REVIEW OF HEARINGS BOARD CASES AND COURT CASES **2-2**
2.3.1 Designating Critical Areas and Adopting Regulations to Protect Them 2-3
2.3.2 Relationship of Critical Areas Regulations to Other Land Uses 2-5
2.3.3 Including Best Available Science in Critical Areas Regulations 2-6
2.3.4 Protecting the Functions and Values of Critical Areas 2-8

CHAPTER 3 KEY CONCLUSIONS FROM VOLUME 1 ..... **3-1**

3.1 INTRODUCTION **3-1**
3.2 MAJOR CONCLUSIONS ABOUT OUR CURRENT EFFORTS TO PROTECT WETLANDS **3-1**
3.3 WETLANDS IN WASHINGTON AND HOW THEY FUNCTION (CHAPTER 2 OF VOLUME 1) **3-2**
3.3.1 Types of Wetland Functions and How They Are Controlled 3-2
3.3.2 Classification of Wetlands in Washington as a Key to Understanding Their Functions 3-3
3.4 ENVIRONMENTAL DISTURBANCES CAUSED BY HUMAN ACTIVITIES AND USES OF THE LAND (CHAPTER 3 OF VOLUME 1) **3-4**
3.5 NEGATIVE IMPACTS OF HUMAN DISTURBANCES ON THE FUNCTIONS OF WETLANDS (CHAPTER 4 OF VOLUME 1) **3-7**

3.6 THE SCIENCE AND EFFECTIVENESS OF WETLAND MANAGEMENT TOOLS (CHAPTER 5 OF VOLUME 1)..... 3-9
3.6.1 How Wetlands Are Defined..... 3-9
3.6.2 Wetland Buffers..... 3-10
3.7 THE SCIENCE AND EFFECTIVENESS OF WETLAND MITIGATION (CHAPTER 6 OF VOLUME 1)..... 3-11
3.7.1 Compliance of Projects with Permit Requirements (Volume 1 Section 6.4)..... 3-12
3.7.2 Ecological Effectiveness of Different Types of Compensation (Volume 1 Section 6.5)..... 3-12
3.7.3 Replacement Ratios (Volume 1 Section 6.6)..... 3-12
3.7.4 Functions and Characteristics of Mitigation Wetlands (Volume 1 Section 6.8)..... 3-13
3.7.5 Types of Wetlands Produced through Compensation Projects (Volume 1 Section 6.9)..... 3-13
3.7.6 Suggestions for Improving Compensatory Mitigation (Volume 1 Section 6.10)..... 3-14
3.8 CUMULATIVE IMPACTS TO WETLANDS AND THE NEED FOR A NEW APPROACH (CHAPTER 7 OF VOLUME 1)..... 3-14

CHAPTER 4 FRAMEWORK FOR PROTECTING AND MANAGING WETLANDS USING BEST AVAILABLE SCIENCE..... 4-1

4.1 INTRODUCTION..... 4-1
4.2 FOUR-STEP FRAMEWORK FOR PROTECTING AND MANAGING WETLANDS..... 4-2
4.2.1 Incorporating Different Geographic Scales in the Four-Step Framework..... 4-4
4.2.2 Step 1: Analyzing the Landscape and Its Wetlands (Landscape Analysis)..... 4-7
4.2.2.1 Analyses of the Contributing Landscape and the Management Area..... 4-7
4.2.2.2 Analyzing Wetlands at the Site Scale..... 4-8
4.2.3 Step 2: Prescribing Solutions..... 4-9
4.2.3.1 Prescribing Solutions at the Scale of the Contributing Landscape..... 4-9
4.2.3.2 Prescribing Solutions at the Scale of the Management Area..... 4-9
4.2.3.3 Prescribing Solutions at the Site Scale..... 4-10
4.2.3.4 Characterizing the Risk from Proposed Solutions..... 4-10
4.2.4 Step 3: Taking Actions..... 4-12
4.2.4.1 Taking Action at the Scale of the Contributing Landscape..... 4-12
4.2.4.2 Taking Action at the Scale of the Management Area..... 4-12
4.2.4.3 Taking Action at the Site Scale..... 4-13
4.2.5 Step 4: Monitoring..... 4-13
4.2.6 Adaptive Management..... 4-14

CHAPTER 5 ANALYZING THE LANDSCAPE AND ITS WETLANDS..... 5-1

5.1 INTRODUCTION..... 5-1
5.2 LANDSCAPE PROCESSES AND THEIR INFLUENCE ON WETLANDS AND THEIR FUNCTIONS..... 5-3
5.3 GOALS AND OBJECTIVES OF ANALYZING THE LANDSCAPE..... 5-5
5.4 QUESTIONS THAT CAN BE USED TO GUIDE AN ANALYSIS OF THE CONTRIBUTING LANDSCAPE AND THE MANAGEMENT AREA..... 5-6

5.4.1 Question 1. What are the landscape processes in the contributing landscape in the absence of human alterations, and where are they located geographically? 5-7
5.4.2 Question 2. What are the relationships between these original landscape processes and wetlands and their functions in the management area? 5-8
5.4.3 Question 3. What alterations to landscape processes have occurred, and how have these changes affected wetlands and their functions? 5-8
5.4.4 Question 4. What geographic areas are currently important for maintaining landscape processes and can be impacted by future activities and growth? 5-9
5.4.5 Question 5. What measures can be used to protect and restore landscape processes in order to protect and restore wetlands and their functions? 5-10
5.5 QUESTIONS THAT CAN BE USED TO GUIDE AN ANALYSIS OF INDIVIDUAL WETLANDS 5-10
5.5.1 Question 6. What wetlands are currently performing functions that are associated with important processes identified in the landscape analysis? .. 5-11
5.5.2 Question 7. What degraded wetlands or former wetlands are suitable for restoring landscape processes identified in Question 3? 5-11
5.5.3 Question 8. What are the functions of individual wetlands that need to be protected, preserved, or managed? 5-11

CHAPTER 6 PRESCRIBING SOLUTIONS: LANDSCAPE-BASED LAND-USE PLANS 6-1

6.1 INTRODUCTION 6-1
6.2 OVERVIEW OF PLANNING AND THE GMA 6-2
6.3 THE IMPORTANCE OF INCORPORATING A LANDSCAPE PERSPECTIVE IN PLANNING 6-4
6.4 SMART GROWTH 6-5
6.4.1 Smart Growth Can Be Used to Develop or Update Local Plans 6-7
6.4.2 Planning Approaches Using Smart Growth 6-8
6.4.3 Green Infrastructure Planning 6-9
6.4.3.1 The GRIST Approach 6-10
6.4.3.2 Implementing a GRIST Plan 6-12
6.4.3.3 Typical Steps for a GRIST Plan 6-12
6.4.4 Alternative Futures 6-17
6.4.4.1 Determining the Scope of the Analysis 6-17
6.4.4.2 Local Example of Alternative Futures Planning 6-21
6.4.5 Combining Complimentary Approaches 6-22
6.5 FISCAL SAVINGS AND OTHER BENEFITS 6-23
6.5.1 Using Green Infrastructure Instead of Constructing Infrastructure 6-23
6.5.2 Increase in the Local Tax Base 6-24
6.5.3 Reducing Costs of Public Services 6-25

CHAPTER 7 PRESCRIBING SOLUTIONS: COMPREHENSIVE PLANS 7-1

7.1 INTRODUCTION 7-1
7.2 AN OVERVIEW OF COMPREHENSIVE PLANNING 7-2
7.2.1 County-wide Plans and Policies 7-5

7.2.2 Tools for Implementing Comprehensive Plans 7-5
7.3 MANDATORY ELEMENTS OF COMPREHENSIVE PLANS 7-6
7.3.1 Land Use Element 7-6
7.3.1.1 Incorporating Landscape Analysis into the Land Use Element 7-7
7.3.1.2 Using Landscape Analysis in Different Sections of the Land Use Element 7-8
7.3.1.3 Landscape Analysis in the Policy Language of the Land Use Element 7-11
7.3.2 Capital Facilities Plan Element 7-17
7.3.3 Rural Lands Element 7-18
7.3.4 Transportation Element 7-19
7.3.5 Parks and Recreation Element 7-20
7.3.6 Economic Development Element 7-20
7.4 OPTIONAL ELEMENTS OF COMPREHENSIVE PLANS 7-20
7.4.1 Conservation Element 7-20
7.4.1.1 Natural Setting Element Used in Yakima County 7-21
7.4.2 Subarea Plans 7-22

CHAPTER 8 PRESCRIBING SOLUTIONS: REGULATORY TOOLS 8-1

8.1 INTRODUCTION 8-1
8.2 ISSUES IN ESTABLISHING REGULATIONS 8-4
8.2.1 Balancing Predictability with Flexibility 8-4
8.2.2 Staff Expertise and the Role of Third-Party Review 8-5
8.2.3 Separate Critical Area Permit vs. Provisions Throughout the Code 8-5
8.2.4 Risk Management for Wetland Resources 8-5
8.3 IMPORTANT ELEMENTS OF THE REGULATORY COMPONENT OF A PROTECTION PROGRAM 8-6
8.3.1 Designating, Identifying, and Mapping Wetlands 8-6
8.3.2 Applicability of Regulations 8-8
8.3.2.1 Protection of Wetlands Triggered by Various Development Permits 8-9
8.3.2.2 Separate Critical Area Permit 8-10
8.3.3 Exempted Activities, Allowed Activities, and Exceptions 8-11
8.3.3.1 Wetland Size 8-13
8.3.3.2 Size of Minimum Wetland Impact 8-14
8.3.3.3 Isolated Wetlands 8-14
8.3.3.4 Wetlands that are Prior Converted Croplands 8-14
8.3.3.5 Irrigation-Induced Wetlands 8-16
8.3.3.6 Clearing, Grading, and Placement of Fill 8-18
8.3.3.7 Ongoing Agriculture 8-18
8.3.3.8 Conversion of Wetlands to New Agriculture 8-19
8.3.3.9 Conversion of Agricultural Lands to Other Uses 8-19
8.3.3.10 Removal of Noxious Weeds 8-20
8.3.3.11 Forest Practices and Conversions 8-20
8.3.3.12 Removing Hazard Trees 8-21
8.3.3.13 Non-Compensatory Restoration and Enhancement 8-22
8.3.3.14 Stormwater Management 8-22
8.3.3.15 Emergency Activities 8-24

8.3.4 Wetland Rating 8-24
8.3.5 Requirements for Wetland Reports 8-25
8.3.6 Mitigation Sequencing 8-26
8.3.7 Compensatory Mitigation Requirements 8-26
8.3.7.1 Standards for Compensatory Mitigation 8-27
8.3.7.2 Special Types of Compensatory Mitigation 8-31
8.3.7.3 Impacts to buffers 8-36
8.3.8 Buffers 8-36
8.3.8.1 Issues Regarding the Regulation of Wetland Buffers 8-37
8.3.8.2 Reasonable Use Criteria 8-40
8.3.8.3 Buffer Averaging 8-41
8.3.8.4 Uses Within Buffers 8-41
8.3.8.5 Enhancement and Restoration of Buffer Areas 8-42
8.3.8.6 Best Management Practices to Enhance or Ensure Effective Functions of Buffers 8-43
8.3.8.7 Issues in Managing Buffers 8-44
8.3.8.8 Buffers in Urban Areas 8-46
8.4 MONITORING THE EFFECTIVENESS OF THE REGULATORY COMPONENT OF A PROTECTION PROGRAM 8-47

CHAPTER 9 PRESCRIBING SOLUTIONS: NON-REGULATORY TOOLS 9-1

9.1 INTRODUCTION 9-1
9.2 THREE CATEGORIES OF NON-REGULATORY ACTIONS TO CONSIDER 9-2
9.2.1 Preservation 9-3
9.2.2 Conservation 9-4
9.2.3 Restoration 9-4
9.3 FISCAL BENEFITS OF USING NON-REGULATORY TOOLS 9-5
9.4 IMPORTANT CONSIDERATIONS WHEN INCORPORATING NON-REGULATORY TOOLS 9-6
9.4.1 Funding Mechanisms 9-7
9.4.1.1 Common Forms of Conservation Revenue in Washington 9-9
9.4.1.2 Land Banking 9-9
9.4.2 Landowner Incentives 9-10
9.4.2.1 Incentive-based Tools: Open Space Current Use Taxation 9-10
9.4.2.2 Other Incentive-Based Tools 9-11
9.4.3 Incentive Zoning and Regulation 9-12

CHAPTER 10 PRESCRIBING SOLUTIONS: CHARACTERIZATION OF RISKS 10-1

10.1 INTRODUCTION 10-1
10.2 RISK AND THE GROWTH MANAGEMENT ACT 10-2
10.3 A PROCESS FOR CHARACTERIZING RISKS 10-4
10.3.1 Identifying the Environmental Disturbances or Benefits that Result from Proposed Actions 10-5
10.3.2 Identifying the Risks of Disturbances to the Functions and Values of Wetlands 10-6

10.3.3 Proposing Measures to Minimize the Risk or Replace the Resource at Risk…. 10-7

CHAPTER 11 TAKING ACTIONS: REGULATORY AND NON-REGULATORY ACTIVITIES 11-1

11.1 INTRODUCTION 11-1
11.2 IMPLEMENTING THE REGULATORY COMPONENT OF A PROTECTION PROGRAM 11-2
11.2.1 Adequately Trained Staff or Qualified Wetland Professional 11-2
11.2.2 The Process for Reviewing Permits 11-3
11.2.3 Inspecting and Monitoring the Wetland During Construction 11-4
11.2.4 Enforcing Regulations 11-4
11.2.5 Monitoring the Effectiveness of Regulations 11-5
11.2.6 Educational Materials 11-5
11.3 IMPLEMENTING THE NON-REGULATORY COMPONENT OF A PROTECTION PROGRAM 11-5
11.3.1 Staffing the Non-Regulatory Component 11-6
11.3.2 Identifying, Mapping, and Prioritizing Sites 11-7
11.3.3 Creating Partnerships for Locally Sponsored Projects 11-7
11.3.4 Identifying a Recipient to Hold and Manage Land or Rights to Land 11-8
11.3.5 Establishing Funding Mechanisms and Incentives for Landowners 11-8
11.3.6 Educating and Involving the Public 11-9
11.3.7 Monitoring Preservation and Restoration 11-9

CHAPTER 12 MONITORING AND ADAPTIVE MANAGEMENT 12-1

12.1 INTRODUCTION 12-1
12.2 WHAT SHOULD BE MONITORED? 12-3
12.2.1 Monitoring Trends in the Resource 12-3
12.2.2 Monitoring the Implementation of Protection Measures 12-4
12.2.2.1 Monitoring Implementation at the Scale of the Contributing Landscape 12-5
12.2.2.2 Monitoring Implementation at the Scale of the Management Area 12-5
12.2.2.3 Monitoring Implementation at the Site Scale 12-6
12.3 ADAPTIVE MANAGEMENT 12-6

REFERENCES

GLOSSARY

APPENDICES

Appendix 1-A Members of Core Team and Local Government Wetlands Advisory Team

Appendix 1-B Reviewers of Volume 2

Appendix 5-A Some Sources of Existing Data for Use in Landscape Analysis

Appendix 5-B Methods and Information Resources for Use in Analyzing Landscapes and Wetlands

Appendix 6-A References on Smart Growth and Related Topics

Appendix 7-A Examples of Cross-Jurisdictional Planning for Aquatic Resources

Appendix 8-A An Overview of Ways to Protect and Manage Wetlands

Appendix 8-B Recommendations for Wetland Language in a Critical Areas Ordinance

Appendix 8-C Guidance on Widths of Buffers and Ratios for Compensatory Mitigation for Use with the Western Washington Wetland Rating System

Appendix 8-D Guidance on Widths of Buffers and Ratios for Compensatory Mitigation for Use with the Eastern Washington Wetland Rating System

Appendix 8-E Rationale for the Guidance on Recommended Widths of Buffers and Other Methods for Protecting Wetlands

Appendix 8-F Rationale for the Guidance on Recommended Ratios for Compensatory Mitigation

Appendix 8-G Widths of Buffers Needed to Protect Some Threatened/Endangered/ Sensitive Wildlife Species Associated with Wetlands

Appendix 8-H Hiring a Qualified Wetland Professional

Appendix 9-A Additional Information on Preservation, Conservation, and Restoration

Appendix 10-A Example of a Characterization of the Risks of Wetlands

List of Tables

Table 1-1. Ecological principles and their implications in making decisions about land use (adapted from Dale et al. 2000 to focus on wetlands rather than land use in general). 1-9

Table 3-1. Subclasses and families of wetlands in different regions of Washington State (Hruby et al. 1999, 2000). 3-3

Table 3-2. Summary of types of environmental disturbances created by some types of land use. 3-6

Table 3-3. Synthesis of the information reported in the literature on the negative impacts of different human disturbances on wetland functions. 3-8

Table 3-4. Synthesis of the negative impacts of some land uses on wetland functions. . 3-9

Table 9-1. Common sources of financing for conservation. 9-7

Table 10-1. An example of a table summarizing risks associated with common land-use actions. 10-6

Table 10-2. An example of a table summarizing the risks of land-use actions and measures to minimize the risks. 10-7

Table 12-1. Monitoring common solutions to protecting and managing wetlands at the scale of the management area 12-6

List of Figures

Figure 4-1. A suggested framework for local governments to use in protecting and managing wetlands. 4-3

Figure 4-2. An example of contributing landscape, management area, and site scales. . 4-5

Figure 4-3. Four-step framework incorporating the three geographic scales. 4-6

Figure 5-1. Step 1 in the process of protecting and managing wetlands (analyze wetland resources). 5-1

Figure 5-2. Wetlands and their functions are an expression of landscape processes. Wetland functions can in turn modify the landscape processes. 5-4

Figure 6-1. Developing plans and policies fits into Step 2 within the four-step framework recommended for protecting and managing wetlands. 6-1

Figure 6-2. Conceptual representation of a landscape that has been inventoried as part of creating a GRIST plan (Figure provided by Heritage Conservancy, a non-profit land trust based in Doylestown, PA). 6-14

Figure 6-3. Conceptual representation of how hubs and links are identified as part of creating a GRIST plan (Figure provided by Heritage Conservancy, a non-profit land trust based in Doylestown, PA). 6-15

Figure 6-4. Conceptual representation of a completed GRIST plan (Figure provided by Heritage Conservancy, a non-profit land trust based in Doylestown, PA). 6-16

Figure 7-1. Comprehensive planning is part of Step 2 in the four-step framework recommended for protecting and managing wetlands. 7-1

Figure 8-1. Developing regulations is part of Step 2 in the four-step framework discussed in this volume. 8-1

Figure 9-1. Developing non-regulatory tools is part of Step 2 in the four-step framework for protecting and managing wetlands. 9-1

Figure 10-1. Characterizing risks is part of Step 2, Prescribing Solutions, within the four-step framework recommended for protecting and managing wetlands. 10-1

Figure 11-1. Implementing regulatory and non-regulatory components of a wetland protection program is Step 3 in the four-step framework presented in this volume 11-1

Figure 12-1. Monitoring is Step 4 of the four-step framework discussed in this volume, and Adaptive Management provides feedback for improving wetland protection programs. 12-1

Figure 12-2. Conceptual representation of how wetlands can be protected and managed using adaptive management 12-2

Acknowledgements

As with Volume 1, a great effort was put forth to complete this volume. A huge thank you is extended to the authors and Core Team members who spent many hours discussing, writing, and re-writing the public review draft as well as the final, some working after hours and on weekends. They deserve great kudos for their patience during the many rounds of edits that took place.

A special acknowledgement goes to Sara Noland of 2N Publications and Dyanne Sheldon of Sheldon and Associates for their work on the draft. Both went beyond the "call of duty" writing, reviewing and editing text while attending to their other demanding responsibilities. Sara had the patience of a saint as she edited text from multiple authors and incorporated Core Team comments throughout the process. Tom Noland of 2N Publications also lent his creative technical support during the production of the draft.

The team of local government staff that advised the Core Team during the development of the draft document are also acknowledged. The Local Government Wetland Advisory Team met numerous times to discuss complex and heated issues and provided invaluable suggestions and perspectives.

Steve Penland from the Washington State Department of Fish and Wildlife is commended for his responsiveness and collaboration on various iterations of this volume, as is Katherine March for her participation on the Core Team and Bob Ziegler for his review comments. Thanks to Michael Rylko from U.S. Environmental Protection Agency for lending his expertise on landscape-based land-use plans.

Tom Hruby of the Washington State Department of Ecology went beyond the call of duty to gladly work on any task asked of him even if they involved chapters not of his authorship. Thank you also to Erik Stockdale for his pain-staking work on the reference list and glossary.

Thank you to Susan Grigsby of Ecology for her responsiveness and technical assistance related to landscape analysis. Ecology staff Yolanda Holder and Paige Boulé are both acknowledged for their ready willingness to finalize and proof files; checking spelling, formatting, pagination, and reading the text from the standpoint of a non-expert. Donna Bunten of Ecology assisted with proofing the copy-ready version. Thank you to Tim Schlender of Ecology for working on the covers and assisting with the development of the web site and posting of the documents on the site.

Dana Mock of Ecology must be praised greatly and thanked profusely for her dedication, persistence, thoroughness, and patience during the completion and distribution of the final document. The project could not have been completed (nor would it have been as much fun) without her.

Special kudos also to Teri Granger for again managing an overwhelming project with aplomb. Working with an advisory team, multiple authors, and the support staff needed to

produce a coherent guidance document (as well as writing and editing) is akin to herding cats; tasks Teri does with patience, skill, and tact.

Andy McMillan must be applauded for his inspiration regarding the entire project and the production of both volumes. He served as the wise leader and creative problem-solver for all aspects of the project, and he is a good writer to boot. In addition, as noted in Volume 1, he obtained funding for the project from several sources. In the most literal sense, the project would never have happened nor been successful without his extensive knowledge, skills, and experience. In this sense, this tome is his.

The U.S. Environmental Protection Agency provided the primary financial backing for Volume 2 as it did for Volume 1. The Washington Department of Ecology also contributed funding for this volume. As with Volume 1, we thank the agencies for their support in undertaking such an ambitious endeavor.

Chapter 1
Introduction to Volume 2

1.1 Overview of Volumes 1 and 2

This document is the second in a two-volume series addressing wetlands in Washington and their protection and management. The first volume, *Freshwater Wetlands in Washington State - Volume 1: A Synthesis of the Science* (Sheldon et al. 2005), is a synthesis of the most current science and was released in draft form to the public in the fall of 2003. The comments from reviewers of the draft were used to revise the document and create the final version. All of the comments received on Volume 1 and the author's responses to them, as well as a 10-page summary of the significant comments, are posted on the project's web page: http://www.ecy.wa.gov/programs/sea/bas_wetlands.

Volume 1 synthesized the literature regarding:

- Freshwater wetlands in Washington and how they function
- The effects of human activities on Washington's freshwater wetlands and their functions
- The tools used to protect and manage freshwater wetlands and their functions and values

The key conclusions from Volume 1 are summarized in Chapter 3 in this document.

Volume 2 contains guidance primarily for local governments on protecting and managing wetlands and their functions based on the synthesis of the science in Volume 1. Although the primary audience is local governments, the information contained in this document should be useful to anyone who has an interest in the protection and management of wetlands in the state.

The key themes or messages in Volume 2 are as follows:

- By relying on a site-by-site approach to managing wetlands, we are failing to effectively protect them
- To effectively protect wetlands and their functions, we must understand and manage their interaction with the environmental factors that control wetland functions
- To understand and manage these environmental factors and wetland functions, information generated through landscape analysis is needed

- Landscape analysis should be one step in a four-step framework that should be used in developing a diversified program to protect and manage wetlands and their functions; the four-step framework should include analyzing the landscape, prescribing solutions, taking actions, and monitoring results and applying adaptive management

- Protection and management measures developed and implemented in steps two and three of the four-step framework (prescribing solutions and taking action) should incorporate a full range of components including:

  – Policies and plans such as landscape-based plans (such as Green Infrastructure), comprehensive plans, subarea plans, etc.

  – Regulations such as critical areas ordinances, clearing and grading ordinances, etc.

  – Non-regulatory activities such as incentives that encourage conservation, restoration, and preservation through voluntary efforts

1.2 Purpose and Goals of Volume 2

Both Volumes 1 and 2 were written to assist local governments in complying with requirements in the Growth Management Act (GMA) to include the best available science when adopting development regulations to designate and protect critical areas, including wetlands. The GMA requires that local governments protect wetland functions and values, and evaluate and include relevant scientific information when determining what policies, plans, and regulations are needed. (See Chapter 2 for a discussion of the relevant mandates in the Growth Management Act.)

This is a challenging task and one that some cities and counties are poorly equipped to undertake. Many local governments have asked the state departments of Ecology and Fish and Wildlife to assist them by synthesizing the science (Volume 1) and providing general guidance as well as specific recommendations for protecting wetlands based on the science (Volume 2). (See Section 1.4 on how Volume 2 was developed.)

The guidance presented in Volume 2 is advisory only. Local governments are not required to use this guidance. The guidance in and of itself is not "best available science." Rather, it represents the recommendations of the departments of Ecology and Fish and Wildlife as to how a local government could include the best available science in policies, plans, and regulations to protect wetlands.

Volume 2 was also written to address the fact that wetlands continue to be lost and degraded through human activities in spite of the adoption of "no net loss" policies at local, state, and federal levels and an increased knowledge of the complex processes that drive wetland functions. The results of the scientific research synthesized in Volume 1 are clear: We have not stopped the continued degradation of our wetlands and their functions (Sheldon et al. 2005).

As concluded in Volume 1, wetland losses often result from a combination of impacts from human activities that occur both within and outside individual wetlands. Changes from human activities result in cumulative impacts across the landscape. Currently, however, the majority of decisions about managing wetlands in Washington State fail to consider environmental factors that control wetland functions or the consequences of human actions that occur at a landscape scale; they are made on a case-by-case basis related to specific projects.

The departments' goals for Volume 2, therefore, are to help local governments:

- Include current scientific information in their decisions about the protection and management of wetlands to meet the requirements of the GMA
- Incorporate a diversified, landscape-based approach to better protect wetlands and their functions and values and to manage cumulative effects

Where possible, the authors of Volume 2 provide several options for protecting and managing wetlands using landscape analysis, processes for planning, regulatory options, as well as non-regulatory approaches. For example, three alternatives for buffer widths are presented, one being a matrix using factors such as wetland rating, intensity of the proposed, adjacent land use, wetland functions, and other characteristics. Such approaches allow more flexibility.

In the future, it is hoped that:

- The protection and management of wetlands will be integrated with the management of all environmental resources across the landscape
- Impacts to wetland functions and values from decisions about land uses will be understood at the appropriate geographic scales
- Local jurisdictions will plan for future development in a proactive manner, so impacts to the environmental factors that control functions are minimized before they occur
- When tradeoffs between conflicting values are made, the decision will be made with a full understanding of the "true value" lost or gained

1.2.1 Implementing a More Comprehensive Approach

This volume presents a four-step framework that integrates scientific information about the landscape (landscape analysis), planning approaches, and regulatory and non-

regulatory actions at the different geographic scales at which natural resources should be managed. It represents the ideal situation where a local government has adequate resources and commitment to undertake this process. The available scientific information makes clear that the most effective way to protect wetland functions and values is to use a comprehensive, landscape-based approach. Addressing only some of the recommendations in this volume, therefore, increases the risk that wetland functions and values will not be adequately protected. (See Chapter 10 for additional discussion of characterizing the risk of proposed solutions for protecting and managing wetlands.)

The departments of Ecology and Fish and Wildlife understand that not all local governments are currently in a position to implement the diversified, comprehensive program described in Volume 2. The entire process is presented so users can understand what information or tasks they are missing and to help understand the tradeoffs being made and the risks taken.

The authors of Volume 2 also recognize that many jurisdictions will face a challenge in updating their development regulations to meet the state GMA deadlines, even without incorporating a landscape perspective at this time. In addition, transforming our approach to managing wetlands from a site-specific focus to a view of the broader landscape is a change of practice for local governments. It will most likely occur incrementally as local governments collect and analyze landscape data and incorporate that information into their various policies, plans, and regulatory and non-regulatory activities. Local governments, therefore, should at a minimum adopt strong wetland regulations until they can incorporate landscape-based plans, policies, and non-regulatory elements.

Working with local governments on developing and using landscape analysis

This document provides ideas on how to analyze the landscape as well as references for the various analyses that are available (see Chapter 5 and Appendix 5-B). One method for landscape analysis that is described is a method currently being developed by Ecology. It provides suggestions on how to analyze landscape information (such as geology, soils, and water flow) for use in planning, developing protection measures, and identifying wetlands for restoration and preservation.

Ecology's method for landscape analysis is being improved as it is applied in different jurisdictions. In addition, the methods are currently lacking an analysis of wildlife habitat and corridors. This gap will be addressed in the near future as the departments of Fish and Wildlife and Ecology work together to better include wildlife factors in the analysis.

Ecology invites local governments to work with the agency to conduct landscape analyses and use the information to develop more effective approaches to protecting and managing the landscape and its wetlands. In this way, local governments can play an important role in further developing this approach to landscape analysis.

1.3 Scope of Volume 2

1.3.1 Non-GMA Protection of Wetlands is Not Addressed in Volume 2

The regulations and management programs implemented by federal, state, and tribal governments are not discussed in Volume 2. For example, the Clean Water Act administered by the U.S. Army Corps of Engineers is not discussed. These laws are only mentioned in relation to direct mandates to local governments. For example, the definition of wetlands used by local governments is mandated in state statute (see Chapter 8).

There is, however, a brief discussion of the Shoreline Management Act (SMA). In Chapter 4, the SMA is mentioned in relation to the four-step framework recommended in this volume for local wetland protection programs. The SMA guidelines include requirements for the inventory and analysis of "ecosystem-wide processes" (landscape processes). These requirements are consistent with the recommendations in Volume 2 for incorporating landscape analysis into local planning and protection efforts. The reader is referred to the following web site more information on the SMA guidelines (http://www.ecy.wa.gov/programs/sea/SMA/index.html).

1.3.2 Vegetated Tidal Wetlands are Addressed in Volume 2

The recommendations made in this document are not strictly limited to freshwater wetlands. Vegetated tidal wetlands (a subset of all tidal wetlands including vegetated wetlands in estuaries and coastal lagoons) are addressed specifically in the revised wetland rating system for western Washington (Hruby 2004b) because they were included in past versions of the rating system, even though the scientific information about them was not summarized in Volume 1. The scientific information on which recommendations for tidal wetlands were based is summarized in Appendices 8-E and F.

1.3.3 How Values are Addressed in Volume 2

As discussed in Volume 1, wetland functions are the things that wetlands "do." Society, however, does not necessarily attach "value" to all wetland functions. Value is usually associated with goods and services that society recognizes. For example, trapping sediments is a wetland function that improves water quality, and this is often valued by society. Not all of the environmental factors that control wetland functions or the functions themselves, however, are recognized or valued.

Sometimes what is valued is not what a wetland does but some other aspect of the wetland ecosystem that is considered important socially. For example, "recreation" is valued by society and is often called a function even though it is not something a wetland "does." Other aspects of the wetland ecosystem that are valued and have been called

functions include "education" and "aesthetic quality." These values are sometimes referred to as *social functions* to separate them from functions based on environmental factors.

The social functions cannot be assessed or rated using the same methods used to assess functions based on environmental factors. Valuing social functions requires methods based on economic, sociologic, and psychological tools, rather than on ecology and other environmental sciences. Therefore the literature on social functions was not synthesized in Volume 1.

The values of a community are an important consideration when developing the plans and polices of local governments. Values in this context are opinions held by communities in regard to what is important to them. For example, a community (urban or rural) might value one wetland function more than another. Water quality improvement might be more valued than flood control in an area with water quality problems if that community is not in an area prone to flooding. In addition, a community might value certain amenities in their neighborhoods or rural areas above others. For example, a neighborhood might value keeping the maximum amount of vegetated area through clustered development as opposed to scattered development that results in fragmented islands of vegetation. The need to identify and consider these values is discussed in Chapters 6 and 7. The landscape analysis discussed in Chapter 5 provides important information needed when making decisions about a community's values as well as what communities, and their wetlands, will be like in the future.

1.4 Developing Volume 2

Production of this document and Volume 1 was funded through a grant from the U.S. Environmental Protection Agency. Attendees of two focus groups provided early direction for the volumes. Meetings of focus groups were held in Olympia and Moses Lake in early 2002 to solicit ideas for the scope and objectives of the project. This information was used to guide the development of both volumes. These focus groups were attended by over 60 individuals, primarily representatives from local governments and consulting firms.

Both volumes were developed by a team (called the Core Team). Membership of the Core Team changed somewhat with the initiation of Volume 2. The Core team for Volume 2 consisted of staff from the departments of Ecology, Fish and Wildlife, and Community, Trade and Economic Development; Sheldon & Associates; and 2N Publications (the contract editor for the draft). A list of the members of the Core Team for Volume 2 is provided in Appendix 1-A. Several members of the Core Team wrote the various sections, chapters, and appendices of Volume 2.

The Core Team developed the guidance in conjunction with a team of local government staff: a Local Government Wetlands Advisory Team (LGWAT). The LGWAT members are also listed in Appendix 1-A. The LGWAT convened in December 2003 to provide ongoing input and guidance during the development of this volume. The team met

several times to review and respond to draft concepts and materials developed by the Core Team. Additionally, meetings were held with representatives from the business and environmental communities to solicit their ideas and comments on concepts and early draft documents (see Appendix 1-B).

The draft of Volume 2 was distributed for review during a four-week period to solicit comments. It was provided to all those who requested a hard copy, or a CD, or who downloaded it from the project's web page. Prior to the completion of the draft, a newsletter was sent to the project's mailing list of over 1,200 recipients, informing them of the review period. They were requested to inform Ecology if they wanted to review the draft and in what form they wanted to receive it. The Core Team requested that reviewers critique the general guidance as well as specific recommendations or additions. Comments regarding organization and ease of reading were also welcomed.

Seven reviewers provided comments (see Appendix 1-B) which were reviewed by the authors and were compiled in a separate document along with the author's responses to the comments. All four documents (responses to comments on the draft of Volume 1, the final version of Volume 1, responses to comments on the draft of Volume 2, and the final version of Volume 2) are posted on the project's web page and can be obtained as a CD or paper copy (http://www.ecy.wa.gov/programs/sea/bas_wetlands).

1.5 How Volume 2 is Organized

Volume 2 is organized into 12 chapters plus references, a glossary, and appendices. The first three chapters in this document explain the purpose, legal basis, and basic scientific foundation for the recommendations that follow. Chapter 4 outlines a suggested framework (divided in to four steps) which local governments can use to develop a diversified program to protect and manage wetlands. The remaining chapters, Chapters 5-12, describe the four steps and the primary components of a wetland protection program. The chapters include discussions of analyzing the landscape, landscape-based plans, comprehensive plans, regulatory and non-regulatory tools, characterizing the risk of wetland protection, implementing components of a protection program, and monitoring and adaptive management. Methods for analyzing landscapes and wetlands, recommended language for an ordinance, and various supporting information are provided in the appendices.

1.6 How to Use Volume 2

Local governments are encouraged to read and understand the entire document before determining how they want to protect wetland functions and values. This document is not intended to be a scientific treatise and, in general, references to specific scientific literature are limited. While Chapter 3 provides an overview of the scientific basis for the recommendations in this document, the more detailed, peer-reviewed and referenced information on wetland science is contained in Volume 1. We highly recommend reading Volume 1 as well, especially key points and conclusions.

As noted above, many of the recommendations in this document cannot be tied to a specific scientific article and cannot be cited as such (or the list of citations would be extremely long and cumbersome). Citations are provided only when a specific recommendation was also made within the scientific literature. Additional literature sources are cited in Chapters 6, 7, 9 and elsewhere in various parts of Volume 2. Many of these are more oriented towards policy and are not strictly scientific in nature. They were not, therefore, included in the synthesis of the science in Volume 1. Lastly, references are provided in various appendices. These are not necessarily included in the list of cited references but are at the end of the individual appendix in which they are mentioned.

In Volume 2, measurements are given in English Customary instead of metrics, whereas in Volume 1 both metric and standard are provided. For example, buffer widths are listed in feet only, not feet and meters. This was chosen because most local governments use English Customary measurements in their plans and regulations.

As mentioned previously, the guidance provided in Volume 2 is advisory only. The Growth Management Act <u>does not</u> require that local governments adopt the protection measures recommended in this document. Local governments are free to use or adapt the four-step framework and the options and recommendations presented here or develop entirely different approaches to protecting wetlands to fit their particular circumstances.

1.7 Using Science to Protect and Manage Wetlands

We recognize that it is challenging for local governments to include the best available science in developing or updating measures to protect and manage wetlands. In the following sections we discuss several topics relevant to this challenge. The topics include ecological principles to use when considering options for protecting and managing wetlands, some reasons why including the science can be challenging, and understanding the risks of the decisions made.

"To be effective, the nation's wetlands protection and management programs must anticipate rather than react. They should focus on future, not the present or the past; on effectively protecting the remaining resources and actively restoring or creating additional wetlands. They should anticipate needs and problems on the basis of rigorous analyses of regional resources, trends, stresses, and values. They should consider the whole, not just the individual parts."

The Conservation Foundation, *Protecting America's Wetlands: An Action Agenda. The Final Report of the National Wetlands Policy Forum* (1988).

1.7.1 Ecological Principles to Consider

The Ecological Society of America has taken a lead in compiling and explaining scientific principles on managing natural resources, such as wetlands (Dale et al. 2000). The ecologist's goal is to ensure that future decisions include the best scientific information available. The principles illustrate the need to take a more holistic, landscape approach to managing our natural resources. The principles and their implications in environmental decision making are briefly summarized in Table 1-1.

Table 1-1. Ecological principles and their implications in making decisions about land use (adapted from Dale et al. 2000 to focus on wetlands rather than land use in general).

Ecological Principle	Implication for Managing Land Use in and Around Wetlands
The type, intensity, and duration of disturbances are the major factors shaping populations and the ecosystem as a whole. Disturbances can occur at many different spatial and temporal scales.	Changes in land use that cause new disturbances are likely to cause changes in animal and plant populations and the functions of a wetland. We need to manage disturbances at the scale at which they occur. For example, the eutrophication of a wetland may be a result of disturbances throughout its watershed and this problem cannot be managed only within the wetland itself. Also, it is not possible to target a specific "end point" when creating or restoring wetlands because changes are continuous.
Ecological processes operate at many time scales, and ecosystems change through time.	The current state of a wetland is in part a consequence of historical conditions. Therefore, historical information may be needed to understand how a wetland will respond to disturbance. Managing wetlands to protect their valuable functions requires us to consider how ecological processes change through time both with and without the influence of human activities.
Some species have key, broad-scale effects on the ecosystem (keystone species).	The removal of keystone species can radically change the functions in a wetland and spread well beyond the boundaries of the wetland. Because the effects of keystone species are complicated and not fully understood, we cannot predict the effects on the ecosystem of changes in their numbers or distribution. For example, removing beavers from a river system has significant impacts on the biological diversity and flooding patterns of the entire watershed.
Local conditions strongly affect environmental functions at a site.	The position of a wetland in the landscape defines the functions it performs. Wetlands in a specific landscape position may perform only certain functions and at specific rates. We need to understand these local conditions when creating, restoring or enhancing wetlands so we do not "plan" for functions that the landscape will not support. For example, wetlands on slopes do not pond water. Creating a ponded wetland on a slope is not compatible with the position in the landscape, and maintaining this wetland will require constant management of the dikes and the outflow structure.
The size, shape, and location of different types of uplands around a wetland influence its functions.	An understanding of the surrounding landscape is needed to understand the implications of decisions made about an individual wetland.

The Ecological Society of America has also proposed guidelines for managers to use in considering the ecological impacts of their decisions about land use (including wetlands) (Dale et al. 2000). These guidelines, listed below, can be considered a checklist of factors to consider when making decisions about protecting or managing wetlands:

- Examine the impacts of local decisions in a regional (or landscape) context
- Plan for long-term change and unexpected events
- Preserve rare landscape elements, critical habitats, and associated species
- Avoid land uses that deplete natural resources over a broad area
- Retain large contiguous or connected areas that contain critical habitats
- Minimize the introduction and spread of non-native species
- Avoid or compensate for the effects of development on ecological processes
- Implement land use and land management practices that are compatible with the natural potential of the area

1.7.2 Interpreting the Science

Decisions by hearings boards and the courts have made clear that the requirement to "include the best available science in developing policies and development regulations to protect the functions and values of critical areas" is a substantive requirement, not merely a procedural one. (A review of hearings board and court cases that summarizes the key findings related to best available science, prepared by staff from the Department of Community, Trade and Economic Development and the state Attorney General's office, is presented in Chapter 2.)

However, incorporating scientific information in policies, plans, and regulations is challenging. The science of projecting how future land uses influence aquatic resources, such as wetlands, is still in its infancy (Nilsson et al. 2003). Planners using the scientific information available should not expect to be able to employ detailed methods that provide quantitative assessments of impacts from future development. Using existing data and tools, the ecological forecasts are largely qualitative in nature and essentially based on expert knowledge and correlations (Nilsson et al. 2003). Thus, the results of applying scientific principles are presented in terms of a "high," "moderate," or "low" risk to natural resources rather than a quantitative estimate of impacts (e.g., the number of amphibian species will be reduced by 50% if the county permits the filling of 10% of the remaining wetlands).

In fact, one of the greatest difficulties in applying scientific information in land-use planning and management is that the "science" doesn't provide specific answers for each circumstance that arises. The scientific information available rarely supplies us with exact or precise solutions for local circumstances. For example, some experiments that could be used to estimate the loss of amphibian species may not be applicable outside the immediate geographic area where the experiments were performed.

Furthermore, the scientists who reviewed the literature for Volume 1 found few studies that actually documented the effectiveness of specific protection measures (see Chapters 5 and 6 in Volume 1). Rather, most studies discuss the impacts of human activities on wetlands in general. The results are presented as correlations. For example, a decline in amphibian species in the Stockholm Sweden area has been correlated with the amount of developed land in the immediate vicinity of wetlands (Lofvenhaft 2002). This type of study does not demonstrate a true cause-and-effect relationship. There is no experimental proof that the decline is caused by the change in land use. Many impacts of human activities are not well understood and can only be hypothesized based on correlations.

As a result, recommendations based on scientific information are, to a large degree, based on hypotheses that extrapolate and synthesize all the information collected. Many of the recommendations in this document represent the collective interpretations by the authors (as reviewed by the Department of Fish and Wildlife) of the findings of the scientific literature synthesized in Volume 1 and how it pertains specifically to Washington or specific geographic regions within the state.

For example, the recommendation that a 200-foot buffer will adequately protect the wildlife habitat functions of high-functioning wetlands in eastern Washington is not based on one specific scientific study. Rather, it represents a synthesis of many studies (see Chapter 5 in Volume 1). These studies show that different species need different widths of buffers that range from 100 feet to more than 600 feet. Furthermore, very few studies have focused specifically on the needs of wildlife in wetlands of eastern Washington. Therefore, to provide general guidance, the authors were forced to make an informed decision on the size of buffer needed to protect wildlife in the wetlands of eastern Washington. In the absence of information about the species actually using a wetland, it was judged that a 200-foot buffer would adequately protect wildlife in wetlands that provide good habitat and are well connected in the landscape with a moderate risk that the protection standard will result in some degradation or loss of function. A local jurisdiction that wants to take a low-risk approach would increase the buffer widths above what is recommended in this volume.

1.8 Science and Risk Management

One of the major recommendations made in Volume 2 is that local jurisdictions should understand the risk to the wetland resource resulting from their decisions. The uncertainties of translating the science to specific protection measures, described above, is one of the reasons that local governments need to assess the risks. Using buffers again as an example, one might ask: *How wide a buffer is enough to protect wetland functions?* The science does not say that a 100-foot buffer will protect a certain kind of wetland, whereas a 95-foot buffer will not. Instead, scientific information on buffers clearly states that buffers are important, that they perform many functions that are critical to maintaining wetland functions, and that a wide range of buffer widths provides a variety of benefits depending on a number of factors.

Therefore, answering the critical question *How wide a buffer is enough?* is largely an exercise in assessing the science and deciding how much risk is acceptable. A regulation that sets a 300-foot buffer around every wetland significantly reduces the risk to those wetlands from human activities in the immediate vicinity of the wetland. That regulation can be characterized as relatively "low risk." On the other hand, a jurisdiction that decides they will provide a 50-foot buffer for all wetlands would have to characterize their action as "high risk" because a 50-foot buffer will not protect many wetland functions.

In this document, risk is addressed by tailoring the degree of protection to several factors that the scientific literature says are important. Continuing to use buffers as an example, one option presented in Volume 2 provides different buffer widths depending on the type of wetland and the functions it performs, as well as the type and intensity of adjacent land use. The widths recommended in this volume were selected from the middle of the range of buffers suggested in the literature: This, therefore, represents a moderate risk approach to determining buffer widths.

"Characterizing the risk" of decisions is also an important tool for improving approaches to wetland protection. Scientific data on the effectiveness of measures for protection can be collected and used to monitor the success of wetland management. This information then provides an objective basis on which to revise management approaches. (Risk characterization is discussed in detail in Chapter 10, and Chapter 12 provides information on monitoring and adaptive management.)

Many local governments will be inclined to rely largely on a regulatory approach to protect wetlands, and will tend to skip over the guidance on using a landscape approach as well as recommendations regarding landscape-based plans and non-regulatory tools. However, we believe the key message from the scientific literature is that reliance upon a strictly regulatory, permitting approach will fail to adequately protect wetland functions and values. Decision-makers should, therefore, consider the entire context of wetland protection and management when choosing the protections afforded to wetlands — from reducing impacts to wetlands through planning and zoning based on landscape analysis to using non-regulatory approaches such as stewardship incentives and restoration programs.

Chapter 2

The Growth Management Act and Protection of Critical Areas

2.1 Introduction

This chapter provides background on the Washington State Growth Management Act (GMA) and its directives to local governments to protect critical areas such as wetlands. It also clarifies issues regarding the protection of critical areas and incorporation of best available science into critical areas regulations.

> As defined in Chapter 36.70A.030(5) Revised Code of Washington (RCW), "critical areas" include: wetlands; areas with a critical recharging effect on aquifers used for potable water; fish and wildlife habitat conservation areas; frequently flooded areas; and geologically hazardous areas.

2.2 An Overview of the GMA

In 1990, the Washington State Legislature passed the GMA (RCW 36.70A) to guide local jurisdictions in their decisions regarding land use. The GMA dictates that counties and cities with certain characteristics must plan for future growth (RCW 36.70A.040). The GMA (RCW 36.70A.020 and RCW 90.58.020) identifies 14 goals that are to be used by local governments to "guide" the development of comprehensive plans and development regulations, including critical areas ordinances, to meet its intent and requirements. The goals consist of a range of actions, including concentrating urban development to reduce sprawl, providing a range of affordable housing, ensuring that transportation infrastructure is coordinated between jurisdictions, and assuring property rights.

In addition, the GMA includes goals that address maintaining the extraction of natural resources, such as timber and mining, and agricultural land uses while avoiding incompatible uses; providing for open space and recreation, including conserving fish and wildlife habitats; and protecting the environment and the quality of life in the state. Cities and counties have responded to these mandates by developing or updating their comprehensive plans and development regulations.

The GMA requires jurisdictions to develop regulations that implement their comprehensive plan provisions (RCW 36.70A.040). Comprehensive plans and development regulations, including critical areas regulations, are subject to continuing review and evaluation by the county or city that adopted them. In 2002, the Legislature

amended the GMA to require counties and cities to take legislative action to review and, if needed, revise their comprehensive land-use plans and regulations on a seven-year cycle to ensure the plans and regulations comply with the requirements of GMA (RCW 36.70A.130). (The review cycle had previously been five years.)

The GMA also requires local jurisdictions to include the best available science in the development of policies and development regulations used to both designate and protect the functions and values of critical areas (RCW 36.70A.172). The Legislature considered the requirement for best available science an important step toward regulatory reform and timely permitting of projects.

The GMA contains a variety of provisions that are directly related to landscape-based planning and developing regulations based on science. For example, there is a requirement to identify open space corridors within and between urban growth areas (RCW 36.70A.160). In addition, the GMA states that the corridors are to provide lands that are "… useful for recreation, wildlife habitat, trails, and connection of critical areas as defined in RCW 36.70A.030." This provision relates to one of the key findings of the synthesis of the science in Chapter 3 of Volume 1, which identifies habitat fragmentation (elimination of habitat links between wetlands) as one of the significant, adverse effects of urbanization on biodiversity. Other examples include provisions under the land use element (RCW 36.70A.070(1)) which requires the "protection of the quality and quantity of groundwater used for public water supplies" and, where applicable, the review of "drainage, flooding, and storm water run-off in the area and nearby jurisdictions and provide for guidance for corrective actions to mitigate or cleanse those discharges that pollute waters of the state, including Puget Sound, or waters entering Puget Sound."

In passing the GMA, the Legislature also required that local governments coordinate their comprehensive plans with jurisdictions that share either common borders or regional issues, to be consistent across political boundaries. Variations in zoning regulations, density of housing, for example, as well as the infrastructure built for transportation, water service, sewage, and other necessary public utilities, had been resulting in inconsistent and incompatible uses and expectations across jurisdictional boundaries.

2.3 A Review of Hearings Board Cases and Court Cases

The following sections present a review of court cases and Growth Management Hearings Board cases prepared by Alan Copsey, Washington State Attorney General's Office, and Chris Parsons, Washington State Department of Community, Trade and Economic Development. The text in these sections is from a memorandum (dated April 2004) to state agencies developed by Chris Parsons, summarizing Alan Copsey's information about GMA and critical areas protection. Minor edits have been made to the formatting of this text, such as the addition of subheadings, and to punctuation to make it consistent with the format of other chapters in this volume.

2.3.1 Designating Critical Areas and Adopting Regulations to Protect Them

The GMA recognizes that the first formal step required in implementing the GMA is the designation and protection of critical areas. This is important for two reasons: 1) to exclude critical areas from urban growth designations and impacts, and 2) to prevent irreversible environmental harm while comprehensive plans and implementing development regulations are prepared.

All three Growth Management Hearings Boards in Washington State (Central Puget Sound, Eastern Washington, and Western Washington) have recognized and given effect to the required priority of critical areas designation and protection.[1] The phrase *given effect to* implies a legal review and decision conferring status. In an oft-quoted passage, the Central Board explained:

> *It is significant that the Act required cities and counties to identify and conserve resource lands and to identify and protect critical areas before the date that IUGAs had to be adopted. This sequence illustrates a fundamental axiom of growth management: "the land speaks first." Only after a county's agricultural, forestry and mineral resource lands have been identified and actions taken to conserve them, and its critical areas, including aquifers, are identified and protected, is it then possible and appropriate to determine where, on the remaining land, urban growth should be directed pursuant to RCW 36.70A.110.*[2]

RCW 36.70A.170(1) requires that all critical areas in all counties and cities must be designated where appropriate. The GMA permits no exemptions, exclusions, or limitations on applicability that would result in some critical areas not being designated. The requirement to designate may be met by designating or mapping known critical areas at the time the critical areas ordinance is adopted or by adopting a process to designate or map critical areas as information becomes available.

RCW 36.70A.060(2) requires all counties and cities in Washington to adopt development regulations to protect designated critical areas.[3] The Western Board has described RCW 36.70A.060(2) as imposing a *duty* on local governments to adopt development

---

[1] *See Bremerton v. Kitsap Cy.*, CPSGMHB No. 95-3-0039c (Final Decision & Order, Oct. 6, 1995); *Association to Protect Anderson Creek v. City of Bremerton*, CPSGMHB No. 95-3-0053 (Final Decision & Order, Dec. 26, 1995); *City of Port Townsend v. Jefferson Cy.*, WWGMHB No. 94-2-0006 (Final Decision & Order, Aug. 10, 1994); *C.U.S.T.E.R. Ass'n v. Whatcom Cy.*, WWGMHB No. 96-2-0008 (Final Decision & Order, Sept. 12, 1996); *Knapp v. Spokane Cy.*, EWGMHB No. 97-1-0015c (Final Decision & Order, Dec. 24, 1997).

[2] *Bremerton v. Kitsap Cy.*, CPSGMHB No. 95-3-0039c (Final Decision & Order, Oct. 6, 1995).

[3] RCW 36.70A.060(2).

regulations that protect critical areas; inherent in that duty is the requirement that the regulation contain appropriate and specific criteria and standards to ensure protection.[4]

All designated critical areas must be protected but not all critical areas must be protected in the same manner or to the same degree.[5] To "protect" critical areas means to maintain their values and functions, this requires no net loss of critical areas values and functions.[6] The required standard of protection should be to prevent adverse impacts or, at the very minimum, to mitigate adverse impacts.[7]

While local governments have discretion to adopt critical areas regulations that may result in local impacts upon some critical areas, or even the loss of some critical areas, there must be no net loss of the structure, value, and functions of the natural systems constituting the protected critical areas.[8] A county or city must provide a detailed and reasoned justification for any designated critical area not protected.[9] All such decisions and justifications must be based on a substantive consideration of the best available science.[10]

Development in critical areas is not absolutely prohibited under the GMA, so long as the structure, functions, and values of the critical areas are protected.[11]

---

[4] *See Whatcom Envtl. Coun. v. Whatcom Cy.*, WWGMHB No. 95-2-0071 (Final Decision & Order, Dec. 20, 1995); *Willapa Grays Harbor Oyster Growers Ass'n v. Pacific Cy.*, WWGMHB No. 99-2-0019 (Final Decision & Order, Oct. 28, 1999).

[5] *Tulalip Tribes of Wash. v. Snohomish Cy.*, CPSGMHB No. 96-3-0029 (Final Decision & Order, Jan. 8, 1997); *Pilchuck Audubon Soc'y v. Snohomish Cy.*, CPSGMHB No. 95-3-0047 (Final Decision & Order, Dec. 6, 1995); *Easy v. Spokane Cy.*, EWGMHB No. 96-1-0016 (Final Decision & Order, Apr. 10, 1997); *Confederated Tribes & Bands of the Yakama Indian Nation v. Yakima Cy.*, EWGMHB No. 94-1-0021 (Final Decision & Order, Mar. 10, 1995); *Save Our Butte Save Our Basin Soc'y v. Chelan Cy.*, EWGMHB No. 94-1-0015 (Final Decision & Order, Aug. 8, 1994); *Clark Cy. Natural Res. Coun. v. Clark Cy.*, WWGMHB No. 92-2-0001 (Final Order, Nov. 10, 1992).

[6] RCW 36.70A.172(1); WAC 365-195-825(2)(b); *Tulalip Tribes of Wash. v. Snohomish Cy.*, CPSGMHB No. 96-3-0029 (Final Decision & Order, Jan. 8, 1997); *Pilchuck Audubon Soc'y v. Snohomish Cy.*, CPSGMHB No. 95-3-0047 (Final Decision & Order, Dec. 6, 1995).

[7] *Save Our Butte Save Our Basin Soc'y*, EWGMHB No. 94-1-0015 (Compliance Hearing Order, Apr. 8, 1999, and Final Decision & Order, Aug. 8, 1994); *English v. Bd. of Cy. Comm'rs of Columbia Cy.*, EWGMHB No. 93-1-0002 (Final Decision & Order, Nov. 12, 1993).

[8] *Tulalip Tribes of Wash. v. Snohomish Cy.*, CPSGMHB No. 96-3-0029 (Final Decision & Order, Jan. 8, 1997); *Pilchuck Audubon Soc'y v. Snohomish Cy.*, CPSGMHB No. 95-3-0047 (Final Decision & Order, Dec. 6, 1995). These decisions address wetlands and fish and wildlife habitat conservation areas, but their rationale applies also to frequently flooded areas and critical aquifer recharge areas insofar as they are protected for their ecological or hydrological function and value.

[9] *Friends of Skagit Cy. v. Skagit Cy.*, WWGMHB No. 96-2-0025 (Final Decision & Order, Jan. 3, 1997); *Whatcom Envtl. Coun. v. Whatcom Cy.*, WWGMHB No. 95-2-0071 (Final Decision & Order, Dec. 20, 1995).

[10] RCW 36.70A.172(1); *Honesty in Envtl. Analysis. & Legislation (HEAL) v. Cent. Puget Sound Growth Mgmt. Hrgs. Bd.*, 96 Wn. App. 522 (1999).

[11] *Knapp v. Spokane Cy.*, EWGMHB No. 97-1-0015 (Final Decision & Order, Dec. 24, 1997); *Association to Protect Anderson Creek v. Kitsap Cy.*, CPSGMHB No. 95-3-0053 (Final Decision & Order, Dec. 26,

The GMA does not categorically exempt pre-existing land uses from the requirement to protect critical areas. A city or county may need to regulate pre-existing uses in order to fulfill its statutory duty to "protect critical areas" under RCW 36.70A.060(2).[12] Any exemptions for pre-existing use must be limited and carefully crafted.[13]

Some critical areas, such as wetlands and fish and wildlife habitat conservation areas, may transcend the boundaries of individual parcels and jurisdictions, so that it is necessary to address the protection of their structure, function, and values on a larger scale (such as a watershed).[14]

2.3.2 Relationship of Critical Areas Regulations to Other Land Uses

Critical areas regulations are to overlay all other land uses, including designated natural resource lands and designated urban growth areas, and are to preclude land uses and developments that are incompatible with the protection of critical areas.[15] This overlay requirement makes sense in the overall scheme of the GMA, under which all lands are designated in one of three categories:

- Urban land (i.e., within a designated urban growth area)
- Natural resource land (i.e., designated as agricultural, forest, or mineral resource land)

1995); *Pilchuck Audubon Soc'y v. Snohomish Cy.*, CPSGMHB No. 95-3-0047 (Final Decision & Order, Dec. 6, 1995).

[12] *Protect the Peninsula's Future v. Clallam Cy.*, WWGMHB No. 00-2-0008 (Final Decision & Order, Dec. 19, 2000).

[13] *Id.*; *Friends of Skagit Cy. v. Skagit Cy.*, WWGMHB No. 96-2-0025 (Final Decision & Order, Jan. 3, 1997).

[14] *Tulalip Tribes of Wash. v. Snohomish Cy.*, CPSGMHB No. 96-3-0029 (Final Decision & Order, Jan. 8, 1997).

[15] WAC 365-190-020. Critical areas overlaying designated urban growth areas, *see Advocates for Responsible Dev. v. City of Shelton*, CPSGMHB 98-2-0005 (Final Decision & Order, Aug. 10, 1998); *Litowitz v. City of Federal Way*, CPSGMHB No. 96-3-0005 (Final Decision & Order, July 22, 1996); *Pilchuck Audubon Soc'y v. Snohomish Cy.*, CPSGMHB No. 95-3-0047 (Final Decision & Order, Dec. 6, 1995); *Association of Rural Residents v. Kitsap Cy.*, CPSGMHB No. 93-3-0010 (Final Decision & Order, June 3, 1994).Critical areas overlaying designated natural resource lands, *see Protect the Peninsula's Future v. Clallam Cy.*, WWGMHB Nos. 00-2-0008/ 01-2-0020 (Compliance Order/Final Decision & Order, Oct. 26, 2001); *Mitchell v. Skagit Cy.*, WWGMHB No. 01-2-0004 (Final Decision & Order, Aug. 6, 2001); *Saddle Mtn. Minerals v. City of Richland*, EWGMHB No. 99-1-0005 (Order Finding Partial Compliance, Apr. 18, 2001); *Friends of Skagit Cy. v. Skagit Cy./Skagit Audubon Soc'y v. Skagit Cy.*, WWGMHB Nos. 96-2-0025/ 00-2-0033c (Compliance Hearing/Final Decision & Order, Aug. 9, 2000); *Saddle Mtn. Minerals v. Grant Cy.*, EWGMHB No. 99-1-0015 (Final Decision & Order, May 24, 2000); *Island Cy. Citizens' Growth Mgmt. Coalition*, WWGMHB No. 98-2-0023 (Final Decision & Order, June 2, 1999); *Friends of Skagit Cy. v. Skagit Cy.*, WWGMHB No. 96-2-0025 (Final Decision & Order, Jan. 3, 1997). Critical areas overlaying rural lands, *see City of Anacortes v. Skagit Cy.*, WWGMHB No. 00-2-0049c (Final Decision & Order, Feb. 6, 2001).

- Rural land (which may include limited areas of more intense rural development and a variety of land uses)

These three designations have been called the "fundamental building blocks of land-use planning under the GMA;"[16] other land-use designations and restrictions overlay these three primary designations. As long as critical areas are protected, "other, non-critical portions of land can be developed as appropriate under the applicable land-use designation and zoning requirements."[17]

2.3.3 Including Best Available Science in Critical Areas Regulations

RCW 36.70A.172(1) requires all local governments to include the best available science when adopting development regulations to designate and protect critical areas. In addition, they "shall give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries." This language actually imposes three inter-related requirements:

- The requirement to include the best available science when designating and protecting critical areas
- The requirement to give special consideration to the preservation or enhancement of anadromous fisheries
- The requirement to adopt development regulations that protect the functions and values of critical areas

There are two reported appellate court decisions interpreting RCW 36.70A.172, focused primarily on what it means to *include* the best available science.[18] In the HEAL case, the Court did not attempt to explain what constitutes best available science, although it suggested in passing that the Board could not displace a local government's judgment as to which science in the record is the "best."[19] On the other hand, the Court strongly stated that a local government "cannot ignore the best available science in favor of the science it prefers simply because the latter supports the decision it wants to make."[20] This language suggests the Board in fact may review whether a local government has

---

[16] *See Forster Woods' Homeowners Ass'n v. King Cy.*, CPSGMHB No. 01-3-0008 (Final Decision & Order, Nov. 6, 2001)

[17] *See Association to Protect Anderson Creek v. City of Bremerton*, CPSGMHB No. 95-3-0053 (Final Decision & Order, Dec. 26, 1995); *Knapp v. Spokane Cy.*, EWGMHB No. 97-1-0015c (Final Decision & Order, Dec. 24, 1997).

[18] *Honesty in Envtl. Analysis & Legislation (HEAL) v. Cent. Puget Sound Growth Mgmt. Hrgs. Bd.*, 96 Wn. App. 522 (1999). *Whidbey Environmental Action Network [WEAN] v. Island County*, ___ Wn. App. ___, 93 P.3d 885, 893 (2004)

[19] *Id.*, 96 Wn. App. at 530.

[20] *Id.*, 96 Wn. App. at 534.

identified and relied on the best available science and remand to the local government to achieve compliance with RCW 36.70A.172(1).

In the WEAN case (see footnote 18 on the previous page), the Central Board concluded that some of the stream buffers in Island County that were adopted to protect fish and wildlife habitat conservation areas were not supported by the scientific information in the record before the County. The Court of Appeals affirmed, rejecting the County's argument that the Board must defer to the local government's discretionary balancing of the best available science with other factors. The Court explained that RCW 36.70A.172(1) requires the best available science to be included in the record and considered substantively in the development of critical areas policies and regulations.[21] The Court briefly reviewed the science in the record and held that the Board's disapproval of the stream buffers was supported by sufficient evidence.

If a local government chooses to depart from best available science, then it is recommended that the jurisdiction follow the criteria provided in Chapter 365-195-915 WAC for demonstrating that the best available science has been "included" in the development of critical areas policies and regulations. The local government's record supporting adoption of those policies and regulations should include the following:

- The specific policies and regulations adopted to protect the functions and values of critical areas
- Copies of (or references to) the best available science used in the decision making
- The nonscientific information used as a basis for departing from science-based recommendations
- The rationale supporting the local government's reliance on the identified nonscientific information
- Actions taken to address potential risks to the functions and values of the critical areas the policies and regulations are intended to protect

Implicit in the rule is the presumption that the Growth Management Hearings Boards and the courts review both the local government's assessment of what constitutes the best available science and the substantive relationship between the best available science and the adopted critical areas regulations. Local governments must substantively consider the best available science when adopting development regulations to designate or protect critical areas. The adopted regulations must protect the functions and values of the critical areas. If the local government determines this protection can be assured using an approach different from that derived from the best available science, the local government must demonstrate on the record how the alternative approach will protect the functions and values of the critical areas.

[21] 76 Wn.2d at 1222-23, citing *Honesty in Environmental Analysis & Legislation (HEAL) v. Central Puget Sound Growth Management Hearings Board*, 96 Wn. App. 522, 532, 979 P.2d 864 (1999).

2.3.4 Protecting the Functions and Values of Critical Areas

Local governments must adopt development regulations that protect the functions and values of critical areas. This reference to functions and values has been interpreted to mean the functions and values of the resources of which a given critical area is a part. Accordingly, while a local government is not prohibited from allowing localized impacts on some critical areas, or even the loss of some critical areas, it may not allow a net loss of the functions and values of the resources including the impacted or lost critical areas. Moreover, any loss or adverse impact should be allowed only for good cause and evaluated using the best available science.

The Central Board has explained that RCW 36.70A.172(1), read together with RCW 36.70A.060 and RCW 36.70A.020(8), requires local governments to protect critical areas, maintain and enhance anadromous fisheries, and conserve fish and wildlife habitat.[22] RCW 36.70A.172(1) thus conveys a legislative intent to protect the functions and values of critical areas, recognizing that wetlands and fish and wildlife habitat conservation areas, in particular, are interrelated ecosystems important to the preservation and enhancement of anadromous fisheries:

> *[T]he Act's requirement to protect critical areas, particularly wetlands and fish and wildlife habitat conservation areas, means that the values and functions of such ecosystems must be maintained. While local governments have the discretion to adopt development regulations that may result in localized impacts upon, or even the loss of, some critical areas, such flexibility must be wielded sparingly and carefully for good cause, and in no case result in a net loss of the value and functions of such ecosystems within a watershed or other functional catchment area*.[23]

[22] *Tulalip Tribes of Wash. v. Snohomish Cy.*, CPSGMHB No. 96-3-0029 (Order on Motions, Oct. 6, 1996).

[23] *Id.*

Chapter 3
Key Conclusions from Volume 1

3.1 Introduction

This chapter briefly summarizes the information and conclusions presented in Volume 1 of this two-volume document. The first section highlights the major conclusions from the scientific literature that relate to protecting and managing wetlands. The subsequent sections summarize the findings of Chapters 2 through 7 of Volume 1.

Please note that this is intended to be a brief overview of Volume 1. More detailed lists of key points and discussions of conclusions are provided at the end of major sections in each chapter of Volume 1.

3.2 Major Conclusions About Our Current Efforts to Protect Wetlands

In spite of wetland regulatory programs at federal, state, and local levels, the data show that impacts to wetlands continue. The existing scientific information points to the fact that we have not achieved the federal and the state of Washington goal of "no net loss of wetland functions or area." From 1986 to 1997, the estimated annual loss of wetlands nationwide continued to be about 58,500 acres per year. On a positive note, this was about a quarter of the rate of previous losses (National Research Council 2001). Such losses of wetlands have also been documented for the Pacific Northwest (see Chapter 7 in Volume 1).

The review of the information on how we manage wetlands points to several reasons why losses continue. These include:

- Case-by-case permitting under current regulations does not meet the goal of "no net loss" (National Research Council 2001). The majority of decisions concerning wetlands in Washington State and the nation are based on case-by-case actions related to specific projects, without any opportunity to consider the broader landscape, the environmental factors that control wetland functions, or consequences. This pattern is a result of the current structure of programs at local, state, and federal regulatory agencies. The results of the research on case-by-case permitting processes are clear: There are consistent wetland losses regionally and statewide. These impacts are often the result of cumulative and synergistic impacts across the landscape.

- The functions performed by wetlands can be affected by actions taken in other parts of the watershed (see Chapter 2 in Volume 1).

- Decisions made without an understanding of how a wetland is affected by and can affect its watershed often result in actions that do not adequately protect functions of wetlands. Since the case-by-case approach has not worked to ensure that there is "no net loss" of wetland area and functions for over 20 years, it can be assumed that wetlands and their functions will be adequately protected to meet this goal only if protection and management occur at a larger geographic scale. The National Research Council (2001) concludes that "a watershed approach would improve permit decision-making."

3.3 Wetlands in Washington and How They Function (Chapter 2 of Volume 1)

3.3.1 Types of Wetland Functions and How They Are Controlled

Chapter 2 of Volume 1 discusses the functions of wetlands, which are things that wetlands "do." Wetland functions are generally grouped into three broad categories:

- Biogeochemical functions, which are related to trapping and transforming chemicals and include functions that improve water quality in the watershed
- Hydrologic functions, which are related to maintaining the water regime in a watershed and include such functions as reducing flooding
- Food web and habitat functions

The functions that wetlands perform are controlled by environmental factors that occur in the broader landscape as well as within the wetland. The primary factors that control wetland functions are climate, geomorphology, the source of water, and the movement of water. These factors affect wetland functions directly or through a series of secondary factors including nutrients, salts, toxic contaminants, soils, temperature, and the connections between different ecosystems.

The most important environmental factors that control wetland functions at an individual site may occur outside the boundary of the wetland. For example, riverine wetlands are affected to a great degree by processes operating at the scale of the entire watershed of the river. In contrast, depressional wetlands often are subject to processes that occur primarily within the basin that contributes surface or groundwater to the wetland. Thus, the environmental factors that control the structure and functions of a wetland occur at both the landscape scale (in the watershed where the wetland is located and beyond) as well as at the site scale (within and near the wetland).

Information about the factors that control functions at the landscape scale is still evolving. Ongoing research is continually strengthening our understanding of these factors.

An understanding of wetland functions for the purposes of protecting and managing them will require knowledge of how the major controls of functions change or are affected by humans at different geographic scales. We need to understand how climate, topography, and the movement of water, nutrients, sediment, etc. are affected by human activities in the larger landscape as well as within and in the immediate vicinity of the wetland. Environmental disturbances caused by human activities and their affects on the functions of wetlands are summarized in Sections 3.3 and 3.4 below.

3.3.2 Classification of Wetlands in Washington as a Key to Understanding Their Functions

The diverse areas of Washington State support many kinds of wetlands that vary in functions. For example, vernal pools on the scablands differ greatly from the floodplain marshes along the Snoqualmie River, and wetlands that formed in the potholes created by glaciers have different functions from those found along the shores of salt lakes in the Grand Coulee.

Scientists have divided wetlands in Washington into different groups based on their functions (see Table 3-1). The environmental factors of geomorphology, the source of water, and the movement of water are the basic characteristics used to divide wetlands into these groups.

Table 3-1. Subclasses and families of wetlands in different regions of Washington State. (Hruby et al. 1999, 2000)

Class	Subclasses and Families by Region			
	Lowlands of Western WA	**Lowlands of Eastern WA**	**Columbia Basin**	**Montane (East and West)**
Riverine	Impounding Flow-through	ND	ND	ND
Depressional	Outflow Closed	ND	Alkali Freshwater Long-duration Short-duration	ND
Slope	ND	ND	ND	ND
Flats	ND	Probably does not occur in the region.	Probably does not occur in the region.	ND
Lacustrine (lake) Fringe	ND	ND	ND	ND
Tidal Fringe	Salt Water Fresh Water	Does not occur in the region.	Does not occur in the region.	Does not occur in the region.
ND = Subclasses in the region have not yet been defined.				

3.4 Environmental Disturbances Caused by Human Activities and Uses of the Land (Chapter 3 of Volume 1)

Chapter 3 of Volume 1 discusses the major types of environmental disturbances created by human activities and uses of the land and water. These disturbances change the environmental factors that in turn control wetland functions. Chapter 3 of Volume 1 addresses the disturbances created by four major types of land uses in Washington State: agriculture, urbanization, forest practices, and mining.

Several types of disturbances have been documented to change the factors that control wetland functions. These disturbances include:

- Changing the physical structure within a wetland (e.g., filling, removing vegetation, tilling soils, compacting soils)
- Changing the amount and velocity of water (either increasing or decreasing)
- Changing the fluctuation of water levels (volume, frequency, amplitude, direction of flow)
- Changing the amount of sediment (increasing or decreasing the amount)
- Increasing the amount of nutrients
- Increasing the amount of toxic contaminants
- Changing the temperature
- Changing the acidity (acidification)
- Increasing the concentration of salt (salinization)
- Fragmentation (decreasing area of habitat and its spatial configuration)
- Other disturbances that are not as well documented including, alteration of soils, construction of roads, noise, recreational access, invasion of exotic species, and access by domestic pets

As with performance of functions, a general conclusion that can be made from the scientific literature is that disturbances can also occur at several geographic scales. Much of the early research focused on disturbances at a single site or wetland. More recent research has documented the significance of disturbances that occur at the much larger scale of the landscape.

The effects of different human land uses on the flow and fluctuations of water are well documented. Changes in land uses and vegetation communities alter the patterns of surface and shallow groundwater movement across a landscape. Flows of water can be

reduced or increased by different land uses, as can the volume, frequency, and amplitude of water levels downgradient of the disturbance. Removal of vegetation and/or compaction of native soils through agricultural practices, creation of lawns or grazed pastures, or creation of impervious surfaces through urbanization all have the same relative consequence: increased volumes of water and rates of flow after a given storm event. As with urbanization, agriculture can influence the water regime of wetlands, leading to loss of wetlands in some areas and creation or maintenance of wetlands in other areas where wetlands did not originally exist, such as areas influenced by irrigation.

Human activities also increase sediment and other pollutants in runoff. Pollutants often adhere to sediment particles that enter wetlands. In agricultural areas, pesticides and fertilizers can contribute to contamination of surface waters. In urban areas, stormwater runoff frequently contains sediment, organic matter, phosphorus, metals, and other pollutants. Mining increases the acidity of surface waters as well as adding toxic heavy metals. Logging increases sediments and can also change the amount of water and its fluctuations.

Fragmentation of habitats is also of increasing concern in the literature. As connections between wetlands and other habitats are broken and more wetlands across the landscape are converted to other uses, the remaining habitat becomes more isolated. This potentially puts wildlife populations at risk.

A key finding is that different land uses may cause the same change in the controls of wetland functions. For example, changing the input of sediment can affect wetland functions (as discussed in Section 3.4 below). Urban land uses, agricultural practices, and forest practices have all been shown to increase sediments in a watershed. From the wetland's "point of view," the source of the sediment is irrelevant—the impact of excess sediments on wetland functions is similar, regardless of the source of the sediments.

The disturbances created by some types of land use are summarized in Table 3-2. The table is organized by the type of land use and the scale at which the disturbance occurs. This table represents a synthesis of the severity of impacts as compiled by the authors of Volume 1 based on the information in the literature.

Table 3-2. Summary of types of environmental disturbances created by some types of land use.

Disturbance	Scale of Disturbance	Agriculture	Urbanization	Mining
Changing the physical structure within wetlands (filling, vegetation removal, tilling of soils, compaction of soils)	Site scale	xx	xx	h
Changing the amounts of water	Landscape scale	xx	xx	?
	Site scale	xx	xx	h
Changing fluctuations of water levels (frequency, amplitude, direction of flows)	Landscape scale	xx	xx	?
	Site scale	xx	xx	h
Changing the amounts of sediment	Landscape scale	xx	xx	h
	Site scale	xx	xx	h
Increasing the amount of nutrients	Landscape scale	xx	xx	nm
	Site scale	xx	xx	nm
Increasing the amount of toxic contaminants	Landscape scale	xx	xx	x
	Site scale	xx	xx	xx
Changing the acidity	Landscape scale	nm	nm	x
	Site scale	nm	nm	xx
Increasing the concentrations of salt	Landscape scale	x	nm	nm
	Site scale	x	nm	nm
Fragmentation	Landscape scale	xx	xx	h
Other disturbances	Site scale	xx	xx	h

Key to symbols used in table:

(xx) land use creates a major disturbance of environmental factors that affects large areas in the state

(x) land use creates a disturbance

(nm) studies on impacts of this land use do not mention this disturbance

(h) literature is lacking but disturbances can be hypothesized based on authors' experiences

(?) information lacking

3.5 Negative Impacts of Human Disturbances on the Functions of Wetlands (Chapter 4 of Volume 1)

As described above, Chapter 3 of Volume 1 discusses how human land uses cause disturbances in the environmental factors that control wetland functions. Chapter 4 takes the discussion a step further by explaining how a change in these environmental factors can actually result in a change in wetland functions.

The literature findings are displayed in a summary format in Table 3-3. This table summarizes the effects on wetland functions of each type of human disturbance listed in Table 3-2 (e.g., change in physical structure, change in the amount of water, change in the amount of sediment, etc.).

By combining the information in Tables 3-2 and 3-3, it is possible to associate changes in functions of wetlands with general types of human land use, as shown in Table 3-4.

For example, Table 3-2 shows that urbanization creates significant disturbances that change the amount of water, fluctuations of water levels, input of sediments, nutrients, and contaminants to wetlands. Table 3-3 shows that disturbances to water flows, fluctuations of water levels, and input of sediments, nutrients, and contaminants have a significant impact on the wetland functions of providing habitat for plants, invertebrates and reptiles/amphibians. Table 3-4 synthesizes the information from the previous two tables to show that urbanization impacts the habitat for plants, invertebrates, reptiles, and amphibians in wetlands. These tables, therefore, summarize how human land uses create various disturbances in the environment, and those disturbances in turn affect the factors that control wetland functions, ultimately leading to changes in those functions.

Table 3-3. Synthesis of the information reported in the literature on the negative impacts of different human disturbances on wetland functions.

Disturbance Type	Functions							
	Hydrologic	Water Quality	Plants	Habitat for Invertebrates	Habitat for Amphibians and Reptiles	Habitat for Fish	Habitat for Birds	Habitat for Mammals
Changing the physical structure within a wetland	+	+	++	++	+	+	++	+
Changing the amount of water	+	+	++	++	++	+	+	?
Changing fluctuations of water levels	?	?	++	+	++	+	?	?
Changing amounts of sediment	+	?	++	++	?	?	?	?
Increasing amounts of nutrients	+	+	++	++	++	+	+	+
Increasing amounts of toxic contaminants	?	+	++	++	++	++	++	?
Changing acidity	0	+	+	++	++	+	+	+
Increasing concentrations of salt	0	?	++	++	?	?	+	?
Fragmentation	0	?	?	?	++	?	++	+
Other disturbances	?	?	++	+	++	++	++	++

Note: A disturbance can decrease or increase a function depending on the intensity of the disturbance (e.g., small amounts of nutrients can increase invertebrate richness and abundance, but too much will cause eutrophication and a negative impact).

Key to symbols used in table:

++	Major negative impacts on specific functions have been documented
+	Some data suggest impacts, or impacts could be hypothesized
0	Data indicate that impacts are minimal
?	Information is lacking and/or may vary by species

Table 3-4. Synthesis of the negative impacts of some land uses on wetland functions.

Land Use	Functions							
	Hydrologic	Water Quality Improvement	Plants	Habitat for Invertebrates	Habitat for Reptiles and Amphibians	Habitat for Fish	Habitat for Birds	Habitat for Mammals
Agriculture	+	+	++	++	++	++	++	+?
Urbanization	+	+	++	++	++	++	++	+?
Mining	?	?	+	++	++	+	+	+?

Key to symbols used in table:

++ Major negative impacts on specific functions have been documented
+ Some data suggest impacts or impacts could be hypothesized
? Information is lacking
+? Some impacts have been documented but more information is needed

3.6 The Science and Effectiveness of Wetland Management Tools (Chapter 5 of Volume 1)

3.6.1 How Wetlands Are Defined

Wetlands are defined using well established language that is generally consistent between federal and Washington State laws. In some jurisdictions, all lands that meet the definition of wetland are regulated. However, it is not unusual for a jurisdiction to differentiate within its regulations between *wetlands* (i.e., biological wetlands) and *regulated wetlands* (i.e., wetlands that they intend to regulate). The definition of what constitutes a regulated wetland may vary from jurisdiction to jurisdiction.

Delineation of wetland boundaries is conducted according to either the federal or state delineation manual. These manuals are consistent and, when applied correctly, will result in the same wetland boundary. In the State of Washington, however, local jurisdictions are required by state law to use the state manual (RCW 36.70A.175, Chapter 173.22.080 WAC).

As discussed in Chapter 5 of Volume 1, certain wetland types are sometimes excluded from regulation. These can include small wetlands, isolated wetlands, and wetlands that are designated as Prior Converted Croplands. The scientific literature makes clear that small wetlands and isolated wetlands provide important functions and does not provide any rationale for excluding these wetlands from regulation. Little scientific information is available on Prior Converted Croplands that are wetlands, but there is no evidence to suggest that they are unimportant in providing wetland functions.

Wetland rating systems are a useful tool for grouping wetlands based on their needs for protection. In Washington, a wetland rating system for both eastern and western Washington (Hruby 2004a, 2004b) has been developed, which places wetlands in categories based on their rarity, sensitivity, our inability to replace them, and their functions. Many local governments in Washington have modified these state rating systems for use in their own jurisdictions.

3.6.2 Wetland Buffers

Wetland buffers are one management tool for protecting wetland functions. The findings in the literature on buffers and their effectiveness are related to the type of wetland function, what activities are being buffered, and the characteristics of the wetland and the buffer itself.

The literature confirms that for improving water quality (e.g., sediment removal and nutrient uptake) there is a non-linear relationship between the width of the buffer and increased effectiveness in water quality improvement. Sediment removal and nutrient uptake are provided at the greatest rates within the immediate outer portions of a buffer (nearest the source of sediment/nutrient), with increasingly larger widths of buffers required to obtain measurable increases in those functions beyond this initial removal. Additionally, the long-term effectiveness of buffers in providing this function is not well documented in the literature and represents a need for future research.

To protect wildlife that depends on wetlands, the literature has documented the need for significantly larger buffers than those that are adequate to provide sediment removal and nutrient uptake. Research confirms that many wildlife species depend upon wetlands for only portions of their life cycles and they require upland habitats adjacent to the wetland to meet all their life needs. Some species use upland habitats that are far removed from the wetland. The literature documents that, without access to appropriate upland habitat and the opportunity to move safely between habitats across a landscape, it is not possible to maintain viable populations of many species.

In the long term, human actions can reduce the effectiveness of buffers through removal of buffer vegetation, soil compaction, sediment loading, and dumping of garbage.

Authors who synthesized the literature on the effectiveness of buffer widths suggest buffers between 25 and 75 feet for wetlands with minimal wildlife habitat functions and adjacent low-intensity land uses; 50 to 150 feet for wetlands with moderate habitat functions or adjacent high-intensity land uses; and 150 to 300 feet for wetlands with high habitat functions. Effective buffer widths for protecting water quality ranged from 25 to 50 feet for 60% removal of pollutants, to 150 to 200 feet for 80% removal of pollutants.

3.7 The Science and Effectiveness of Wetland Mitigation (Chapter 6 of Volume 1)

As discussed in Chapter 6 of Volume 1, according to the rules implementing the Washington State Environmental Policy Act (Chapter 197.11 WAC), mitigation involves the following steps that are performed sequentially (WAC 197.11.768):

1. *Avoiding the impact altogether by not taking a certain action or parts of an action;*

2. *Minimizing impacts by limiting the degree or magnitude of the action and its implementation by using appropriate technology or by taking affirmative steps to avoid or reduce impacts;*

3. *Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;*

4. *Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;*

5. *Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or*

6. *Monitoring the impact and taking appropriate corrective measures.*

The term *compensatory mitigation* refers to the compensation stage of the mitigation sequence (number 5 in the list of steps above). For wetlands, it typically involves producing new wetland area, functions, or both as compensation for wetland area, function, or both that have been or will be lost due to a permitted activity. Compensatory wetland mitigation generally entails performing one or more of the following types of compensation:

- **Restoring** wetland conditions (and functions) to an area
- **Creating** new wetland area and functions
- **Enhancing** functions at an existing wetland
- **Preserving** an existing high-quality wetland to protect it from future development

Chapter 6 of Volume 1 synthesizes the literature on compensatory mitigation from the last 15 years. The majority of projects that provide compensatory mitigation described in the literature have been neither fully successful nor complete failures. One challenge in synthesizing this information was the range of meanings for and the implications of the very terms success and failure.

3.7.1 Compliance of Projects with Permit Requirements (Volume 1 Section 6.4)

While most of the mitigation projects documented in the literature were implemented, compliance of the projects with permit requirements was generally low. This was a result of inadequate acreage of wetland, failure to achieve performance standards, and a lack of monitoring and maintenance. The few studies that examined the effect of regulatory follow-up suggested that it had a positive influence on the level of compliance and success for compensatory wetland mitigation projects.

3.7.2 Ecological Effectiveness of Different Types of Compensation (Volume 1 Section 6.5)

There is a general lack of information about the relative ecological effectiveness of the various types of compensation (e.g., restoration, creation, enhancement, etc.). Creation is generally the most frequently used type of compensation, but studies of its effectiveness produced mixed results.

Enhancement of wetlands is also frequently used, but few studies have examined its effectiveness. Limited studies from Washington indicated a low level of success among enhanced wetlands, primarily due to a minimal gain in functions in the timeframe between construction of the mitigation project and the evaluation of gain in functions. It may simply take longer for a gain in functions to appear (15 to 20 years rather than 5 to 10 years).

Restoring wetlands was noted as a high priority in the literature, but this type of compensation is not frequently used. This could be because restoration is often not an option on a project-by-project basis when costs and local regulations defer to on-site mitigation options. Restoration appears to be a more frequent choice in non-regulatory situations.

Preservation and the use of a mixture of compensation types appear to be used occasionally based on the literature review, and studies provided limited information on the effectiveness of these types of compensation. Two studies from Washington indicated that mixed compensation projects had a higher level of compliance than creation or enhancement, and all mixed projects were moderately successful.

3.7.3 Replacement Ratios (Volume 1 Section 6.6)

Replacement ratios are a tool used to account for the risk of mitigation failure and the temporal loss of functions. Required replacement ratios vary from one jurisdiction to another, based on the type of compensation proposed and project-specific circumstances.

The review of the literature indicated that the wetland functions and acreage achieved by using replacement ratios were less than what was required. In some cases the result was less than 1:1 replacement of acreage and a net loss of wetland acreage and function on the landscape.

3.7.4 Functions and Characteristics of Mitigation Wetlands (Volume 1 Section 6.8)

The functions performed and the structural characteristics that developed in created and restored wetlands usually differed from those in reference wetlands discussed in the literature. The one exception was the group of functions that improve water quality; these appeared to be performed in a similar capacity in mitigation wetlands as in reference wetlands. (Studies reviewed for Volume 1 did not compare the functions provided by wetlands that had been developed as compensation against the functions provided by the wetlands that were lost. Instead, reference wetlands were used as the basis for comparison with mitigation wetlands.)

For the most part, reference wetlands were found to provide habitat for a greater diversity or abundance of wildlife than created or restored wetlands. Birds were an exception since half of the studies found no difference between created/restored sites and reference wetlands, particularly for ducks.

Created and restored wetlands were also found to exhibit different vegetation characteristics and plant communities than reference wetlands. The effect of wetland age on the vegetation of created and restored wetlands was noted in various studies.

3.7.5 Types of Wetlands Produced through Compensation Projects (Volume 1 Section 6.9)

The review of the literature indicates that compensatory mitigation is producing more acreage of open water wetlands than has been lost. The ability of compensatory mitigation projects to produce wetlands of other Cowardin classes (e.g., emergent, scrub-shrub, forested) varies.

Compensatory mitigation is also producing wetlands with significantly different hydrogeomorphic (HGM) classes than were present in the reference wetlands near that location. (The HGM classification is based on the position of the wetland in the landscape, the wetland's water source, and the flow and fluctuation of the water once in the wetland.) This has resulted in mitigation wetlands that have more inundation for a longer period than in reference wetlands, as well as HGM classes of wetlands that are atypical for the landscapes in which they are being created.

Some unique types of wetlands, such as bogs, fens, and mature forested wetlands, may not be reproducible, especially not within current regulatory timeframes. Other wetland types, such as vernal pools, may be reproducible given the right conditions.

3.7.6 Suggestions for Improving Compensatory Mitigation (Volume 1 Section 6.10)

The literature provides numerous suggestions on virtually every aspect of the compensatory mitigation process. Key suggestions include:

- Improving regulatory guidance on a variety of topics, such as measurable, meaningful, and enforceable performance standards for compensatory mitigation
- Finding better sites that provide increased benefits due to their location within a watershed
- Monitoring compensatory mitigation wetlands more effectively
- Maintaining compensatory mitigation sites
- Increasing the regulatory follow-up of compensation projects

The review of the literature indicates that improvements have been made in compensatory mitigation over the past two decades, particularly in terms of what is required. Based on the research reviewed, the overall success and permit compliance have not noticeably improved. Most studies indicate that created and restored wetlands do not provide the same characteristics or level of functions as reference wetlands (water quality functions may be the exception). Though older created and restored wetlands generally exhibit characteristics of the vegetation that lead to improved habitat for wildlife, the soils and the hydroperiods may remain so modified that they will not replicate reference systems in the foreseeable future. Since the effectiveness of compensatory mitigation remains highly variable, it is important to understand the cumulative effects of the continuing loss of wetland acreage and functions (summarized in the next section).

3.8 Cumulative Impacts to Wetlands and the Need for a New Approach (Chapter 7 of Volume 1)

The literature reviewed for Volume 1 indicates that project-by-project decisions cannot, by their very site-specific nature, adequately address the complexities of wetland systems as they function in a landscape context. The majority of wetland management decisions in Washington State are related to individual projects, without an opportunity to consider the environmental factors that control functions or cumulative impacts.

As discussed in Chapter 7 of Volume 1, the causes of cumulative impacts are not limited to the policies or regulations of a single agency but can also result from multiple agencies making land-use decisions in isolation. Also, cumulative effects are difficult to assess because of the large spatial and temporal scales involved, the wide variety of processes and interactions, and the lag times that often separate a land use activity from resulting effects.

While the literature did not focus on the reasons for the lack of landscape-scale wetland management in Washington, some impediments can be assumed:

- The costs of analysis, inventories, assessments, and rankings
- The costs of implementing a landscape-scale program relative to existing project-driven programs that are often funded by applicant fees
- Inconsistent mandates driving the agendas and priorities of regulatory agencies
- Lack of examples of successful tools for interagency collaboration and implementation
- Lack of awareness and understanding of the ecological consequences of existing regulatory programs by the public and the staff of implementing agencies
- Lack of support for local jurisdictions to tackle the process of identifying and prioritizing aquatic resources for long-term protection and/or potential alteration

The literature recommends a broader approach for the management and restoration of aquatic resources including wetlands. Researchers recognize the need for an analysis of the broader landscape and the environmental factors that control functions and cumulative effects (i.e., the historic, ongoing, and future impacts on an ecosystem).

For this reason, the guidance provided in Volume 2 stresses the importance of starting with an understanding of the landscape as well as wetland functions at the site scale. This understanding of the landscape can then be incorporated into more effective planning, regulatory, and non-regulatory tools.

Chapter 4

Framework for Protecting and Managing Wetlands Using Best Available Science

4.1 Introduction

This chapter outlines a four-step framework for developing and implementing approaches to wetland protection and management by local governments. This chapter introduces the four steps of this framework and the feedback loop called "adaptive management." Following chapters describe each step in more detail. Examples and additional information are provided in the appendices.

The framework is an adaptation of one developed for the *Statewide Strategy to Recover Salmon* (Washington State Joint Natural Resources Cabinet 1999). The framework incorporates the findings of the synthesis of the science from Volume 1, such as using landscape analysis to guide the decision-making process when developing plans, policies, codes, ordinances, and non-regulatory approaches to protecting and managing wetlands. One goal of the framework, as presented here, is to help local governments integrate all of their activities relating to wetlands so they can work together. The integration of analyses, planning, regulations, and non-regulatory activities by a local government can be considered its "wetland protection program."

The review of the literature in Chapter 2 of Volume 1 emphasizes that wetlands are an integral part of the landscape. Therefore, to protect and manage wetlands and reduce cumulative impacts, local governments need to understand how changes in land use that result from human activities at a landscape scale can affect wetlands at the smaller, site scale. Once such an understanding is developed, it is possible to plan for, and minimize, the impacts of human activities at all geographic scales, and thereby effectively protect wetlands and their functions.

Analyzing the landscape that influences wetlands is a relatively new idea. Planners and managers of natural resources face a challenge in incorporating landscape information into the planning and protection process. Three common questions posed by planners and managers are:

- What are landscape processes and what do we know about them and their interaction with wetlands?
- What tools can be used to most effectively incorporate a landscape perspective into wetland management?
- How do we organize planning and protection activities to incorporate information about the landscape as well as protecting individual wetlands?

The first question is answered in Chapter 5, which describes what is meant by a landscape analysis. The last two questions are answered in the guidance provided in subsequent chapters and appendices in this document. Collectively, the framework for a program to protect wetlands described below can help minimize cumulative impacts.

Key terms used in this document to describe processes and functions

Landscape processes - Environmental factors that occur at larger geographic scales, such as basins, sub-basins, and watersheds. Processes are dynamic and usually represent the movement of a basic environmental characteristic, such as water, sediment, nutrients and chemicals, energy, or animals and plants. The interaction of landscape processes with the physical environment creates specific geographic locations where groundwater is recharged, flood waters are stored, stream water is oxygenated, and pollutants are removed, and wetlands are created.

Wetland functions - The physical, biological, chemical, and geologic interactions among different components of the environment that occur within a wetland. There are many valuable functions that wetlands perform but these can be grouped into three categories: functions that improve water quality, functions that change the water regime in a watershed such as flood storage, and functions that provide habitat for plants and animals.

4.2 Four-Step Framework for Protecting and Managing Wetlands

The framework for protecting and managing wetlands is designed to provide a number of opportunities to incorporate landscape information into decision-making at the planning stages as well as into decisions regarding individual wetlands. The four steps of the framework include:

1. Analyzing landscape processes that influence wetland resources (called "landscape analysis"), as well as processes that occur at the scale of the site itself

2. Prescribing solutions for protecting and managing wetlands based on information from Step 1 (such as developing policies, plans, codes, ordinances, and non-regulatory approaches, etc.)

3. Taking actions to implement the solutions (such as applying regulations at individual wetlands, restoring wetlands, and providing non-regulatory incentives)

4. Monitoring the results of the actions taken and the effectiveness of the solutions (such as tracking acreage and functions of wetlands lost and gained and determining whether plans and programs are being implemented); this information will help determine if cumulative impacts are occurring

The four-step framework should be iterative and ongoing. If the data collected through monitoring in the fourth step indicates that wetlands are not being adequately protected and cumulative impacts are occurring, the management actions need to be revised accordingly. Evaluation of the monitoring data initiates a feedback loop called adaptive management.

Figure 4-1 conceptually illustrates the four-step framework that can be used by local governments to develop and implement effective approaches to protecting wetlands and other critical areas. The first two steps—analyzing the landscape and its wetlands and prescribing solutions—can be considered long-term planning, and the second two—taking actions and monitoring results—as implementation. As mentioned previously, an additional component is the feedback loop, called adaptive management. This is the process of assessing what has or has not been effective and making modifications based on these insights.

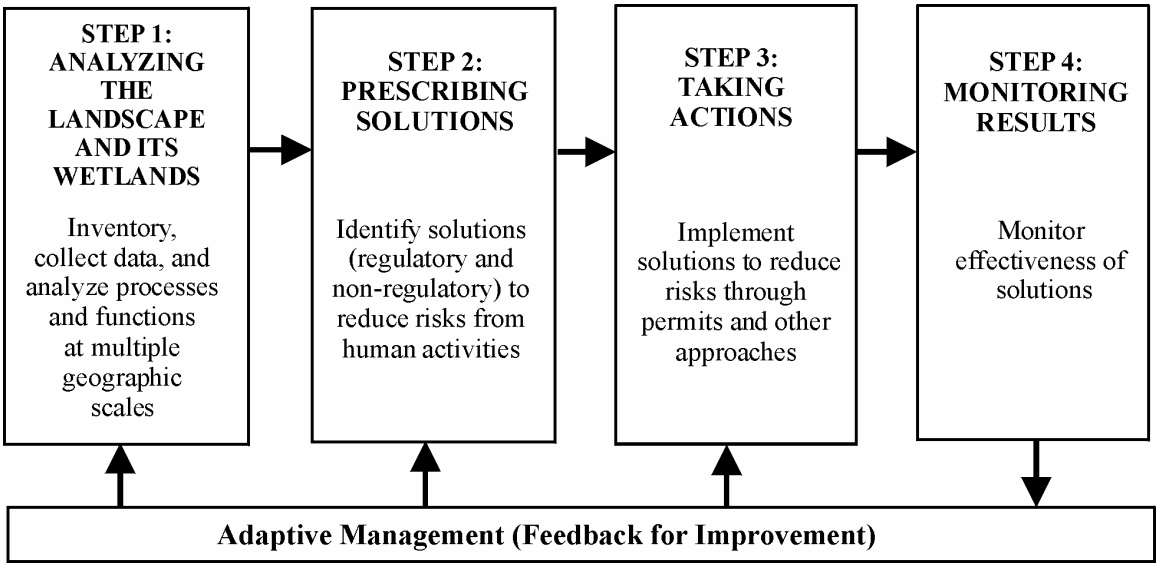


Figure 4-1. A suggested framework for local governments to use in protecting and managing wetlands. These four steps serve as the framework for discussions in this volume and are reproduced at the beginning of each chapter.

4.2.1 Incorporating Different Geographic Scales in the Four-Step Framework

The synthesis of the science presented in Volume 1, and the ecological principles listed in Chapter 1 of this volume, indicate the need for analyzing, planning, and managing at a landscape scale as well as at the scale of individual sites. Therefore, the words used to describe different scales must be clarified to provide a "common language."

Local governments can protect and manage wetlands at different geographic scales. Three geographic scales are discussed in this document. These are the *contributing landscape***,** the *management area*, and the *site*, described in the box below**.** Figure 4-2 provides an example of these three geographic scales.

Geographic scales discussed in this document

The ***contributing landscape*** is the geographic area within which the landscape processes that influence the functions or structure of wetlands located in a *management area* (defined below) occur. A contributing landscape may span jurisdictional boundaries and even span several watersheds (see Figure 4-2). Given that the contributing landscape may cross jurisdictional boundaries, efforts to protect the wetlands need to be coordinated and integrated with programs of other local governments. Because most ecosystems are linked across the landscape, it is important that measures to protect wetlands are coordinated with measures for protecting other resources including riparian areas, floodplains, estuaries, shorelines, and fish and wildlife habitat.

The ***management area*** is the geographic area for which plans and regulations are being developed by a local government. The management area is usually a subset of the contributing landscape because it may be based on political boundaries (e.g., a jurisdiction such as a city), or it may be defined geographically to include a specific Water Resource Inventory Area (WRIA), basin, or sub-basin in a county.

The ***site*** is the area encompassed within the boundary of a single wetland. It, too, may span private property lines or jurisdictional boundaries.

In Figure 4-3, each of the four steps of the framework described earlier is divided into a series of actions that would be undertaken at each of these three geographic scales.

Steps 1 through 4 of the framework are described in detail following the figures.

Figure 4-2. An example of contributing landscape, management area, and site scales.

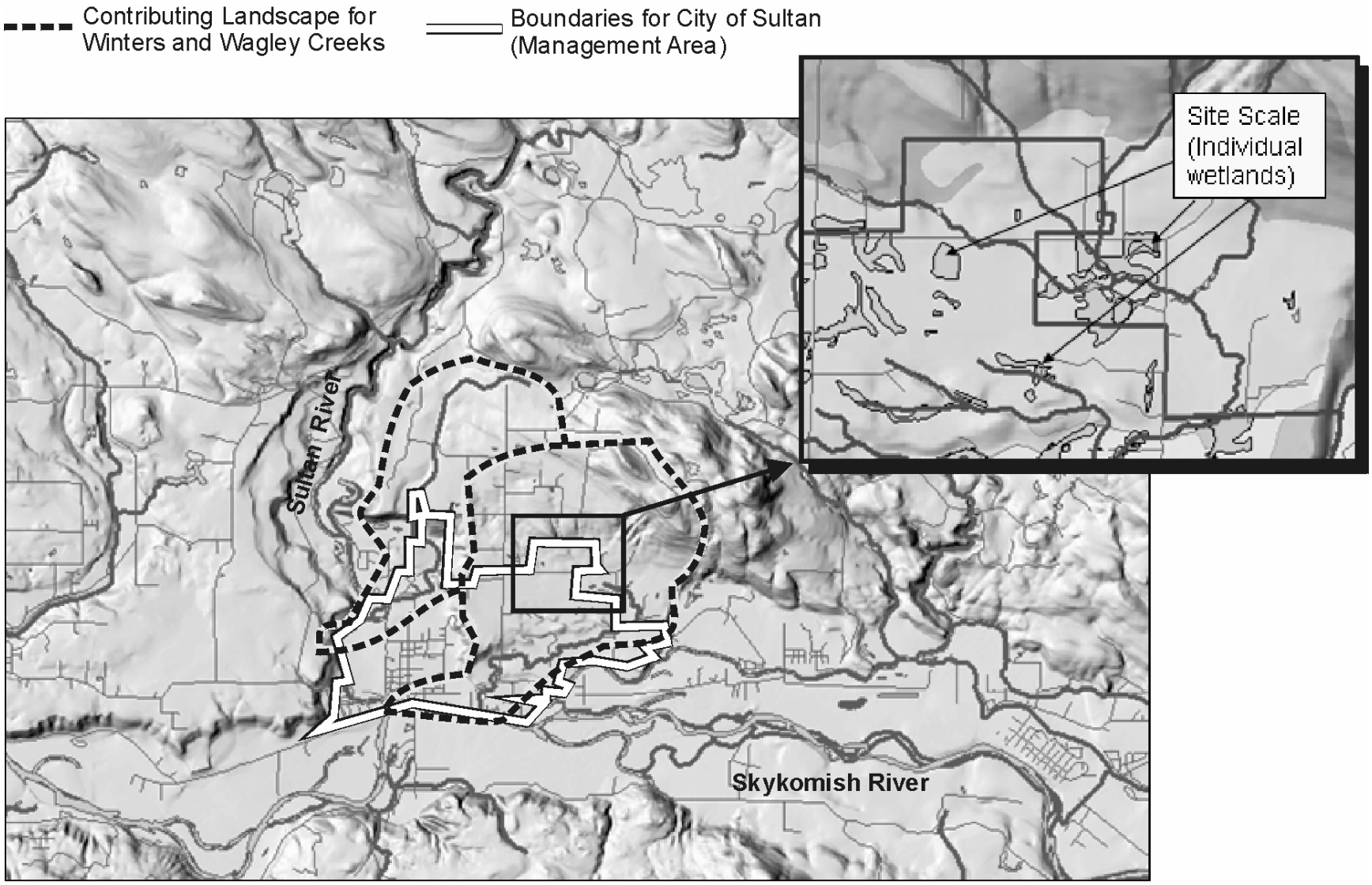
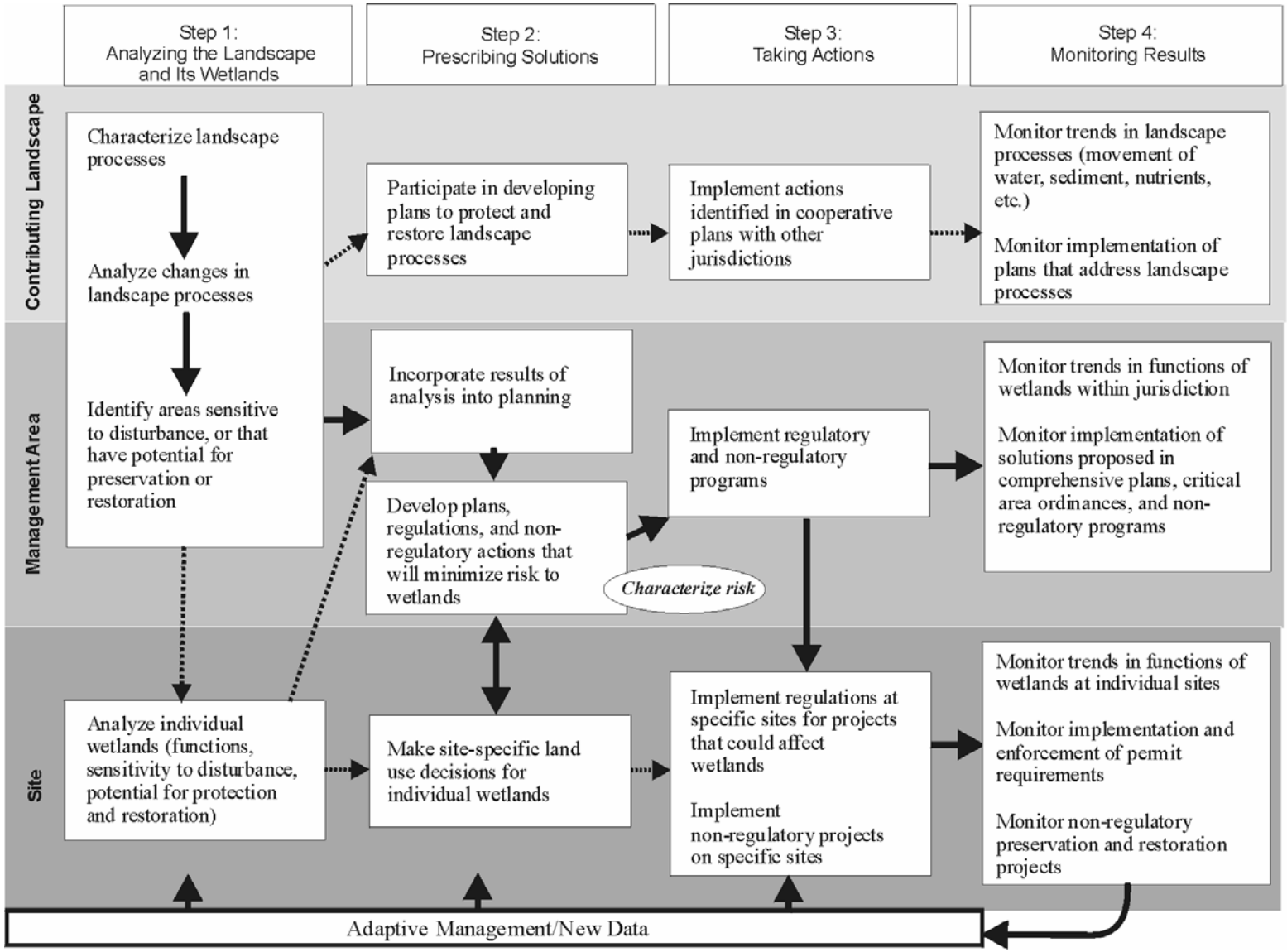


Figure 4-3. Four-step framework incorporating the three geographic scales. Solid arrows represent the process that should be undertaken in developing comprehensive plans and critical areas ordinances. Dashed arrows show additional pathways that can be followed to enhance a protection and management program for wetlands.



4.2.2 Step 1: Analyzing the Landscape and Its Wetlands (Landscape Analysis)

Step 1 involves a *landscape analysis*, which is needed to understand landscape processes and their influence on wetlands. A landscape analysis provides important information that forms the basis of a program to protect wetlands. For example, information from a landscape analysis is crucial in developing comprehensive plans (see Chapter 7) or for planning under an Alternative Futures approach (see Chapter 6). The analysis is applicable to all types of planning done at the scale of the watershed, sub-basin, contributing basin, or site. For example, a landscape analysis can be used to interpret an analysis of the functions of an individual wetland when a change in land use is being considered.

As will be discussed in Chapter 5, a landscape analysis is more complex than what is typically required for a wetland inventory, though the two share some similarities. When doing a landscape analysis, it is recommended that annotated maps be produced that identify areas of critical concern for managing wetlands and their contributing landscape. A series of annotated maps can summarize complex geographic information and provide a scientific basis for establishing land-use designations and in making other decisions about land use. The information can be used in evaluating the relative impacts for a range of alternative scenarios of future development, such as Alternative Futures, that are created in Step 2.

The paragraphs below briefly describe Step 1 at the various geographic scales shown in Figure 4-2. The process for the landscape analysis is described in detail in Chapter 5.

4.2.2.1 Analyses of the Contributing Landscape and the Management Area

The analyses of the contributing landscape and the management area are similar. The difference in the analyses for these two geographic scales is more an issue of resolution than of approach. If the management area is smaller than the contributing landscape, the analysis of the management area can make use of more detailed information, such as detailed wetland inventories and ratings. Local jurisdictions can then develop a more detailed program and have better assurance that the risks to their wetlands are minimized. The same tools and methods, however, can be used at either geographic scale.

The purpose of the analysis at either scale is to develop an understanding of landscape processes that can affect wetland functions. This includes understanding the movement of water, nutrients, sediments, and toxic compounds, and how wetlands that function as habitat are affected by fragmentation of the landscape. It involves inventorying wetland resources, identifying where critical landscape processes occur, and determining how those critical processes have been modified by human activities. From this understanding, one can then determine how these landscape processes may have been changed in the past, and how they might change with future development.

There are two main goals of the landscape analysis. The first goal is to identify locations within the contributing landscape and the management area where landscape processes could be negatively influenced by human land uses (e.g., paving areas that provide groundwater recharge). When planning future changes in land use, these areas can be considered sensitive and in need of specialized management approaches because changes in these locations can be a major cause of cumulative impacts. These areas may not necessarily include only wetlands but may encompass important upland areas that influence wetlands (e.g., areas where groundwater is recharged or corridors of undisturbed uplands that connect wetlands).

The second goal is to identify areas where landscape processes have been degraded but could be repaired, such as through wetland restoration. Planning for restoration could help offset unavoidable impacts identified through the planning process.

This information is used during Step 2 (Prescribing Solutions) and Step 3 (Taking Actions).

4.2.2.2 Analyzing Wetlands at the Site Scale

The main goal of the analysis at the site scale is to understand the functions of an individual wetland and how that wetland interacts with the landscape. This analysis can occur at two different times in the planning and regulatory process: during comprehensive planning and during review of permits for individual projects.

If a local jurisdiction's program to protect and manage wetlands involves preservation or restoration, then individual wetlands will need to be analyzed. Information from the analysis can be used during comprehensive planning (Step 2) to identify those wetlands most suited for preservation and restoration.

The functions of individual wetlands are also often analyzed when permits are sought to alter a wetland. It is, therefore, important for local governments to establish what will be required for site-specific analysis of wetlands during Step 2, when administrative rules, guidance, or regulations are developed (Chapter 8). For example, the requirements should state what must be included within wetland reports and plans for compensatory mitigation. The local jurisdiction should also consider methods for assessing wetland functions and for establishing ratings, buffers, and mitigation ratios. Site-specific analysis is usually the responsibility of the applicant who is proposing changes to a specific wetland.

For further guidance on Step 1, Analyzing the Landscape and Its Wetlands, see Chapter 5 and Appendices 5-A through 5-C of this volume.

4.2.3 Step 2: Prescribing Solutions

Step 2 describes the processes by which local governments develop solutions to protect and manage wetlands within their jurisdiction. The goal of Step 2 is to identify means for incorporating the results of the landscape analysis in Step 1 into effective planning, regulatory, and non-regulatory tools. This is the step in which Smart Growth planning approaches, such as Green Infrastructure or Alternative Futures (discussed in Chapter 6), can be applied and when comprehensive plans, critical areas ordinances, shoreline management plans, restoration plans, and incentives for conservation are typically developed.

4.2.3.1 Prescribing Solutions at the Scale of the Contributing Landscape

To develop solutions for a contributing landscape, which often extends outside the regulatory authority of a local jurisdiction, the jurisdiction will need to coordinate with other, contiguous governments. In reality, however, adjacent jurisdictions may not share the same values or priorities. Because the ability of a local jurisdiction to plan for geographic areas outside of its purview may, therefore, be limited, this document only provides general guidance at this time.

For areas of the contributing landscape that fall within the management area, the process of prescribing solutions is the same as for the management area, as described below.

4.2.3.2 Prescribing Solutions at the Scale of the Management Area

Solutions for protecting and managing wetlands within the management area can be prescribed in many forms. Generally, they include policies contained within comprehensive plans or community plans; codes (such as zoning) and ordinances (including those for critical areas and clearing and grading); stormwater management plans; shoreline master programs; non-regulatory approaches, such as preservation and restoration plans; and incentives for conservation, such as tax relief.

The approach proposed here is to plan for future development and the protection of wetlands by analyzing different alternative scenarios (called Alternative Futures) in terms of their impacts on wetlands and landscape processes. These scenarios should include both general planning approaches, such as different patterns of zoning, and more specific approaches, such as different widths of buffers for wetlands with different ratings. The local government usually incorporates other factors into the scenarios based on the priorities of citizens for their communities. (See Chapter 6 for further discussion.)

The effects of the different scenarios can be compared and evaluated to determine which solution might reduce or limit the impacts to landscape processes. Analyses of scenarios are an important way to summarize detailed scientific information, and they can be very helpful in decision-making.

Step 2 is also the step at which a jurisdiction should ensure consistency between various policies, plans, and regulations administered by the jurisdiction that may influence wetland resources. For example, a grading code may have to be modified to reflect considerations for wetlands or their buffers.

4.2.3.3 Prescribing Solutions at the Site Scale

Prescribing solutions at the site scale involves developing ways to protect wetlands which require tailored protection that is different from the protection afforded to most other wetlands through critical areas regulations. These wetlands are often called "wetlands of local significance." They may include wetlands with a high value for recreation, aesthetics, potential for restoration, or potential as mitigation banks; or they may be crucial to supporting a landscape process, such as aquifer recharge.

The solutions for protecting these wetlands can be specified in advance by using policies in the comprehensive plan or community plans or even site-specific or wetland-type-specific regulatory language. For example, the City of Everett identified specific actions at individual wetlands at the mouth of the Snohomish River estuary that could be taken to restore landscape processes (City of Everett 1997). There was a high probability of success with an important increase in functions.

For guidance regarding tools for Step 2, Prescribing Solutions, see Chapters 6 through 9 of this volume.

4.2.3.4 Characterizing the Risk from Proposed Solutions

A characterization of risks should be used to evaluate the different solutions being suggested for protecting and managing wetlands. Such a characterization provides a way to develop, organize, and understand the decisions being made about future land uses. It also enables decision-makers and the public to make more informed decisions about land uses and wetland resources. Solutions that cause a higher risk to the wetland resource because they are driven by other societal needs can be balanced by solutions that reduce the risks (e.g., through restoration). Avoiding impacts and maintaining functions, however, is generally more cost effective and less risky than trying to replace functions (see Volume 1 and Chapter 6 of this volume for further discussion).

For guidance on characterizing the risk from proposed solutions see Chapter 10 of this volume.

Prescribing solutions incorporating shoreline planning

Solutions for protecting and managing wetlands can be provided in the context of both the Growth Management Act (GMA) and the Shoreline Management Act (SMA). The goal of Step 2 is to incorporate the results of the landscape analysis in Step 1 into plans, regulations, or other actions that will protect wetlands.

The SMA was adopted by Washington's public in a 1972 referendum "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines." One of the policies in the SMA is to protect shoreline natural resources including "…the land and its vegetation and wildlife, and the water of the state and their aquatic life…" Some wetlands, therefore, are protected by both the SMA and the GMA. In 1995, the Legislature amended the GMA and the SMA to partially integrate the two statutes (1995 c 347). The amendments incorporate the goals and policies of the SMA as the 14th goal of the GMA; specifically designating the goals and policies of a shoreline master program (SMP) as an element of a local government's comprehensive plan, and designating the balance of the SMP as a segment of the jurisdiction's development regulations (RCW 36.70A.480). In 2003 the Legislature added a requirement that new SMPs must provide a level of protection to critical areas within shoreline jurisdiction that is "at least equal" to the level of protection provided to critical areas under the local government's critical areas ordinances.

On December 17, 2003, Ecology adopted new guidelines for SMPs to implement the revisions to the SMA. The guidelines provide a process for local jurisdictions to implement the policy of the SMA of protecting natural resources of shorelines through the protection and restoration of ecological functions (and environmental processes) necessary to sustain these natural resources. The guidelines specifically state that effective management of shorelines depends on sustaining the functions provided by: 1) ecosystem-wide processes (i.e., flow and movement of water, sediment, and organic materials and movement of fish and wildlife; these are called landscape processes in this volume); and 2) individual components and localized processes such as those associated with shoreline vegetation, soils, and water movement through the soil and across the land [WAC 173.26.201(2)(c)]. The guidelines incorporate the use of scientific knowledge of environmental processes (physical, chemical, and biological processes) that affect the ecological functions of shorelines (and their associated wetlands). Thus, the guidelines for preparing SMPs include an assessment of many of the same environmental processes that are outlined in this volume.

Further, the new guidelines require that SMP policies and regulations ensure "no net loss" of ecological functions necessary to sustain natural ecosystems of shorelines. Updated SMPs must regulate new development in a manner that is protective of existing ecological functions and provide policies that "promote restoration of impaired ecological functions" (WAC 173.26.201(2)(c) and (f)).

The process for preparing an updated SMP is compatible with the four-step framework outlined in this document. The rules (WAC 173.26.201(3)) spell out a general process for updating SMPs that includes: comprehensive inventory of shoreline conditions; characterization and analysis of functions and ecosystem-wide processes; development of shoreline policies, regulations, and environment designations; and development of goals, policies, and actions for the long-term restoration of impaired shoreline ecological functions. The guidance for analyzing the aquatic resources, developing solutions, implementing the solutions, monitoring and adaptive management provided in this document can prove useful to jurisdictions planning under the SMA.

4.2.4 Step 3: Taking Actions

Step 3 ensures that the solutions developed and adopted in Step 2 are effectively implemented through taking actions at the different geographic scales. Examples of taking actions include:

- Implementing regional, subarea, or community plans on the ground
- Applying critical areas and clearing and grading ordinances at specific wetland sites when a development is proposed
- Restoring or preserving wetlands identified in a restoration plan through a landscape analysis
- Setting up a Public Benefit Rating System to provide tax relief for landowners with wetlands (see Chapter 9 for more information)

4.2.4.1 Taking Action at the Scale of the Contributing Landscape

Taking action at the scale of the contributing landscape requires adequate funding and coordination over time. Although the benefits can be great if the solutions are carried out, the challenges are great as well. For example, of the three regional plans that have been developed to protect wetlands—the Everett Snohomish Estuary Wetland Integration Plan (SEWIP) (City of Everett 1997), the Mill Creek Special Area Management Plan (SAMP) (U.S. Army Corps of Engineers 1997), and the Port of Skagit Wetland Industry Negotiations (WIN)—only one (Skagit WIN) was ever adopted and implemented. (For more information on the Skagit WIN contact the Port of Skagit County in Burlington, Washington.)

4.2.4.2 Taking Action at the Scale of the Management Area

Taking action to implement plans, regulations, and non-regulatory approaches adopted by a jurisdiction for its management area is critical to protecting wetlands. The scientific literature reviewed for Volume 1 indicated that one of the major reasons why the functions and values of wetlands continue to be degraded is a lack of resources to implement and monitor proposed solutions.

In the case of a critical areas ordinance for wetlands, an adequate number of staff is needed. The staff should be trained to review permit proposals and enforce the conditions placed on those proposals to ensure that wetlands are protected as planned. This holds true especially for compensatory mitigation. Chapter 6 of Volume 1 highlights the fact that many compensation projects designed to replace wetland functions lost through development have failed in part because of a lack of regulatory oversight and follow-through. Likewise, plans that call for restoration need staff and sources of funding to implement the plans, acquire sites, and monitor the efforts.

4.2.4.3 Taking Action at the Site Scale

Taking action at the site scale means applying the management measures identified for a specific wetland; for example, an individual wetland that is restored using a plan developed for a management area. Implementation at the site scale also requires monitoring the compliance and effectiveness of compensatory mitigation or non-regulatory actions taken at individual sites.

For further discussion of Step 3, Taking Actions, see Chapter 11 of this volume.

4.2.5 Step 4: Monitoring

Monitoring at all three geographic scales (contributing landscape, management area, and site) should be an integral part of a strategy to protect and manage wetlands. It is a key step in determining whether cumulative impacts have actually been minimized during Step 3, Taking Action. Monitoring should address the following central question: *Are the actions taken by a local jurisdiction effectively protecting or restoring the functions and values of the wetlands within its purview and thereby addressing cumulative impacts?*

Local jurisdictions cannot determine whether their solutions (developed in Step 2 and implemented in Step 3) are actually protecting wetlands without collecting data that monitor the success of their approach at the three geographic scales. Monitoring whether adequate protection has been achieved, followed by any needed corrective action, is especially critical. All the information collected to date and reviewed in Volume 1, indicates that there is continued loss of wetlands and their functions and values (cumulative impacts).

Monitoring associated with assessing the protection and management of wetlands by local jurisdictions can be divided into three categories:

- **Monitoring the effectiveness of actions taken to protect and manage wetlands** to determine how well the overall approach (including all solutions) is meeting the goals to protect and manage wetlands at all geographic scales
- **Monitoring the actions taken to implement** the regulatory and non-regulatory solutions developed at all geographic scales
- **Monitoring trends** regarding changes in landscape processes and the level of performance of the functions provided by wetlands at the site scale (i.e., monitoring cumulative impacts)

If the functions and values of wetlands are not adequately protected, managers need to know whether this results from inadequate implementation, inadequate standards, or inadequate strategies. Therefore, all three aspects of monitoring are important in providing feedback to guide future decision-making.

For further discussion of Step 4, Monitoring, see Chapter 12 of this volume.

4.2.6 Adaptive Management

Adaptive management—the feedback loop—is based on a review of the information collected through the monitoring step and a determination of what changes are necessary to improve protection when goals are not met. In this way, future management, policies, and regulations can be more effective in protecting the wetland resource (Washington State Joint Natural Resources Cabinet 1999). Scientists agree that some of the continued degradation of the functions and values of natural systems such as wetlands is a result of a lack of monitoring and adaptive management (Dale et al. 2000). This aspect of protecting and managing wetlands is, therefore, vital to successfully protecting wetlands over time.

The key element of adaptive management is a commitment to periodically revisit the four steps in the framework described earlier. Monitoring should provide new data and information that feed back into the analysis the landscape and its wetlands (Step 1). As the data are analyzed, new information can be generated that may require changing the solutions prescribed (Step 2) and the actions that need to be taken (Step 3). The effectiveness of the new solutions and actions then also needs to be monitored (Step 4), and the cycle repeated over time.

For further discussion of Adaptive Management, see Chapter 12 of this volume.

Chapter 5

Analyzing the Landscape and Its Wetlands

5.1 Introduction

This chapter describes the first step (Analyzing the Landscape and Its Wetlands) in the four-step framework for the program to protect wetlands outlined in Chapter 4. It describes how the landscape, and the wetlands found within it, might be analyzed by a local jurisdiction (see Figure 5-1). Section 5.2 summarizes the importance of the interaction between landscape processes and wetland functions because this information may not be common knowledge for some planners. Section 5.3 provides background on the goals of landscape analysis, because this is a relatively new approach in protecting and managing wetlands. Section 5.4 describes the basic questions that should be answered when analyzing the contributing landscape and management area to assist with decision-making. Identifying important questions should enable local governments to choose the most appropriate method to analyze the landscape for their jurisdiction. Any method or methods that provide answers to these questions can be used. Section 5.5 addresses analyses at the scale of individual wetlands.

The questions discussed in this chapter are derived from the work on environmental processes nationally and in the Pacific Northwest done by Bedford (1996, 1999), Beechie and Bolton (1999), Booth (1991), Brinson (1993), Gersib (2001), Horner (1986), Horner et al. (1996), LaBaugh et al. (1987), Naiman et al. (1992, 1993), Naiman and Rodgers (1997), Stanley and Grigsby (2003), Winter (1983, 1986, 1988, 1989, 1992), and Ziemer and Lisle (1998).

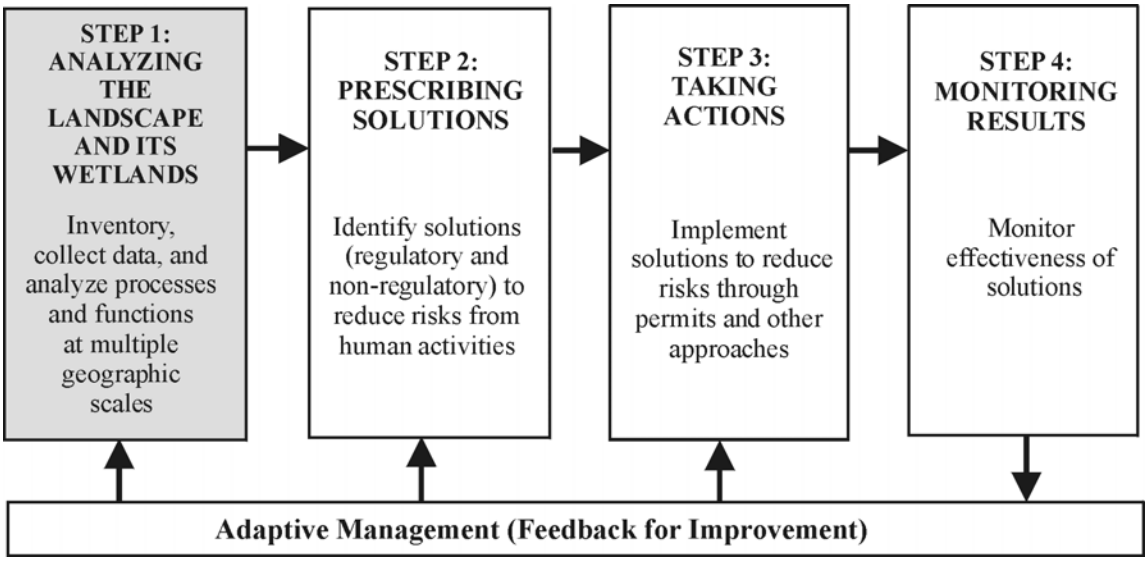


Figure 5-1. Step 1 in the process of protecting and managing wetlands is to analyze wetland resources (shaded box).

Why do we analyze more than just wetlands?

The synthesis of current science (Chapter 2 in Volume 1) indicates that the functions performed by wetlands are controlled by processes that may occur in other parts of the landscape as well as at the site of the wetland itself. To protect and manage the functions and values of wetlands, we therefore need to understand how changes to these wider-scale processes can impact wetlands. In this way, cumulative impacts to wetlands can be minimized.

The following appendices provide additional information and details to help the reader more fully understand the landscape analysis described in this chapter:

Appendix 5-A identifies some of the existing sources of data that can be used to answer the questions when analyzing the landscape and its wetlands.

Appendix 5-B summarizes numerous literature sources that provide more detail on how to analyze environmental processes at the contributing landscape, management area, and site scales.

The reader is also directed to a web site describing a method for completing a landscape analysis for aquatic systems being developed by Ecology (http://www.ecy.wa.gov/programs/sea/landscape/). The analysis uses existing geographic data to characterize environmental processes at the larger landscape scale, and helps identify the relationship of these processes to the functions of wetlands and other aquatic resources.

The method being developed can help local governments protect and manage wetlands as well as other aquatic resources. It is useful for both planning purposes as well as regulatory and non-regulatory applications at the site scale. Currently, however, the method does not address the analyses needed to protect and manage wildlife. This gap will be addressed in the near future as the departments of Fish and Wildlife and Ecology work together to expand the wildlife component of the analysis.

The questions that need to be addressed in the analysis of the landscape and its wetlands apply regardless of the methods used to analyze the resource. The method being developed by Ecology is one way they can be answered.

The web site for Ecology's method for analyzing the landscape is updated periodically as changes and innovations are incorporated. It is currently being revised following application in several jurisdictions. Even when undergoing revisions, the web site is useful in understanding the basic principles, information sources, and steps used in Ecology's method to analyze the landscape and apply the results in context of land-use planning.

5.2 Landscape Processes and Their Influence on Wetlands and Their Functions

Chapter 2 in Volume 1 describes how landscape processes interact with climate, topography, and surface geology to determine the biological, physical, and chemical characteristics (structure) of wetlands and other aquatic resources. The structure of wetlands (e.g., the soils, plant species, configuration of inlets and outlets, etc.) then has a direct influence on the type and level of functioning within wetlands. The sequence, however, does not go only in one direction. Some wetland functions can in turn influence the structure of other wetlands and landscape processes (e.g., when wetlands provide habitat for beavers; see Figure 5-2).

Terms used in this document to refer to environmental factors

Surface and subsurface water flows through the landscape within drainage systems. These drainage systems are often called basins, sub-basins, watersheds, or river basins depending on the size of the area. In this document, drainage systems are generally referred to using one of two terms:

- ***Watershed*** **-** A geographic area of land bounded by topographic high points in which water drains to a common destination.
- ***Contributing basin*** **-** The geographic area from which water drains to a particular wetland.

Environmental factors that affect wetland functions can occur at different geographic scales. In this document two scales are used.

- ***Landscape processes*** **-** Environmental factors that occur at larger geographic scales such as basins, sub-basins, and watersheds. Processes are dynamic and usually represent the movement of a basic environmental characteristic such as water, sediment, nutrients and chemicals, energy, or animals and plants. The interaction of landscape processes with the physical environment creates specific geographic locations where groundwater is recharged, flood waters are stored, stream water is oxygenated, or pollutants are removed, and wetlands are created.
- ***Site processes*** **-** Environmental factors that occur within the wetland itself or within its buffer. The interactions of site processes with landscape processes define how a wetland functions.

In the Pacific Northwest, the landscape processes that are often associated with wetland functions include:

- The movement of **water** (surface and subsurface) through the contributing landscape and at the wetland site itself
- The movement of **sediment**
- The movement of **nutrients** and other chemicals (salts, toxic contaminants)
- The movement of **energy** in the form of carbon (plant and animal material)
- The movement, population dynamics, and habitat use of **wildlife**
- The dispersal of **plants**

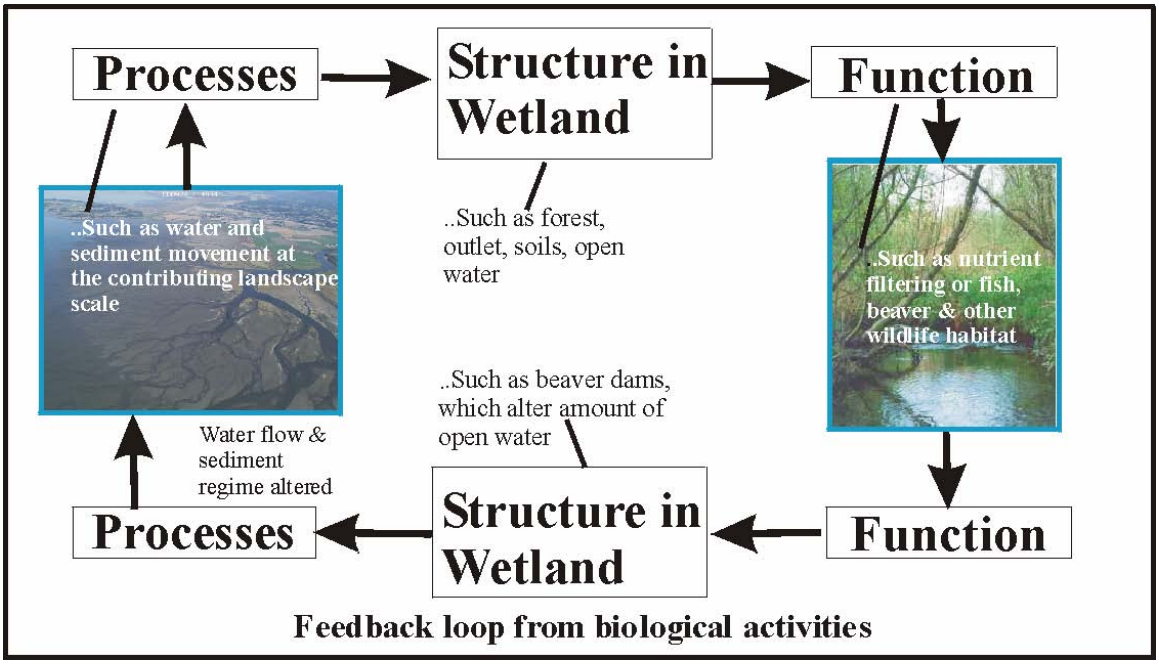


Figure 5-2. Wetlands and their functions are an expression of landscape processes. Wetland functions can in turn modify the landscape processes.

As an example, a wetland may function to support a rich food web in the aquatic resources downstream by exporting large quantities of plant material. In order to provide this function, the wetland needs to have the following:

- Water with adequate nutrients coming into the wetland
- Good exposure to sunlight
- A way for the plant material to pass from the wetland into downstream aquatic resources

The major processes that control the export of food are the movement of water to and from the wetland, and the movement of nutrients into and within the wetland. Thus, human alterations in the movement of water and nutrients into the wetland from the contributing landscape may change how the wetland supports the food web downstream.

5.3 Goals and Objectives of Analyzing the Landscape

The primary goal of a landscape analysis is to develop an understanding of where landscape processes occur and where they are particularly sensitive to human disturbances. As mentioned previously, changes to landscape processes will often result in changes to the functions in wetlands. An understanding of the geographic locations where processes are most sensitive to change is needed to identify appropriate and effective solutions for protecting wetlands and their functions (these solutions are then developed in Step 2 of the framework). Understanding environmental factors in the landscape is basic to planning how humans should use the land in the future, where they should preserve it, or how they might restore it.

Landscape analysis can support land-use planning, including comprehensive planning, because it provides a basis for understanding the future impacts of different zoning configurations and development scenarios. The following objectives for a landscape analysis help achieve this goal:

- Identifying which parts of the landscape provide essential environmental processes (landscape processes)
- Identifying the range of disturbances that affect landscape processes, and whether they are caused by human activities or natural disturbances
- Identifying which geographic areas are most susceptible to these disturbances, and therefore pose environmental constraints to land uses in these settings
- Determining how the landscape processes and the geographic areas that provide these processes influence wetlands and their functions

These objectives can be met by answering the questions posed in the following section.

The objectives apply to analyzing both the contributing landscape and the management area. Landscape processes are not geographically constrained by political boundaries. The reason for presenting a framework that separates the contributing landscape into two geographic units (the management area and the contributing landscape outside the management area) is to simplify the task of protecting and managing the wetland resources. Landscape processes and wetlands that occur within a jurisdictional boundary can be protected and managed by that jurisdiction. Protection outside the jurisdictional boundary will require a cooperative effort by several jurisdictions.

5.4 Questions that Can Be Used to Guide an Analysis of the Contributing Landscape and the Management Area

The questions listed below can be used to guide an analysis of the landscape and are phrased so the answers can be used to meet the goals and objectives described above. Each question is discussed in detail in the subsections that follow.

The questions that direct a landscape analysis are similar for both the contributing landscape and the management area. As previously mentioned, the difference in the analysis for these two geographic scales is more an issue of resolution than a different approach. If the management area is smaller in size than the contributing landscape, the analysis of the management area can make use of more detailed information. Local jurisdictions can then develop more detailed plans and be provided a better assurance that the risks to their wetlands are minimized. The same tools and methods, however, can be used at either geographic scale.

- **Question 1.** What are the landscape processes in the contributing landscape in the absence of human alterations (i.e., before they were altered by human activities on the land), and where are they located geographically?
- **Question 2.** What are the relationships between these original landscape processes and the wetlands and their functions in the management area?
- **Question 3.** What alterations to landscape processes have occurred, and how have these changes affected the wetlands and their functions?
- **Question 4.** What geographic areas are currently important for maintaining landscape processes and can be impacted by future activities and growth?
- **Question 5.** What measures can be used to protect and restore landscape processes in order to protect and restore the wetlands and their functions?

These questions should be answered by local jurisdictions prior to completing Step 2, Prescribing Solutions (e.g., developing critical areas ordinances, shoreline master programs, restoration programs, etc.), and Step 3, Taking Actions (i.e., implementing the solutions identified in Step 2), in the four-step framework. Although each question is directed toward wetlands and their functions, some of the landscape processes analyzed in answering these questions involve other aquatic resources and critical areas and can be used to help other planning efforts.

5.4.1 Question 1. What are the landscape processes in the contributing landscape in the absence of human alterations, and where are they located geographically?

The focus of this question is on processes that affect wetlands in the management area, but it can apply to all landscape processes in the contributing landscape because they are important factors for all natural resources and other critical areas. Understanding the landscape processes that were present in the absence of human disturbances defines the baseline conditions against which changes can be compared. In addition, it helps to identify the aspects of processes that are essential to maintaining current functions of wetlands.

Understanding the environmental processes in the absence of human disturbance is important even if recreating the "undisturbed conditions" is not a goal of the planning process.

This question can be answered by identifying and mapping the landscape processes that support or maintain wetlands and their functions. In general, these processes will fall into the following categories: the movement of water, sediment, nutrients, energy, and wildlife, as well as physical, chemical, and biological interactions that can occur at the watershed and sub-basin scale. To identify these processes, the jurisdiction will need to consider the historic condition and location of the following:

- Drainage patterns of surface water – how surface water reaches the wetlands (e.g., areas contributing water to the wetlands including streams, culverts, stormwater outfalls, and sheet flow)
- Flow paths of groundwater – where groundwater is recharged and discharged and where discharge has created wetlands
- Sediment and its path through the contributing landscape – likely sources of sediment, areas where sediment is deposited, and ways that sediment moves through the landscape to the wetlands
- Nutrients and their path through the contributing landscape – likely sources of nutrient inputs, areas where nutrients would be removed, and pathways for nutrients reaching the wetlands
- Corridors along which wildlife moves and plants are dispersed

Sources for this information include soils maps, aquifer recharge maps, stream inventories, topographic maps, resource/habitat maps from state and federal agencies, zoning maps of active agricultural lands, or even environmental documents such as environmental impact statements. Note that some of these landscape processes may occur at a scale much larger than the extent of the historic wetlands and may extend throughout the contributing landscape.

5.4.2 Question 2. What are the relationships between these original landscape processes and wetlands and their functions in the management area?

Answering this question requires analyzing the connections between the location of landscape processes and existing and historic wetland resources. The most important process to consider is where on the landscape water reaches the surface, or where surface water is slowed down enough to be ponded. Generally wetlands will form in these locations. For example, extensive peat deposits at the base of a slope where groundwater surfaces would indicate a probable location of wetlands. Topographic depressions in a floodplain would indicate locations where floodwaters can be stored and where wetlands also often occur.

The connections between wetlands and landscape processes are very specific to the topographic, geologic, and climatic conditions of an area. If an existing method to analyze the landscape, such as that being developed by Ecology, is not used, local experts will need to be consulted to develop an understanding of the links between wetlands and landscape processes.

5.4.3 Question 3. What alterations to landscape processes have occurred, and how have these changes affected wetlands and their functions?

Answering this question will require understanding where the following alterations have occurred:

- Changes to water flow. For example, areas where:
  - Surface water flow has been diverted, channelized, or culverted
  - Subsurface flow has been converted to surface flow
  - Increased flooding occurs
  - Stormwater management facilities have been installed
- Changes in the sources and transport of sediment. For example, areas where:
  - Active land clearing, construction activities, or agricultural practices occur
  - Sediments are deposited
  - Streams are entrenched
  - There is excessive bank erosion
  - Sediment enters streams from roads and roadside ditches

- Changes in water quality. For example, areas with:
  - Increased input and transport of nutrients (may be associated with sediment sources)
  - Increased input and transport of toxic compounds and pathogens
  - Biological impacts such as closure of shellfish beds or an increase in harmful algal blooms
- Wetlands have disappeared (e.g., from filling or ditching and draining)

Answering this question provides an understanding of how landscape processes and wetland resources have been altered. It is not necessary to measure or quantify changes in landscape processes directly to answer this question. Instead this can be accomplished by comparing maps of the disturbed conditions (generated through the analysis for this question) to the undisturbed conditions as mapped in the analysis needed to answer Question 1. Changes in processes can be inferred from specific indicators of change listed in the bullets above.

For example, the most readily available information on changes in types of land use may be through comparison of historic aerial photographs to current conditions. Such a comparison can illustrate changes such as conversion of forested lands to an agricultural or a built condition; conversion of agricultural lands to a built condition; changes in land use from low to high density or residential to commercial/industrial uses; and so on. Additional data on water quality from monitoring reports, information from surveys of the numbers and types of road crossings on streams and rivers, and/or information on the physical alteration of streams and rivers (e.g., ditching, diking, etc.) can all serve as indicators of changes in processes.

5.4.4 Question 4. What geographic areas are currently important for maintaining landscape processes and can be impacted by future activities and growth?

Once a jurisdiction has identified the areas where landscape processes historically occurred and where they have been changed, it is possible to identify those areas where landscape processes still occur today. This information can be used to predict where additional changes to processes and wetlands might occur from future activities. The purpose is to identify areas where the movement of water, sediment, nutrients, energy, and wildlife are particularly sensitive to additional human activities and disturbances.

The following are some human activities occurring in areas that are particularly sensitive:

- Filling in floodplains alters the movement of water and especially flood storage
- Paving in areas where groundwater is recharged resulting in reduced infiltration and baseflow to streams

- Building roads through the remaining vegetated corridors reduces the movement of animals and increases the potential invasion of unwanted plant species (Vegetated corridors are sensitive to being fragmented)

5.4.5 Question 5. What measures can be used to protect and restore landscape processes in order to protect and restore wetlands and their functions?

Answering this question is primarily an analytical process that relies on data and information collected in the previous questions. There are two objectives associated with this question. The first is to identify areas that have not yet been altered but are critical to maintaining processes and functions—the sensitive areas identified in Question 4. These should be managed to minimize the potential impacts of human activities through regulatory and non-regulatory means. The second is to identify where landscape processes have been altered but can be restored. Chapters 6 through 9 of this volume discuss in detail the regulatory and non-regulatory approaches that can be used for protection and restoration.

5.5 Questions that Can Be Used to Guide an Analysis of Individual Wetlands

The questions listed below can be used to guide an analysis of individual wetlands. The questions are phrased so the answers can be used to meet both regulatory and non-regulatory needs to protect and manage wetlands. The landscape analysis described in the previous section is appropriate for the development of land use and other plans. It does not, however, provide enough detail for making decisions about individual wetlands, either permit decisions which are site-specific or site-specific decisions about restoration or preservation. Questions 6 and 7 reflect analyses that are usually done during the planning process and in conjunction with the landscape analysis done for Questions 1-5. Question 8 addresses analyses that are most often done when proposals are submitted for altering specific wetlands.

- **Question 6.** What wetlands are currently performing functions that are associated with important processes identified in the landscape analysis?

- **Question 7.** What degraded wetlands or former wetlands are suitable for restoring landscape processes identified in Question 3?

- **Question 8.** What are the functions of individual wetlands that need to be protected, preserved, or managed?

5.5.1 Question 6. What wetlands are currently performing functions that are associated with important processes identified in the landscape analysis?

Answering this question is primarily an analytical process that relies on data and information collected in Question 4. The purpose is to identify specific wetlands where the movement of water, sediment, nutrients, energy, and wildlife are particularly sensitive to additional human activities and disturbances. These wetlands will be a subset of the sensitive areas identified in Question 4, and they should be specifically highlighted in any general plan to protect and manage wetlands.

For example, headwater wetlands are very important in desynchronizing flood flows in downgradient areas. This desynchronization maintains the landscape process of water flow, and protecting this function in headwater wetlands is important for the entire watershed downstream.

5.5.2 Question 7. What degraded wetlands or former wetlands are suitable for restoring landscape processes identified in Question 3?

Opportunities for restoration can be identified by developing a map of wetlands that have been degraded, and furthermore that may no longer meet the definition of a wetland. This is accomplished using hydric soils, wetland inventories, and land-use maps. The locations where these former or degraded wetlands intersect the areas where landscape processes occur (from Questions 1 and 4) are the areas best suited for restoration. This information is the basis for developing regional restoration plans, developing mitigation banks, and developing an understanding of the type of compensatory mitigation that is appropriate for permitted alterations to existing wetlands.

5.5.3 Question 8. What are the functions of individual wetlands that need to be protected, preserved, or managed?

The functions present in a wetland need to be understood in order to apply protective measures that will adequately protect these functions, such as buffers and appropriate mitigation plans. Not all wetlands provide the same functions or function at the same levels (see Chapters 2 through 4 in Volume 1 for further discussion). The analyses of functions of individual wetlands are usually done as part of permitting for actions that could affect that wetland.

Most analyses of wetlands at a specific site use rapid approaches that assess a range of wetland functions and values. Many methods have been developed in the last decade to analyze wetland functions and values, and these have been summarized in numerous

compilations (e.g., Hruby 1999, Bartoldus 1999, and the Army Corps of Engineers Ecosystem Management and Restoration Information System http://el.erdc.usace.army.mil/emrrp/emris/ go to Index, Wetland Procedure Descriptions).

In addition, Ecology has developed several methods that can be used for the analysis of functions at the site scale. The *Washington State Wetlands Rating System for Eastern Washington - Revised* (Hruby 2004a) and the rating system for western Washington (Hruby 2004b) were developed to categorize wetlands based on their sensitivity to disturbance, how difficult they may be to replace through compensatory mitigation, the rarity of the wetland type, and the groups of functions they provide.

Methods for Assessing Wetland Functions (Hruby et. al. 1999, 2000) (also called Washington State Wetland Functions Assessment Method or WFAM) provides more detailed information on up to 15 specific functions that a wetland performs. Both the rating systems and the methods for assessing functions do not address other benefits wetlands provide such as aesthetics, provision of educational and recreational opportunities, etc. WFAM is currently available for a subset of wetland types in both eastern Washington (Hruby et al. 2000) and western Washington (Hruby et al. 1999).

Other methods that have been developed for analyzing individual wetlands in Washington State include the *Wetland Functions Characterization Tool for Linear Projects* from the Washington State Department of Transportation, which characterizes functions as "probably present" or "probably not present" and as "principal" or "secondary" functions (Null et al. 2000). A brief description of these and other assessment methods that are often used in the state is provided in Appendix 5-B.

In some cases all the wetlands in a basin or sub-basin are analyzed in advance of any actions as part of a regional plan using one of the "rapid" methods described above. This information is used to guide planning by identifying up front those individual wetlands that should not be altered because they perform important functions that cannot be replaced. Wetlands are also identified that do not function well. These can be identified as suitable for development with appropriate compensation. Potential or recommended mitigation sites can also be identified during this planning process. Examples from the Puget Sound area include the Mill Creek Special Area Management Plan or SAMP (U.S. Army Corps of Engineers 1997) and the Everett Snohomish Estuary Wetland Integration Plan or SEWIP (City of Everett 1997).

Chapter 6

Prescribing Solutions: Landscape-Based Land-Use Plans

6.1 Introduction

This chapter presents approaches to developing plans and policies that incorporate the information collected during Step 1 of the four-step framework—the analysis of the landscape and its wetlands—as described in Chapter 5. Developing plans and policies is part of Step 2 (Prescribing Solutions) in the framework of a wetland management program (Figure 6-1).

Plans and policies are enhanced by information generated in Step 1, which involves analyzing the role that wetlands play in landscape processes. Landscape processes both maintain and interact with wetlands and the functions they perform. Landscape processes can include physical processes such as those that maintain hydrology and the physical stability of shorelines; chemical processes such as those that maintain or degrade water quality; and ecological processes such as those that maintain habitats and species.

The results of these landscape analyses are used in Step 2 to identify solutions that reduce the risk of human activities that degrade or eliminate wetlands and landscape processes.

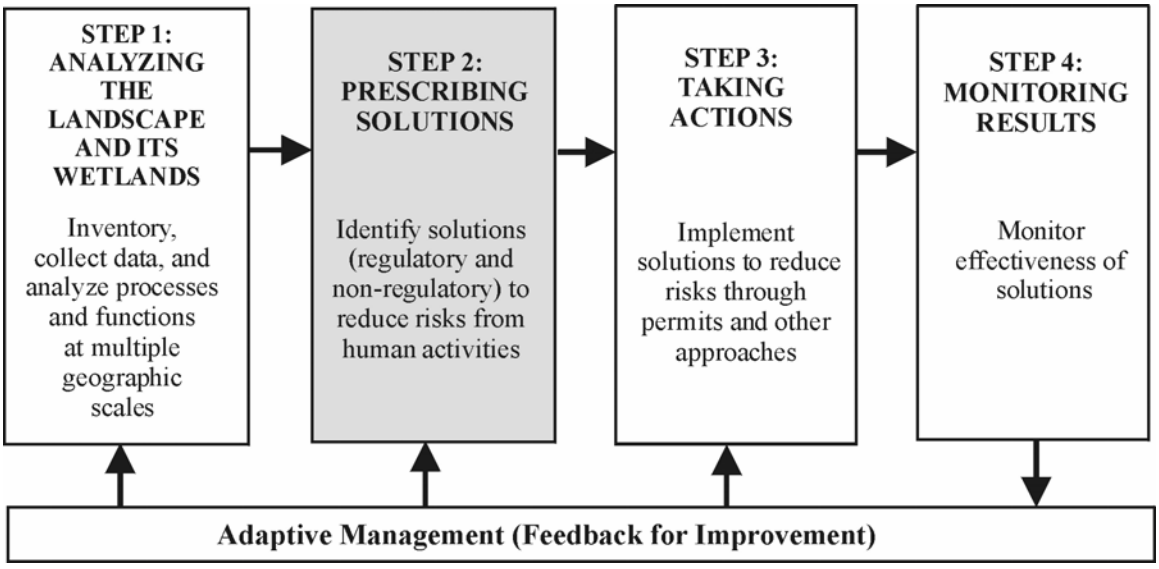


Figure 6-1. Developing plans and policies fits into Step 2 within the four-step framework recommended for protecting and managing wetlands (shaded box).

This chapter begins with a brief overview of planning and the Washington State Growth Management Act (GMA) (Section 6.2). It then describes the importance of using landscape analysis and approaches (at the appropriate scales) when initiating and completing planning processes (Section 6.3). Next, Smart Growth is introduced (Section 6.4); the concepts of which form the foundation for two complementary planning applications called Green Infrastructure and Alternative Futures which are described in some detail. These approaches have been used as reliable frameworks for the inclusion of landscape analysis and perspectives within both local (such as subarea plans) and comprehensive planning processes (described in Chapter 7). The chapter concludes (Section 6.5) with a discussion of the fiscal benefits of maintaining landscape processes by protecting critical areas such as wetlands, floodplains, streams and riparian areas, nearshore areas, etc.

6.2 Overview of Planning and the GMA

Land-use planning, in the context of resource management, is the formalized process by which jurisdictions identify what can or cannot occur on lands within their regulatory authority. In Washington State, land-use planning is implemented at a local (county or city) level of government and is directed by the Growth Management Act (GMA), with state agency technical assistance and oversight.

In 1990 the Washington State Legislature passed the GMA (RCW 36.70A) to guide local jurisdictions in their land-use planning efforts. The GMA dictates that counties and cities with certain characteristics must fully plan for future growth (RCW 36.70A.040). (Chapter 2 of this volume provides an overview of the GMA and a review of Hearings Board and court cases relating to the GMA, critical areas, and best available science.)

The GMA identifies goals to be used by local governments to "guide" the development of comprehensive plans. A full range of actions is included, such as concentrating development to limit urban sprawl; coordinating infrastructure for transportation; avoiding incompatible uses while maintaining the extraction of natural resources from forests and mines and agricultural production on designated lands of long-term commercial significance; as well as protecting the environment and the quality of life in the state. Cities and counties planning under the GMA have responded to these mandates by developing or updating their comprehensive plans and the codes and ordinances that implement the plans.

The planning process should begin with an understanding of existing natural resources (e.g., wetlands, floodplains, riparian areas, etc.) and the functions they provide, as well as the broader landscape processes with which they interact. Once these have been identified, they should be protected through comprehensive plans, other local plans, and the regulations and management practices that implement the plans.

Planning concepts and approaches described in this chapter (Smart Growth, Green Infrastructure, and Alternative Futures) use landscape-scale information to evaluate possible scenarios for future use and management of the land. They incorporate

alternative approaches for meeting future community needs while protecting ecosystems. The general objective of these approaches is to help identify options that both minimize environmental impacts and use the functions (services) provided by the ecosystems that exist within a healthy landscape. Wetlands, for example, will retain and slow floodwaters and recharge both stream flow and aquifers – environmental functions which engineering cannot easily or inexpensively replace. Good planning is therefore vital for protecting ecosystems, including critical areas and the functions they provide, as well as saving money for the community in the long run.

The planning approaches described below can be used as a basis for revising comprehensive plans or subarea plans, developing watershed protection and restoration plans, and supporting other planning and management efforts. They also provide a pragmatic approach for actively engaging the public by incorporating their direct input in the evaluation phase and by participating in making decisions about the future of their communities and surrounding landscapes.

Factors to consider when making land-use decisions affecting the future

In the paper *Ecological Principles and Guidelines for Managing the Use of Land* by V.H. Dale et al. (2000), scientists from around the country collaborated to identify factors to consider when making land-use decisions. These factors include the following:

1. Examine the impacts of choices in a regional (or landscape) context

2. Plan for long-term change and unexpected events

3. Preserve rare landscape elements, critical habitats, and associated species

4. Avoid land uses that deplete natural resources over a broad area

5. Retain large contiguous or connected areas that contain critical habitats

6. Minimize the introduction and spread of non-native species

7. Avoid or compensate for the effects of development on ecological processes

8. Implement land use and land management practices that are compatible with the natural potential of the area

The paper provides guidance for applying each of these factors to the planning process. They note that the mobility of human activities is more flexible (within limits) than the mobility of important landscape processes and ecosystem functions. Therefore, ecological constraints (the need to manage landscape processes for the long term) can be used as the primary consideration in land-use planning. The planning sequence they suggest is to first plan for maintaining water and biodiversity; then for cultivation, grazing, and the harvesting of wood products; then for managing sewage and other wastes; and finally for the placement of homes and industry. (The goals in the list above are also listed in Chapter 1 and should be considered throughout the four-step framework for protecting and managing wetlands and other critical areas.)

6.3 The Importance of Incorporating a Landscape Perspective in Planning

Land-use planning has traditionally focused on human actions implemented through management decisions at the level of the individual site or parcel. It has done so without always considering what is needed to protect environmental processes and wetlands at the landscape level (Dale et al. 2000). The synthesis of the science in Volume 1 indicates that the lack of incorporating information about the landscape in decisions made about land use, including those involving wetlands and their functions, is a major deficiency. For example, Volume 1 concludes that cumulative impacts lead to the degradation of wetlands and other natural resources. This results in the loss of landscape and watershed processes over time. A cumulative impact is "*…the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions...Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time"* (Council on Environmental Quality 1997 http://ceq.eh.doe.gov/nepa/regs/ceq/1508.htm#1508).

Volume 1 goes on to state that regulatory programs that are based on a case-by-case approach and a lack of consistency between jurisdictions are two of the causes of cumulative impacts. Studies cited in Volume 1 found that decision-making that only considers individual projects without taking into account the larger landscape does not address cumulative effects (Johnston et al. 1990, U.S. Environmental Protection Agency 1999, Dale et al. 2000). This is especially significant for landscape processes that occur across jurisdictional boundaries (i.e., processes within the contributing landscape as depicted in Figure 4-2 in Chapter 4 of this volume).

One of the solutions for reducing cumulative impacts in the future, therefore, is developing plans and policies that incorporate information on larger landscape changes on these ecosystems and their respective landscape processes. Through analyses using data generated at this scale, local governments gain an understanding of where processes and functions occur, the interactions between ecosystems and the surrounding landscape, and how land uses may affect them.

With this knowledge comes the ability to minimize cumulative impacts to processes, functions, and resources by developing plans, policies, and setting clear management objectives that affect growth patterns. These can dictate which areas will be most fully protected and which may be degraded or remain in a degraded condition.

Plans, policies, and management objectives can in turn initiate protection programs that go beyond case-by-case decision-making by considering the larger landscape. For example, comprehensive planning based on landscape information can serve as the platform for critical areas ordinances, clearing and grading ordinances, zoning designations, shoreline master programs, protection measures through the Endangered Species Act, as well as non-regulatory restoration and preservation programs.

Local governments, therefore, benefit from having an understanding of key landscape processes and the functions that networks of critical areas provide. Landscape information can identify the capacity of natural resources like wetlands to provide important services to communities such as maintaining water quality, reducing flooding, etc. Local governments gain a clearer understanding of where these processes and functions occur in order to steer development to more appropriate areas and thereby reduce impacts to the processes and functions.

Plans and regulations based on scientific information may result in a more efficient permitting process by reducing the need to complete complex environmental review and detailed studies at the permitting level. They also can facilitate cooperation between jurisdictions, thereby further reducing cumulative impacts.

Minimizing the cumulative impacts of land use through landscape-based plans, policies, and implementing regulations can prevent costly problems by maintaining landscape processes and wetland functions over time. The result is a fiscally responsible approach to sustaining development.

6.4 Smart Growth

Smart Growth is a relatively new, conceptual framework for improving land-use planning and the management of growth in communities. It provides core defining principles intended to guide the development of land-use plans and policies as well as implementing regulations and practices. Its purpose is to minimize the negative effects of sprawl development on both local communities and the environment. Smart Growth integrates better economic, social, financial, and environmental outcomes for a community. It represents planned actions taken with all the community's benefits in mind both in the near term and well into the future.

Applying the principles of Smart Growth has been found to be fiscally beneficial by recognizing that certain patterns of growth and decline significantly hurt communities by undermining both their economies and the environment (Muro and Puentes 2004). In their paper *Investing in a Better Future: A Review of the Fiscal and Competitive Advantages of Smarter Growth Development Patterns*, Muro and Puentes (2004) found that Smart Growth can reduce public costs of installing new infrastructure and delivering new services, improve a region's economic performance, and bring economic gains to suburbs as well as cities. (See Appendix 6-A for additional references and web pages about Smart Growth.)

The National Governors' Association promotes the use of Smart Growth land-use planning and practices as beneficial for local communities. They recognize that it is not necessarily growth that is the problem but the patterns of sprawl-induced growth which are harmful (see the National Governors' Association web site www.nga.org).

Smart Growth focuses on growth that protects open space, revitalizes neighborhoods, and makes housing more affordable while improving the quality of life in communities. Fundamental to the Smart Growth concept are the following defining principles:

- Preserving and restoring critical environmental areas and the functions and services that these areas provide
- Strengthening and directing development toward existing communities
- Fostering attractive communities with a strong sense of place
- Reintegrating compatible uses in neighborhoods (mixed land use)
- Taking advantage of compact building design
- Creating walkable neighborhoods
- Providing a variety of transportation choices

When applying the concept of Smart Growth, local governments analyze the landscape using the best resource information available about the geographic area, identify the needs and desires of the citizens in visioning their community's future, and then evaluate different scenarios to accommodate future growth in a sustainable manner.

Landscape analysis is an important element of Smart Growth planning. However, it is only in recent years, since the advancement of the Geographic Information System (GIS), that conducting landscape analysis has been possible. Even more recent has been the development of methods to analyze landscape data which provide a scientific understanding of the sensitivities and stressors on natural resources and landscape processes. With this science-based knowledge, local governments and communities can, for the first time, improve their decisions about land uses and more effectively incorporate Smart Growth concepts into land management.

The concept of Smart Growth and its guiding principles can be applied through a variety of mechanisms. Land-use policies using Smart Growth principles encourage mixed-use zoning, limited outward expansion, higher density development, reduced travel, revitalization of urban centers, and preservation and restoration of open space essential to maintaining critical areas and landscape processes. Examples of planning tools using Smart Growth principles include Green Infrastructure planning and Alternative Futures analysis. Both are discussed later in this chapter.

Regulatory practices applying the Smart Growth concept focus on reduction of impervious surfaces, maintenance of tree and vegetative cover, compact building design, etc. Low impact development (LID), traditionally applied as a technical approach to

reducing stormwater impacts from developed lands, conceptually falls within the parameters of Smart Growth principles as well. Non-regulatory programs adopted using Smart Growth approaches emphasize preserving and restoring core greenspace areas. Preserving and restoring these areas is most effective when non-regulatory and regulatory tools are both applied.

Smart Growth planning offers the opportunity to take a proactive and resource-based approach to minimizing cumulative impacts on the landscape while maximizing environmental processes that benefit the community. At its best, Smart Growth has the potential to help direct future growth in ways that maintain or improve landscape processes and promote a healthy, functioning environment.

Washington's GMA incorporates some Smart Growth considerations in the directives for the use of critical areas ordinances, concentrating urban development and infrastructure, and conserving resource lands for long-term use. Many of the other Smart Growth elements that are planning and implementation tools can certainly be applied within the GMA context to bring the best land management practices to Washington.

6.4.1 Smart Growth Can Be Used to Develop or Update Local Plans

Smart Growth concepts and associated planning approaches can be applied at any time in the local planning process. (See Sections 6.4.2, 6.4.3, and 6.4.4 for a discussion of planning approaches which use Smart Growth concepts.) It is optimal to incorporate landscape analysis and Smart Growth concepts early in the process whenever a local jurisdiction intends to update its comprehensive plan and implementing ordinances, develop new subarea plans, or expand urban growth areas.

Updates to comprehensive and subarea plans are particularly important times for re-assessing the conditions of local landscapes and evaluating different development options for minimizing future impacts on ecosystems and landscape processes. Smart Growth approaches are more likely to succeed when they are discussed, developed, and implemented as part of a formal planning process. *Watershed academies* or *councils* (committees of scientifically informed citizens) can help guide the planning process. They can make recommendations on how to incorporate information about the landscape and principles of Smart Growth into land-use planning.

In areas close to urban centers that are not yet developed, into which urban growth boundaries may be extended, there is still an opportunity to tailor management needs within the landscape context. In more rural areas, harmful losses can be prevented by re-directing development to the least sensitive locations. These opportunities may well reflect the "best case" scenarios for balancing community needs while maximizing resource protection prior to development, thus sustaining landscape processes and natural resources to avoid expensive land-use problems in the future.

Smart Growth, and other planning processes that incorporate landscape analysis, can help define and identify specific restoration, preservation, and conservation needs and develop plans to address those needs. While it is unrealistic to think that an already built environment will be "un-built," mitigating or compensating actions (e.g., using restoration and preservation) might be identified and take place elsewhere in the vicinity to recover lost functions deemed beneficial by communities and resource managers. In this respect, some of the approaches described in this chapter, and elsewhere in Volume 2, can help identify and address restoration, preservation, and conservation needs in terms of landscape processes and target the type of implementing action needed for each site. (See Chapter 9 for more discussion of non-regulatory tools.)

A case study of the benefits of Smart Growth

A recent study by Preuss and Vemuri (2004) projected the effectiveness of Smart Growth practices implemented in Montgomery County, Maryland, in the 1960s. At that time Montgomery County implemented tools incorporating Smart Growth principles including transfer of development rights, cluster development, and open space acquisition through their land-use plans.

Preuss and Vemuri applied a dynamic model to predict the implications of using Smart Growth tools in Montgomery County during the last four decades. They did so by reviewing three different scenarios: 1) traditional policies, 2) current Smart Growth, and 3) full development. They found that Montgomery's current Smart Growth practices reduced negative effects on water quality and preserved more open space than the other two scenarios. In addition, under Montgomery's existing Smart Growth practices, developable land would still remain into 2050 while being non-existent under the other scenarios.

6.4.2 Planning Approaches Using Smart Growth

To illustrate the application of Smart Growth principles to planning, two approaches are discussed in the following sections: Green Infrastructure (Section 6.4.3) and Alternative Futures (Section 6.4.4). Both of these very similar, yet complementary, approaches examine how the services and infrastructure provided by natural resources can be used to benefit communities while maintaining those resources into the future. These planning approaches can readily be used by local governments to help develop comprehensive plan elements and help guide implementation of regulatory and non-regulatory programs. Comprehensive plans are discussed in Chapter 7.

By developing plans using Green Infrastructure or Alternative Futures, a local jurisdiction can develop the best *greenprint* or preferred alternative for the future. (See Section 6.4.3.1 for a discussion of the approach to developing a Green Infrastructure plan.) The conceptual land-use plan, often presented in the form of a map or maps, includes the location and type of all essential (core) areas that need conservation, preservation, and/or restoration (including degraded areas that provide opportunities to restore processes and functions).

These approaches can include both an assessment of the current and projected needs for infrastructure (e.g., transportation corridors and water and sewage treatment options) as well as the desired land-use patterns that will maintain and protect important environmental processes and functions. The implementation tools used to conserve, preserve, and restore the identified areas may be either regulatory or non-regulatory. Which protection measures work best at any location are determined by the functional attributes of the landscape, the overall risk associated with loss of the resources identified, and, ultimately, the community's vision of the landscape for the future.

See Chapter 8 for a description of restoration and preservation used in a regulatory context and Chapter 9 for restoration, preservation and conservation used in relation to non-regulatory activities. These terms are also defined in the glossary.

6.4.3 Green Infrastructure Planning

Green Infrastructure or *GRIST* is defined as an interconnected network of protected land and water that includes a wide variety of both relatively undisturbed and restored ecosystems and landscape features that make up a system of hubs and links. The network supports native habitat and communities, maintains landscape processes, sustains air and water resources, and contributes to the physical and economic health and quality of life of communities. In addition, this network of lands provides corridors for wildlife movement. (See Section 6.4.3.3 for conceptual illustrations of "hubs and links" and a simplified overview of the typical steps in developing and implementing a GRIST plan.)

The resulting network of ecologically important lands integrates:

- Waterways, wetlands, forests, wildlife habitats, and other such features
- Greenways, parks, and recreation lands
- Working farms, ranches, and forests
- Wilderness and other open spaces that support native species and maintain landscape processes

GRIST plans are an important element of Smart Growth because they help local planners identify and prioritize resources to be preserved, ensure the economic viability of working landscapes, and guide development in a manner that is compatible with sustaining landscape processes and the character of the community. GRIST plans provide a greenprint for accommodating land-use patterns while preserving critical areas, ecosystems, resources, and areas with native species and cultural assets. By integrating the benefits of landscape processes and services, GRIST plans assess current conditions and guide future land uses similar to how a transportation plan provides a blueprint for existing and future travel needs.

The President's Council on Sustainable Development identified Green Infrastructure as a key strategy for achieving sustainability in the report *Towards a Sustainable America – Advancing Prosperity, Opportunity and a Healthy Environment for the 21st Century* (Williamson 2003). Additional references on Green Infrastructure and Smart Growth topics are provided in Appendix 6-A.

6.4.3.1 The GRIST Approach

When developing a GRIST plan (or greenprint), conservation of landscape processes and critical areas establishes the foundation on which the rest of the local comprehensive plan is built.

Integrating the results of landscape analysis (as described in Chapter 5) into the GRIST plan ensures that the functions and processes necessary to maintain long-term protection of natural resources including wetlands are thoroughly understood and considered in avoiding future impacts or loss. For example, areas where significant groundwater discharge/recharge and storage occur would not be appropriate to zone for uses that would result in a high percent of impervious surfaces (e.g., roofs, driveways, roadways, and parking lots). These areas would be more appropriately zoned as open space or other low-density uses, rather than being designated for high-density development. The local jurisdiction might want to consider preserving such areas from development altogether so that the community's water supply is assured into the future.

A GRIST plan can also identify areas that provide important landscape processes that need restoration. For example, this might include areas where construction of levees has separated rivers from their floodplains or where drainage channels are conveying subsurface waters away from wetlands.

Thus, integrating the results of landscape analysis allows a jurisdiction to direct human activities to locations that avoid or minimize impacts to critical areas and other natural resources, sustaining them over time while supporting the community's needs for adequate water supplies, water quality, flood attenuation, etc. In addition, GRIST planning tracks the pace and location of land use in relationship to these outcomes.

GRIST plans are not open space plans

Traditional Open Space Plans (OSP) have been used by jurisdictions throughout Washington for years. These plans are usually developed by the local parks and recreation departments with the intent of securing open spaces which can provide the citizenry with recreation opportunities and/or scenic amenities.

GRIST plans, or greenprints, take the OSP concept further by also examining the functions provided by undeveloped lands and assuring continuity and connectivity between protected features. As the name implies, GRIST plans are designed to protect the "green infrastructure" on the landscape that provides for such "free" functions as flood attenuation, groundwater recharge, water quality filtration, etc. These functions, if lost, would need to be replaced by "engineered infrastructure," if they can be replaced at all. Additionally, conservation of habitat and biodiversity are also critical aspects of greenprints which are addressed by maintaining core areas with linkages (hubs and links) on the landscape.

Greenprints can be viewed as vital components for achieving both a healthy environment and sustainable communities. As such, they are the building blocks for implementing regulatory and non-regulatory programs. Thus, greenprints represent a community commitment to avoid costly environmental problems through proactive measures. For example, funds traditionally used for engineered infrastructure can be committed to implementing the plan when the functions of "green infrastructure" replace the need for built solutions.

Note: Some local greenprints still primarily focus on recreational lands only. These plans do not incorporate all of the broader principles of GRIST planning. Therefore, any reference to GRIST plans or greenprints in this document is referring to the broader description provided here and not plans that focus strictly on recreation.

GRIST Works in Both Undeveloped and Developed Areas

Communities at any stage of planning or development can incorporate Green Infrastructure into their planning processes:

- **GRIST planning for areas with little urban development.** When applying the results of a landscape analysis through a GRIST plan for a jurisdiction (or portion thereof) that has experienced little human development, a network of critical areas and resource lands can be identified for conservation. This network can be coordinated with plans for the built infrastructure such as essential transportation corridors. Essential "green infrastructure" can be preserved and/or restored while transportation corridors and built environments are accommodated. This clearly identifies where both public and private development will be better suited, thereby allowing land uses that are compatible with maintaining the integrity of the landscape and its processes.

- **GRIST planning for areas that are largely developed.** In jurisdictions where the landscapes have already been largely developed, applying the results of a landscape analysis through a GRIST plan can designate and protect remaining natural resources and critical linkages while still considering the existing roads, urban centers, etc. Here the results of a landscape analysis may provide its greatest benefit by identifying those portions of the landscape where essential processes and functions can and need to be restored to fill in the gaps where functions are needed.

6.4.3.2 Implementing a GRIST Plan

Implementing GRIST planning begins with incorporating the GRIST plan into the Land Use Element of the comprehensive plan (as well as the Shoreline Master Program). Other relevant elements of comprehensive plans should include policies and directives for successfully implementing the GRIST plan. In line with these policies and directives, regulatory and non-regulatory programs and tools should also be updated or developed.

The specific programs and tools to be used for implementation, and where and how they are applied, will depend on the goals and needs of the GRIST plan in relation to landscape processes, their level of degradation, their sensitivity to disturbance, and development pressures. For example, in a particular sub-basin it might be most critical to protect and maintain wetlands because the quality of the water is threatened by non-point pollution. Thus, policies for that basin may direct agricultural landowners to provide stronger buffer protections around aquatic resources. They may also encourage active restoration of aquatic habitats and their buffers, while zoning designations could reflect more stringent wetland standards to protect their ability to improve water quality. In an undeveloped area that provides aquifer recharge, policies and regulations may recommend low-impact development practices or even land acquisition as the preferred tool for protection.

6.4.3.3 Typical Steps for a GRIST Plan

While each local jurisdiction might need to develop a GRIST plan in its own way, there are some key steps that each should address (discussed below). Some of these steps may overlap with the landscape analysis discussed in Chapter 5. For detailed guidance on GRIST planning, please refer to the four-volume workbook titled *Local Greenprinting for Growth* (Trust for Public Lands and National Association of County Officials 2002).

Step 1- Develop the Overall Approach and Define the Geographic Scope

Developing a GRIST plan requires 1) defining the scope of the project, 2) establishing a means of engaging the community through education and public input and providing a forum for group decisions on the plan, and 3) understanding fiscal costs and benefits.

Decisions will be needed regarding the geographic scope of the GRIST plan and the resources that will be examined. The geographic scope is the portion of the landscape under consideration: Is it at the scale of the contributing landscape involving several

jurisdictions, or is it a management area such as a county, city, or sub-basin? Defining what areas should be part of a greenprint should ideally be examined in light of the sensitivity of different areas identified during the landscape analysis.

The community must be informed and engaged early in the process because GRIST planning is a process of community visioning and decision-making. Public understanding and involvement are essential to the success of the greenprint design. A communication plan should be created early in the process, identifying how the local citizens will be engaged, what committees will be used to make planning decisions, what will be their composition and decision-making power, etc.

It is advantageous to clearly articulate the fiscal savings that accrue as a result of GRIST planning from the start, both to the citizenry and government decision-makers. Some local jurisdictions conduct fiscal analyses comparing the cost of building infrastructure to the cost of protecting green infrastructure, including the tax savings that green infrastructure can provide to communities. Other fiscal benefits worth considering are those that result from attractive landscapes (e.g., parks and recreation lands, greenbelts, working farms, etc.). These greenspaces are increasingly important in attracting the creative workforce that can add to the economic growth of communities (Florida 2002). As mentioned previously, this is important information since the fiscal value of open space should be communicated to policy-makers as well as the community. (See Section 6.5 of this chapter for further discussion of fiscal benefits.)

Step 2 - Inventory Resources

Conducting an inventory of resources might consist of a landscape analysis as discussed in Chapter 5 or another method that is appropriate to assess the characteristics of the green infrastructure in the planning area. As discussed earlier in this chapter, using a landscape analysis ensures an understanding of the relationship of landscape processes and wetland functions (as well as other natural resources) and how they have been altered. Landscape data can be used in conjunction with information such as detailed ownership patterns and current or projected zoning overlays. Together, this information can assist with deciding how landscape processes and the functions provided by natural resources should be protected, as well as the type and location of preservation and restoration measures needed.

Figure 6-2 provides a simple, conceptual illustration of a landscape that has been inventoried as part of developing a GRIST plan. This graphic serves as the base for Figures 6-3 and 6-4 which illustrate subsequent steps in GRIST planning.

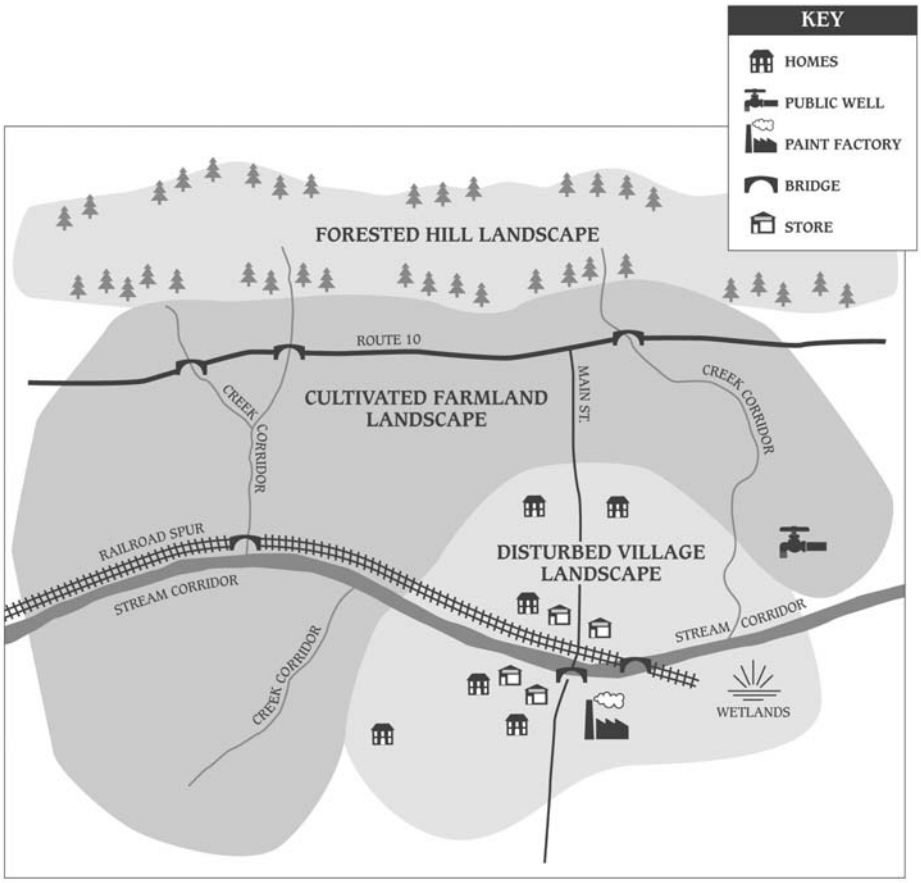


Figure 6-2. Conceptual representation of a landscape that has been inventoried as part of creating a GRIST plan (Figure provided by Heritage Conservancy, a non-profit land trust based in Doylestown, PA).

Step 3 - Envision the Future

Envisioning the future is when the community establishes overriding principles that guide the development of the GRIST plan. These are the goals for the greenprint and may include preserving critical areas and natural resources within each landscape type, maintaining and/or restoring landscape processes, providing or enhancing open space corridors, and so on. The visioning process also inherently should include discussion and identification of the least sensitive lands that are most appropriate for development for a range of uses that are prioritized by the community.

Step 4 - Finding the Hubs and Links

Finding the hubs and links requires a detailed examination of key ownership and land use patterns and defining how they will be addressed in the GRIST plan. Applying a landscape analysis helps to target those areas needing special protection because of their sensitivity or importance. From the landscape analysis, identification of existing or potential hubs and links will become more readily apparent. For example, cultivated lands, areas covered by forest, and existing preserves will be obvious "hub" points from

which to consider retaining or recreating "links" between the "hub" sites (see conceptual illustration in Figure 6-3). As this network is envisioned, steps needed to round out as well as implement the plan (e.g., purchasing parcels of land to connect habitat areas or restoring wetlands or riparian areas) become apparent.

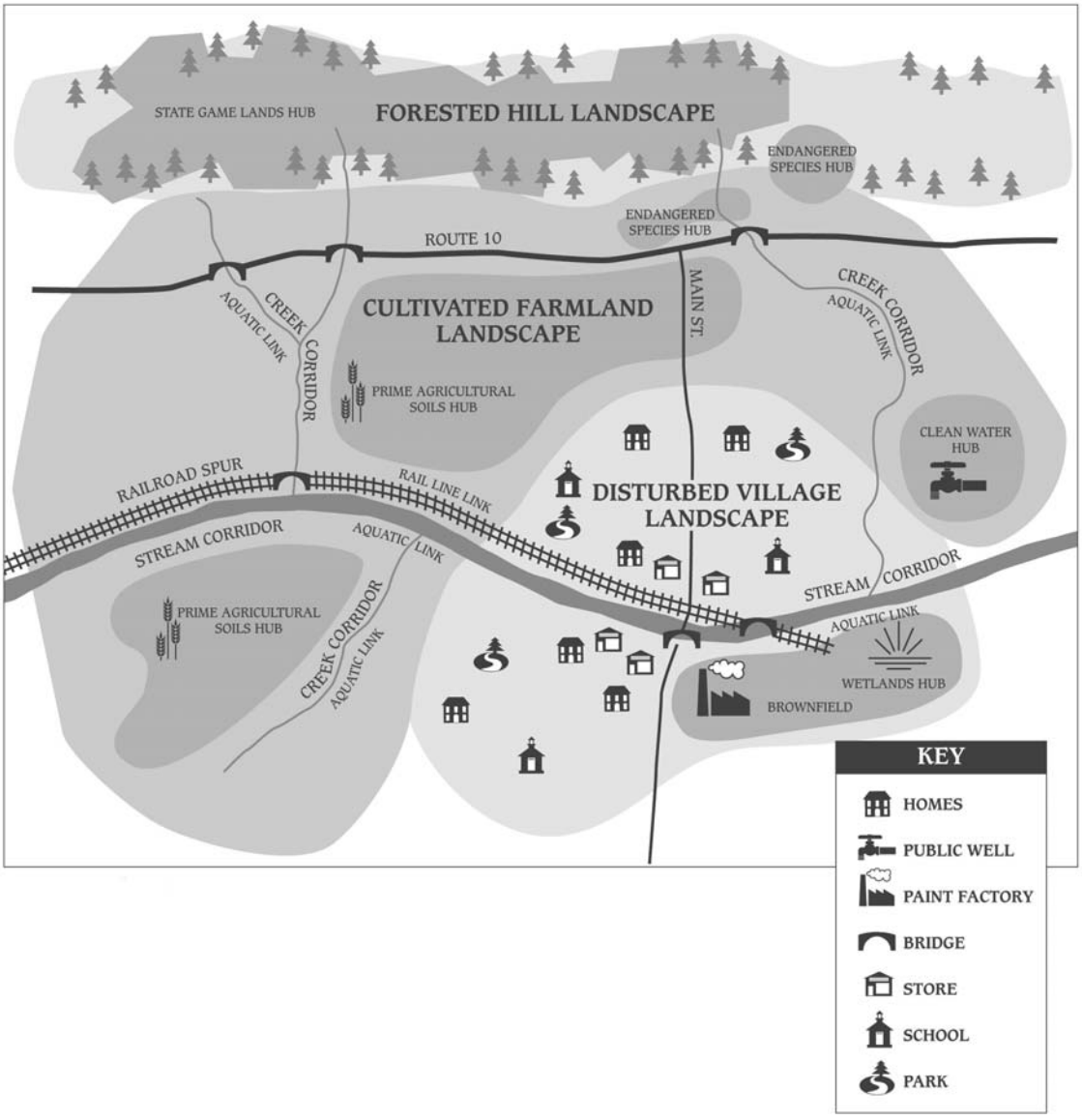


Figure 6-3. Conceptual representation of how hubs and links are identified as part of creating a GRIST plan (Figure provided by Heritage Conservancy, a non-profit land trust based in Doylestown, PA).

Step 5 - Creating the GRIST Plan

Creating the GRIST plan involves identifying potential land-use scenarios based on the information described in the previous steps. Alternative scenarios can be examined using

maps to apply different policy and zoning options. The community's goals for the future are applied to these options, and the appropriate course of action can be identified.

This stage in GRIST planning focuses on what specific provisions should be applied in various portions of the landscape to effectively conserve, preserve, and/or restore core areas of concern. At this stage of the process, the need to develop or revise the comprehensive plan, implementing policies and regulations, and non-regulatory tools should be apparent. Figure 6-4 provides a conceptual illustration of a completed GRIST plan.

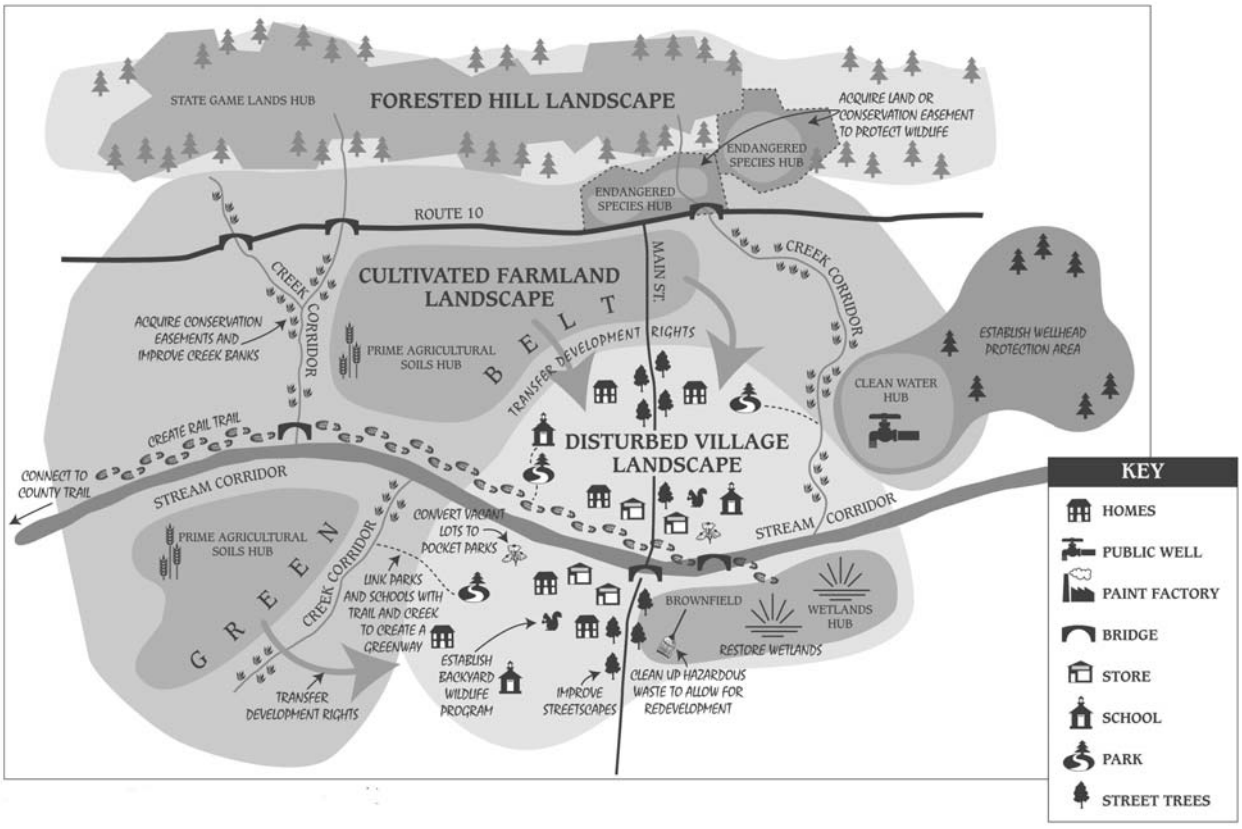


Figure 6-4. Conceptual representation of a completed GRIST plan (Figure provided by Heritage Conservancy, a non-profit land trust based in Doylestown, PA).

Step 6 - Implementing the GRIST Plan

Several means can be used to implement a GRIST plan, beginning with revisions to the Land Use Element of the comprehensive plan. From there, zoning designations and critical areas ordinances or other regulations can be modified as needed. In addition, non-regulatory programs can be established which contain a mix of landowner incentives, acquisition funding, and restoration components. The GRIST plan should be applied throughout the planning area as new zoning decisions and new regulatory protections are developed in proposed urban growth areas, master-planned communities, etc.

6.4.4 Alternative Futures

Alternative Futures is another approach to land-use planning that uses Smart Growth principles. It is similar to Green Infrastructure planning; however, the analysis phase is especially well developed to scientifically quantify the impacts to ecosystems from different, future development scenarios. (See Section 6.4.4.1 on determining the scope of the analysis for more discussion on the topic.)

Alternative Futures offers an excellent example of how a scientific examination of the landscape, when combined with community involvement, leads to a more informed planning process that results in improved environmental conditions and community vitality. As with Green Infrastructure, the community helps to make the informed decisions about land use when evaluating the different scenarios for future development.

A landscape analysis is used to create a series of scientifically supported scenarios that depict what the landscape might look like and how it will perform under different future land-use options. Each scenario is analyzed in regard to the environmental concerns and community priorities that have been identified, similar to those already discussed in the sections on Smart Growth and Green Infrastructure. The analysis uses metric measures (discussed later in this section) to play out the future depictions of development, allowing communities to better assess and evaluate the potential benefits and impacts of each scenario on the environment and community's quality of life.

As with Green Infrastructure, Alternative Futures relies heavily on involving an interested and informed citizenry in the planning and design of a desired future. A strong emphasis is placed on early communication, education, and participation. Community meetings are held to provide the public with maps showing examples of how the landscape will look under the different scenarios. Maps are used to compare different scenarios which reflect various policy and regulatory choices (ranging from more to less stringent protections). The sensitivity of the landscape to disturbances that would result from each scenario is evaluated carefully. Visually comparing the impacts of these scenarios provides an exceptional tool for helping the public to better understand what is at stake and thus make more informed land-use choices about their community's future.

When the preferred option is selected, the result is likely to be a land-use plan based on both protection of the environment and the identified needs of the community. As with Green Infrastructure planning, it is most likely to be both fiscally and environmentally sustainable. It represents the most informed choice, therefore, making it a "smarter growth" alternative.

6.4.4.1 Determining the Scope of the Analysis

The analysis, which is the hallmark of Alternative Futures, involves a broad, logic-driven process that incorporates the specific needs of a local community while evaluating land-use scenarios for their ability to retain long-term environmental and economic vitality. It begins with assessing the current condition of the landscape and land uses.

The community, with the technical assistance of supporting agencies, develops the scope of the analysis: size of the planning unit to be analyzed, scale of the effort, functions and issues that are of interest, the approach, method, and metrics used in the analysis, and the capabilities of the local government.

Size of the Planning Unit

The size of the landscape planning unit to be analyzed may be as large as a regional, terrestrial ecosystem (such as the Puget Lowlands), a large drainage basin (like the Snohomish River) or as small as a local sub-basin. The unit may cross several political boundaries or only encompass a limited portion of one jurisdiction. It may cover many miles and acres or only a few.

Scale of the Effort

The scale of the effort refers to whether the analysis will be designed to provide information for broader strategies and visions or for a more focused effort. This decision affects the type of scientific method(s) chosen and the level of detail that will be used to conduct the analysis. Generally, the analysis for broader strategies or visions involves larger geographic areas, and less detailed (more general) methods are appropriate. By contrast, a more focused planning effort might involve a sub-basin, for example, and require methods that result in more detailed information that is focused on spatially explicit, management options and recommendations. With this information, specific on-the-ground actions, or consequences, can be clearly evaluated.

Functions and Issues of Interest

Analyzing the landscape is the best approach to understand landscape processes and ecosystem functions at work across the planning unit and to examine ecological issues of concern. Therefore, the analysis may need to broadly cover a suite of functions and/or issues, or it may need to focus on specific areas of greatest concern. The community may decide the analysis should focus on current problems or problems that may result from future land uses. For example, the community may select flooding, water quality, habitat and biodiversity, or groundwater recharge as the issues/functions they believe should be examined in the analysis.

Approach, Method, and Metrics

Selecting the approach for conducting the Alternative Futures analysis will follow the previous decisions. Approaches that are "geospatial" must be compatible with the size of the planning unit, the scope of the process, and the scale of the effort. Geospatial refers to the geographic location and characteristics of natural or constructed features and boundaries on the Earth. Generally, geospatial approaches are used to simulate the effects of land-use change on landscape processes and ecosystems.

There are two geospatial approaches that can be used in an Alternative Futures analysis depending on the local community's particular needs:

- **Forecasting**. The common approach is to apply models that evaluate the impacts and environmental outcomes expected under several different development scenarios. Here each policy option is simulated in the model to predict the appearance and environmental performance of the future landscape, resulting from that policy choice.

- **Backcasting.** Alternatively, a concept called "backcasting" can be applied to develop future scenarios aimed at achieving certain desired end-points (Robertson 2003). In this approach, the future landscape condition is selected first. Then analysis and modeling are focused on effectively finding development policies that will successfully achieve that pre-chosen outcome. This is a very effective approach for holding the line in places where further degradation will collapse an entire ecosystem, leaving the community's economic vitality in crisis.

Method for Analyzing the Landscape

Before selecting the approach to use for an Alternative Futures analysis, a good starting point, as previously mentioned, is analyzing the landscape. Appendix 5-B lists some methods that can be used to analyze the landscape and one of the methods is being developed by the Department of Ecology (www.ecy.wa.gov/programs/sea/landscape). It provides a geomorphic examination of landscape processes in a defined area using a Geographic Information System (GIS). It is designed to be used in planning and can provide information at more than one geographic scale. For example, it can be used for larger planning units to provide a broad understanding of the processes at work in the landscape and to identify regional issues of concern such as water quality problems. It can also be used within smaller areas of interest or concern to conduct more refined analyses.

Products of Ecology's method for landscape analysis include characterizations of past, current, and potential environmental conditions. The analysis can identify problem areas that are of concern and relate them to the existing landscape processes and the ecological functions in the area. Examples include beaches with shellfish beds that have been closed, areas with poor water quality, habitat areas that need to be restored, etc. The analysis can be used to develop proactive strategies to avoid future impacts of development.

Assessment Metrics

Along with the landscape analysis method, equally important in the Alternative Futures analysis is the use of appropriate assessment metrics or measures: environmental indicators of condition, stress, or response within an ecosystem that can be used in a predictive manner. Metrics are usually selected based on a significant statistical correlation with scientific data linking environmental stresses to a predictable environmental response (e.g., a correlation between impervious surface and the condition

of aquatic habitats). Assessment metrics are often calibrated to better reflect local conditions within the specific area in which they will be applied. Several metrics are typically used in order to ensure the reliability of the analysis. The selection and use of such assessment metrics is an important and key component of evaluating alternative land-use scenarios.

Current research in the Pacific Northwest, and Puget Sound specifically, is building our understanding of some of the key stresses that affect landscape processes throughout the region and within particular local areas. Local researchers (e.g., Alberti et al. 2003), using geospatial techniques, are investigating and developing various assessment metrics essential to retaining watershed condition such as amounts of impervious surfaces, road density, number of stream crossings, and riparian and floodplain connectivity. These measures are being offered to practitioners for pilot testing and application.

When using these metrics, communities can expect to identify, for example, what percentage of cover from relatively undisturbed vegetation is needed to prevent problems within watersheds. Another example is what percentage of connectivity between habitats will assure that existing habitats remain viable. This information is directly used in the comparison of different land-use scenarios, for choosing the preferred alternative, and for implementation of the preventative or corrective actions that follow.

Local Government Capacity

It is important to recognize that the scientific rigor of the analysis and the success of the planning process may be dependent on a number of local factors such as:

- Type, extent, and reliability of natural resource data currently available in the landscape planning area
- Skills of existing staff in regard to conducting an Alternative Futures analysis, especially GIS applications
- Adequate funding to employ the assistance of consultants if needed
- Time needed to complete the steps of the analysis and planning process
- Ability to engage the public and coordinate the effort

Given all these factors, how an Alternative Futures process is conducted (both analysis and planning) will vary widely between jurisdictions and planning units. The value of conducting an Alternative Futures analysis, however, remains. It can provide important information such as the longer-term environmental costs and benefits of various development scenarios, thereby pointing out possible solutions and misperceptions. The result may be the achievement of multiple goals: protecting valued natural resources, maintaining or improving community quality of life, retaining economic vitality, and saving tax dollars. (See Section 6.5 for a discussion of fiscal benefits.)

6.4.4.2 Local Example of Alternative Futures Planning

In January 2001, the Kitsap County Department of Natural Resources used the Alternative Futures process to examine different scenarios in the Chico Creek watershed. The Chico Creek watershed drains 16.3 square miles of land west of Dyes Inlet in Kitsap County. Their goal was to develop an amendment to the County's comprehensive plan for this subarea. Locally referred to as "Planning by Watershed," the pilot Alternative Futures project was funded by the U.S. Environmental Protection Agency under a grant to the Puget Sound Action Team. Information regarding the details of the project can be found at: www.psat.wa.gov/Programs/growth/LID_futures.htm.

The County found the Alternative Futures approach was a unifying process that resulted in the integration of land-use planning with other regional efforts such as watershed planning, salmon recovery, clean water plans, as well as regulatory directives in the Growth Management Act. Using the Alternative Futures process, the county developed their preferred development scenario by:

- Conducting a technical analysis of current conditions in the watershed
- Involving citizens and interested parties in developing and selecting scenarios
- Testing the scenarios using Geographic Information System and scientific analyses
- Making an informed selection of the preferred scenario for future land use

To accomplish these tasks, they established goals for analysis of the watershed, analysis of the scenarios, and the planning process.

A strong component of Kitsap County's approach was public involvement. Five subcommittees were established, including an education work group, a public involvement work group, a technical work group, a restoration work group, and a watershed advisory committee. From these they constructed an effective education campaign and public involvement process.

Four scenarios were examined: 1) the "current regulatory" condition, 2) a "strong development" scenario, 3) a "strong conservation" scenario, and 4) a "moderate" scenario falling between development and conservation. A suite of analyses, using natural resource indicators, was conducted to identify the impacts of each alternative. The strong development scenario was quickly dropped due to the severity of impacts. The current regulatory condition then became the option with the greatest amount of development. In the end, the community selected the moderate development scenario which incorporated conservation-based patterns and practices.

Kitsap County officials were pleased with the benefits of the Chico Creek project and propose using the Alternative Futures process to develop subarea plans for other watersheds throughout the county.

6.4.5 Combining Complimentary Approaches

Landscape analysis, Green Infrastructure, and Alternative Futures are all complementary approaches. Applying the core elements of these three approaches in combination can offer a strong analytical package for making land-use decisions that will benefit communities while considering landscape processes.

Information about the landscape is an essential component of Green Infrastructure and especially Alternative Futures, as described in the preceding sections. In brief, it can be used as a tool to integrate information about different resources into the planning process in order to identify the issues of highest priority and develop alternative land-use scenarios. These scenarios can be analyzed (using GIS) and visually displayed as maps. Ecology's method for landscape analysis (www.ecy.wa.gov/programs/sea/landscape) can be used from a larger scale of analysis down to a smaller scale, thus assessing across scales and focusing in on key issues. Therefore, landscape analysis together with GRIST or Alternative Futures can provide a very useful complement for visually displaying and analyzing the effects of land-use decisions on the maintenance of landscape processes.

Adding the concepts of GRIST planning to Alternative Futures can:

- Reinforce the benefit of using landscape analysis as the basis for planning so that landscape processes can be sustained
- Emphasize the role of landscape processes and the functions of ecosystems such as wetlands as "infrastructure" and therefore worthy of protection for fiscal reasons
- Add hubs and links as corridors important to the maintenance of landscape processes
- Integrate working landscapes (such as agricultural and forest lands) as valued green space into land-use plans

The results of Alternative Futures may be more successfully implemented if combined with GRIST planning because it focuses on implementation using conservation measures and thus it can immediately advance conservation decisions which result from the Alternative Futures process.

Likewise, Alternative Futures compliments GRIST planning by:

- Applying metrics to quantify the impacts of disturbance on the landscape and to evaluate options
- Targeting sensitive features and critical functions which are important to include in a greenprint

6.5 Fiscal Savings and Other Benefits

Protection of landscape processes and the functions of ecosystems, such as wetlands and other critical areas, can provide important fiscal savings as well as other benefits. Many people assume that revenue will be lost as a result of land protection, while the costs of constructing infrastructure, to provide necessary services once green space is gone and landscape processes are degraded, are often overlooked.

Several recent papers have documented the costs associated with losing ecosystems that provide landscape processes and wetland functions. In *Taking its Toll: The Hidden Costs of Sprawl in Washington State*, Mazza and Fodor (2000) point to water quality and quantity impacts, smog and health issues, habitat and species losses, overall watershed decline, and general quality of life concerns. All of these losses can affect the economic viability of communities.

A report by the Trust for Public Land and The National Association of County Officials (2002) presents the numerous benefits of recognizing certain lands as necessities, not just amenities. The benefits include:

- Fiscal savings, which result when the benefits gained from preserving open space exceed the cost
- Economic benefits, when improved quality of life attracts business investment
- Free infrastructure, when green space provides services that avoid the expense of building infrastructure to replace functions, thus saving tax-payers' money
- Environmental benefits, when land-use planning is linked to the protection of landscape processes
- Health and social amenities, when, for example, recreation opportunities deter antisocial behavior by providing constructive activities, thereby contributing to the health and wellness of communities

The following paragraphs discuss and provide examples of three general types of fiscal savings resulting from protection of landscape processes through the planning processes described in this chapter.

6.5.1 Using Green Infrastructure Instead of Constructing Infrastructure

As demonstrated in the examples that follow, communities around the country that conduct a fiscal analysis of their revenues versus expenditures are finding that conservation of green infrastructure saves money in the long term. Purchasing and preserving land results in cost savings by avoiding the need to build infrastructure such as systems for controlling flood water when landscape processes and the functions of ecosytems are lost.

When New York City was faced with the need to spend $8 billion on new water filtration and treatment plants, they instead purchased 80,000 acres of land in the Catskill Mountains for $1.5 billion. The land functions to filter and purify drinking water. Purchasing the land (which is located in the watershed for the city) saved the city $6.5 billion by not building treatment plants and another $300 million a year in forgone costs of operating them.

In the Charles River Basin in Massachusetts, 8,500 acres of wetlands were acquired and preserved to provide storage for floodwater in the valley. The cost for acquisition was $10 million compared to the $100 million cost of an alternative proposal which would have resulted in the construction of dams and levees to accomplish the same goal (Fausold & Lilieholm, 1996).

The value of the tree canopy was illustrated in the Willamette/Lower Columbia region here in the Pacific Northwest. In a 7-million-acre area, the tree canopy has been reduced from 46% to 24% between 1972 and 2000 due to the expansion of roads, buildings, and pavement. This 28-year loss in canopy has resulted in $2.4 billion in costs for managing the increased stormwater runoff, according to a Regional Ecosystem Analysis by American Forests (2001). In addition, each year the lost canopy of trees would have absorbed 138 million pounds of pollutants and saved $322 million in related cleanup costs.

Despite the significant loss in tree canopy, the remaining forest continues to provide functions related to stormwater and water quality. According to the study, the region's remaining trees are still detaining and purifying a massive quantity of stormwater that would have otherwise required construction of a $20.2 billion treatment plant to manage runoff. The trees also absorb 178 million pounds of pollutants on an annual basis, whose potential cleanup would cost $419 million a year.

6.5.2 Increase in the Local Tax Base

Protecting areas that provide landscape processes can increase the tax base by attracting home buyers to properties near green spaces such as wetlands, thereby improving the homeowner's quality of life. This is called "enhancement value," the tendency of open space to enhance the property value of adjacent properties

Quality of life is a determining factor in real estate values and economic vitality. The green spaces of Portland, Oregon, for example, have helped build this city's reputation as one of the country's "most livable cities." A study in Portland found that residential property values increased, $436 for every $1000 feet, if they were in closer proximity to a wetland (Barclay et al. 2004). "The real estate market consistently demonstrates that many people are willing to pay a larger amount for property located close to parks and open space areas than for a home that does not offer this amenity," writes John L. Crompton, a professor at Texas A&M University (Sherer 2003).

The higher value of these homes means that their owners are paying higher property taxes, thereby benefiting the community as a whole. In some instances, the additional property taxes are sufficient to pay the annual charges on bonds used to finance the

acquisition and development of open spaces. This has been demonstrated in a study examining the proximity of residences to greenbelts in Boulder, Colorado. Here the average values of homes next to the greenbelt were 32% higher than those just 3,200 feet away. The study showed that the greenbelt added $5.4 million to the total property values of one neighborhood, generating $500,000 per year in additional property taxes. This was enough to cover the $1.5 million purchase price of the greenbelt in only 3 years (Sherer 2003).

Home owners can get tax relief to off-set an increase in property values and taxes if conservation easements are involved. Federal income tax law (U.S. Treasury Regulation Sec. 14 (h)(3)(i)) states that valuation of conservation easements is required to take into account the resulting increase in adjacent property value on land owned by the same donor.

The ability to attract business to a community is also affected by the presence of open space and the health of the environment. Barclay et al. (2004) have noted that environmental quality plays a pivotal role in the ability of a region to attract workers and new firms. They state that a community with a degraded environment is more likely to suffer economically.

It is important to note that the value of natural resources is not fixed in time: The values of many of the landscape processes and the functions of natural resources are growing as they become increasingly scarce.

6.5.3 Reducing Costs of Public Services

The cost of providing public services (roads, fire & police protection, etc.) to a community is less in areas with open spaces. A national study by the American Farmland Trust (cited in Mazza and Fodor 2000) showed that for every $1 generated in tax revenue, the median cost to provide services to residential areas was $1.15, while only $0.37 was spent in areas with agricultural or natural resource lands. The Trust conducted a similar study in Skagit County and found that infrastructure costs for residential services were $1.32 for each dollar of tax revenue as compared to $0.32 for farm, forest, and open space lands.

In addition, the tax base generated by new homes does not cover the actual cost of providing the basic services required. A study in Washington showed that the added expense of off-site facilities (such as schools) that would provide services to a typical new home is $20,000 to $30,000, which does not match the tax revenue generated to cover these costs (Mazza and Fodor 2000). Additional information on this topic can be found in a paper on the *Three Myths of Growth* (Fodor 1996), which debunks the belief that growth builds a tax base that provides enough revenues to cover the necessary services.

Developing land using the guidance of a GRIST plan may result in lower property and school taxes. For example, the town of Pittsford, New York, commissioned Behan Planning Associates to apply a fiscal model to determine the costs of expanded urban development versus the costs of land protection. The fiscal model predicted future tax

rates based upon the costs and revenues associated with future land-use patterns. The model estimated that, for the average tax payer, property and school taxes would increase only $1400 over 20 years using the "green infrastructure" scenario, in comparison to $5000 if the lands were fully developed under their existing policies. This analysis revealed that it would be much less expensive to implement the greenprint than allow development in the wrong locations (Trust for Public Land and National Association of County Officials 2002).

Additional resources

Many resources are available for local governments that wish to pursue Smart Growth, Green Infrastructure, Alternative Futures, and associated concepts discussed in this chapter. For further information, see the published and online resources listed in Appendix 6-A.

Chapter 7

Prescribing Solutions: Comprehensive Plans

7.1 Introduction

This chapter builds on the discussion in Chapter 6 about planning approaches that can be used to develop or update a comprehensive plan. The planning tools discussed in Chapter 6, such as Green Infrastructure and Alternative Futures, allow jurisdictions to use the data generated from a landscape analysis to create a vision of the future, integrating landscape-scale issues with the community's priorities regarding land uses.

Developing or updating a comprehensive plan, and the other planning approaches discussed in Chapter 6, are all part of Step 2 (Prescribing Solutions) in the four-step framework discussed in this volume (Figure 7-1). The tools for landscape analysis described in Step 1 (Chapter 5) can provide information to help guide the development or revision of a comprehensive plan, shoreline master program, or other planning effort. Regulatory and non-regulatory solutions, discussed later in Chapters 8 and 9, are also part of Step 2 and can be used to implement plans and policies.

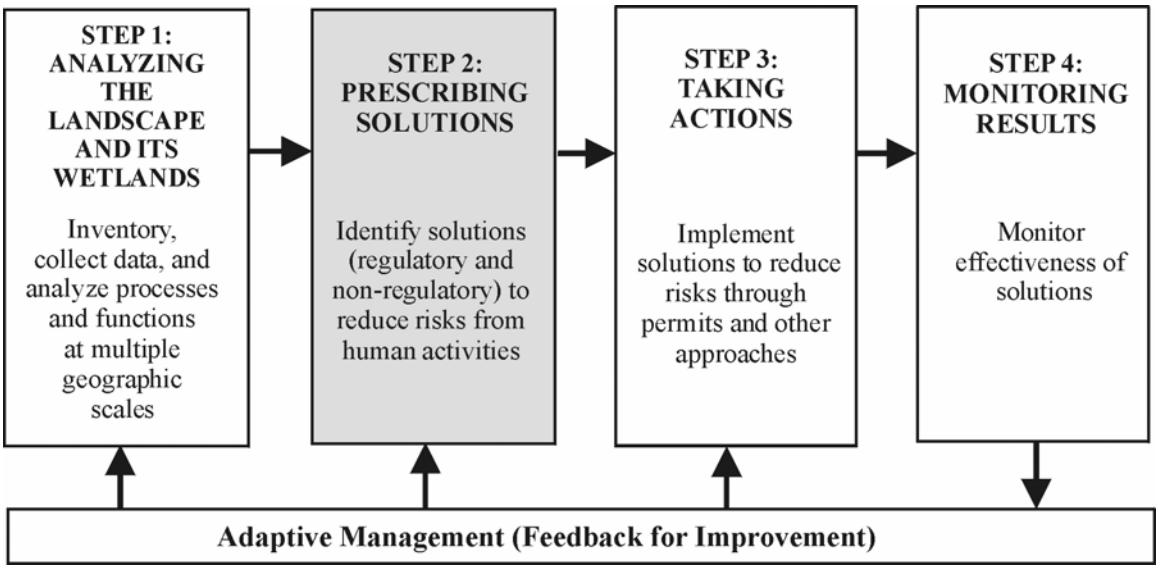


Figure 7-1. Comprehensive planning is part of Step 2 in the four-step framework recommended for protecting and managing wetlands (shaded box).

By integrating landscape analysis and public involvement into the planning process, effective policies and regulations can be developed that reflect choices about land use that will protect, maintain, and restore landscape processes. Therefore, the results of landscape analysis should be incorporated into the goals and policies of the relevant mandatory and/or optional elements included within comprehensive plans. Because comprehensive plan goals and policies establish the basis for much of the regulatory language and codes, such as zoning, developed by a jurisdiction, the information in a comprehensive plan should reflect what is needed to maintain landscape processes and protect wetland functions and values.

Doing a landscape analysis is not a recommendation to implement an entirely new process. Aspects of a landscape analysis, as described in this volume, are already a required part of developing or amending/updating a comprehensive plan. The reader is referred to Chapter 6 for a thorough discussion of the importance of using information generated by a landscape analysis to inform planning, including comprehensive planning.

Although it is important to use information that includes data from the scale of the contributing landscape, comprehensive planning is conducted at the scale of the management area. The management area is restricted to the lands over which a jurisdiction has authority, because the boundaries for planning are political, not driven by the environmental processes at a landscape scale. This chapter provides a brief overview of comprehensive planning (Section 7.2), followed by a discussion of the mandatory and optional elements, including subarea plans, of comprehensive plans as established by the Growth Management Act (GMA) (Sections 7.3 and 7.4). The chapter includes examples of how typical language in a comprehensive plan can be modified to incorporate landscape analysis. It also discusses how subarea plans can be used by jurisdictions that would like to incorporate landscape information within a smaller planning area.

7.2 An Overview of Comprehensive Planning

As discussed in detail in Chapter 2, and summarized briefly in the introduction of Chapter 6, the GMA dictates that counties and cities that meet certain provisions must plan for future growth (RCW 36.70A.040). They must develop comprehensive plans and development regulations, including critical areas ordinances, to meet the intent and requirements of the GMA (RCW 36.70A.020). Comprehensive plans and regulations are subject to continuing review and evaluation by the county or city that adopted them. The GMA also requires local jurisdictions to include best available science in the development of policies and development regulations used to protect the functions and values of critical areas, including wetlands (RCW 36.70A.172).

The key GMA requirements are as follows:

- Identify and protect critical areas and resource lands
- Designate county-wide planning policies and urban growth areas (for counties and cities fully planning under the GMA)
- Prepare and adopt comprehensive plans
- Adopt development regulations to implement the comprehensive plan
- Evaluate and update the comprehensive plan and development regulations

Comprehensive planning, as the name implies, is a planning process that encompasses all the activities that occur or may occur on the land over which a local government has jurisdiction. Typically, a comprehensive plan consists of a "map or maps and descriptive text covering objectives, principles and standards" used for its development (RCW 36.70A.070). A comprehensive plan is a document that provides direction for decisions about land use in a local jurisdiction. As described in the introduction to the Spokane County Comprehensive Plan (http://www.spokanecounty.org/BP/Documents/CompPlan/Chapter1.pdf):

> *The Comprehensive Plan is a set of goals, policies, maps, illustrations and implementation strategies that states how the County should grow physically, socially, and economically. The plan emphasizes innovative and flexible strategies to guide growth and development. One of the central themes of the Plan is the promotion of economic development that occurs in harmony with environmental protection and preservation of natural resources. The Plan recognizes the interests of the entire community and promotes cultural and ethnic diversity.*
>
> *The Comprehensive Plan establishes a pattern of land uses to shape the future in desirable ways...*

A comprehensive plan is composed of elements that address typical issues for a jurisdiction. Elements such as transportation and capital facilities (e.g., domestic water sources, sewage treatment, essential public facilities, and stormwater facilities) are incorporated into the planning process to ensure that adequate infrastructure is provided for existing and future land uses. In addition, there are elements that address the protection of natural resources, such as agricultural areas, and critical areas such as wetlands, geologic hazard zones, and fish and wildlife habitat.

Under the GMA, comprehensive plans must contain the following elements:

- Land Use Element
- Transportation Element
- Housing Element

- Capital Facilities Element
- Utilities Element
- Shorelines Element
- Rural Lands Element (for counties)

Also, if state funding is provided, Economic Development and Parks and Recreation Elements are required to be included in plans.

Optional elements may also be included in comprehensive plans, such as conservation, energy, recreation, and subarea plans, where appropriate. Some jurisdictions include additional elements that consider the environment. For example, Skagit County includes an Environment Element that specifically focuses on the influences of wetlands, streams, wildlife habitat, and other environmental factors on planning and land use, whereas Yakima County includes a Natural Setting Element. Overall, the plan "shall be internally consistent and all elements shall be consistent with the future lands use map" (RCW 36.70A.070) and shall be coordinated with the comprehensive plans of jurisdictions with common borders or related regional issues (RCW 36.70A.100).

The Legislature also set forth goals to guide the development of comprehensive plans. Application of a landscape analysis and principles for low impact development would assist in meeting the following of those goals:

- Encouraging development in existing urban areas
- Reducing sprawl
- Ensuring that adequate public facilities are in place for new development
- Retaining, enhancing, and conserving open space, recreation, and habitat areas
- Protecting the environment and enhancing water and air quality and availability of water
- Meeting the goals and policies of the Washington State Shoreline Management Act as set forth in RCW 90.58.020
- Encouraging economic development that is within the capacity of the state's existing natural resources

The Legislature also directed local governments to include innovative techniques for land-use management in their comprehensive plans, including density bonuses, cluster housing, planned unit developments, and transfer of development rights (RCW 36.70A.090). Landscape analysis and principles of low impact development would also assist local governments in meeting this provision.

7.2.1 County-wide Plans and Policies

The GMA establishes counties as the primary units for regional land-use planning. An important aspect of planning under the GMA is the requirement for counties to adopt planning policies that are county-wide under RCW 36.70A.210. County-wide planning policies are adopted in consultation with the municipalities in the county, to support and guide cross-jurisdictional cooperation between the county and the municipalities located within it.

At a minimum, a county-wide planning policy needs to address the development of urban growth areas, joint planning for these areas, siting public capital facilities of a county-wide or state-wide nature (such as transportation facilities), providing for affordable housing, economic development and employment, and analyzing the fiscal impact of the policies. The county-wide policies are binding on state agencies. Large urbanizing counties (those with population greater than 450,000 people) adjacent to each other are required to adopt multi-county planning policies.

Plans and policies for critical areas may need to be amended to create the basis of regulations that include best available science across jurisdictions. Because critical areas such as wetlands and the landscape processes that support them often span multiple jurisdictions, local governments should consider whether their current policies and regulations are consistent with the programs of neighboring jurisdictions. Jurisdictions should not, however, reduce regulatory protections for critical areas as the sole basis for achieving consistency across jurisdictions.

In fact, managing natural resources at the larger geographic scales of contributing landscapes or watersheds has become recognized internationally as an important approach to protecting aquatic resources, including wetlands (United Nations 1997). While planning at this scale may be beyond the purview of comprehensive planning for some local jurisdictions, it is possible for local jurisdictions to join existing programs to develop plans and actions at larger geographic scales. Examples of regional planning efforts being conducted by state and federal agencies related to aquatic resources are described in Appendix 7-A.

7.2.2 Tools for Implementing Comprehensive Plans

The policies of comprehensive plans can be implemented through a variety of means. The most common and effective approach is to include policies in development regulations adopted through ordinance that then become mandatory. In some jurisdictions, policy language can be implemented through provisions of the State Environmental Policy Act. However, policy language is often viewed as more discretionary than development regulations that are adopted.

Under the provisions of the GMA, development regulations have to be consistent with the comprehensive plan that the jurisdiction has adopted. This is one of the key provisions of the GMA related to comprehensive plans and regulations: Ensure consistency between

plans, policies, and regulations, and provide coordination between contiguous jurisdictions.

The policies, goals, and values identified in the comprehensive plan are implemented through these regulations. Regulations are adopted through ordinances to prescribe general and permanent rules. In conflicts concerning development activity, the development regulations are the primary means for resolving disputes and carry more legal weight than the comprehensive plan policies. Regulatory tools are discussed in Chapter 8.

A comprehensive plan can also be implemented through non-regulatory tools, as discussed in Chapter 9 of this document.

7.3 Mandatory Elements of Comprehensive Plans

Under the GMA, comprehensive plans must contain certain mandatory elements. Many of the mandatory elements of a comprehensive plan (RCW 36.70A.070) can incorporate the results of a landscape analysis and the Smart Growth planning processes described in Chapters 5 and 6. The mandatory elements that are the most applicable to wetlands protection and management include:

- Land Use Element
- Capital Facilities Plan Element
- Rural Lands Element (for counties)
- Transportation Element

Optional plan elements, especially conservation plans and subarea plans, may also be important in order to create an effective program to protect and manage natural resources that minimize cumulative impacts. These optional elements are discussed in greater detail in Section 7.4.

Each of the mandatory elements that can most appropriately be used for protecting and managing the landscape processes that maintain wetlands and their functions are described below. Examples of text for policies that incorporate landscape analysis are provided for each element.

7.3.1 Land Use Element

The Land Use Element is the heart of the comprehensive plan. It determines the "proposed general distribution and general location and extent of the uses of land" including population densities, building intensities, and future population growth estimates (RCW 36.70A.070).

The tone of the Land Use Element is set by the text of the Introduction and Framework, which identify key guiding values and the priorities of the community. For example, as noted in the opening paragraphs of the City of Cheney Land Use Element (http://cityofcheney.org/planning/comp_plan/comp_plan7.pdf):

> *The Land Use Element of Cheney's Comprehensive Plan is central to the entire planning process. The land use patterns are what determine the character of the community and dictate the types and locations of future development. This element of the plan determines the traffic patterns and the ability or inability to effectively alter those patterns over time. It can be sensitive or insensitive to the natural and physical characteristics existing within a community and, overall, it is the primary element which will determine the quality of life for the citizens of Cheney.*

In Skagit County, the Land Use Element focuses almost exclusively on human uses of the land in current and future conditions. The County's Land Use Element assesses the condition, location, and distribution of existing land uses and identifies the appropriate intensity and density of land uses for the future based on development trends in the county and surrounding areas. The Land Use Element includes guidance for the development of commercial and industrial land uses as well as residential, agricultural, and other uses.

In some comprehensive plans, the Land Use Element begins by describing in some detail the natural history and ecological conditions of the landscape within the jurisdiction. This information is then used to plan land use on the landscape. The City of Bainbridge Island, for example, uses this approach to establish a "sense of place" before designating land use types. Other comprehensive plans do not include an extensive natural history section, but limit their descriptions to the existing and proposed land uses within the jurisdiction.

The Land Use Element must specifically provide for the protection of groundwater that is used for potable water. Also, where applicable, the Land Use Element must review drainage, flooding, and stormwater runoff and provide guidance for corrective actions to mitigate or cleanse those discharges that pollute waters of the state.

Most comprehensive plans state one or more "goals" which are vision statements that attempt to identify the priorities and values of the community. Following the goals may be a series of one or more "policies" related specifically to each identified goal. Sometimes the policies overlap or are even repeated from one goal statement to the next or from one element of the comprehensive plan to another.

7.3.1.1 Incorporating Landscape Analysis into the Land Use Element

Logically, landscape data, or any environmental information, should be collected and analyzed prior to drafting the Land Use Element of the comprehensive plan. The analysis outlined in Chapter 5 identifies landscape processes as well as wetlands and their

functions. It identifies which areas need special management because they provide important processes, such as groundwater recharge and how wetlands function and contribute to the larger landscape processes. This type of analysis can also identify areas that, if restored or preserved, could improve functions and reduce cumulative impacts that cannot be avoided.

The Land Use Element can identify:

- The location and type/intensity of development consistent with protecting critical resources
- Areas critical to maintaining processes that support wetlands (e.g., infiltration and recharge areas, areas of critical subsurface and surface flow, discharge areas, areas of potentially high runoff)
- Areas that require restoration of landscape processes
- Areas that require protection (i.e., no development) in order to maintain critical landscape processes

The results of the landscape analysis described in Chapter 5 and additional planning approaches, such as Green Infrastructure or Alternative Futures analysis discussed in Chapter 6, can be used to guide the choices of land-use designations within a jurisdiction. Conducting a landscape analysis identifies critical locations within the management area where key landscape processes or wetland functions are provided. Integrating that information into a Green Infrastructure plan or an Alternatives Futures analysis allows the community to make informed decisions about land use that incorporate both human needs and environmental considerations at many geographic scales. The resulting land use choices, priorities, and goals can then be included in the policies of the Land Use Element. Such an approach can help ensure long-term maintenance of landscape processes and reduce the deficiencies of case-by-case permitting decisions.

7.3.1.2 Using Landscape Analysis in Different Sections of the Land Use Element

The policies in the Land Use Element provide the foundation for developing subsequent elements of the comprehensive plan, other plans, and regulations, and non-regulatory components of programs. The Land Use Element of a comprehensive plan may typically be divided into Overviews, Goals, and Policies. The shaded box on the next two pages provides an example of the Table of Contents of a typical Land Use Element (the example is modified from a draft of the City of Bainbridge Island's Land Use Element). The major sections of a Land Use Element are then discussed in detail following the shaded box. For specific portions of the Land Use Element, modifications are suggested regarding where to incorporate landscape analysis. Explanatory text and policies for the relevant portions and, in some cases, examples of text that could be used directly are provided.

Sample Table of Contents for a Land Use Element

Introduction

Framework of the Plan

Overview of Existing Conditions – Natural Environment

Note: This section describes the biological, physical, and geographic conditions of the jurisdiction. The same combination of data can be used in the landscape analysis (described in Chapter 5) to establish baseline conditions. The results of the landscape analysis would be woven through each of these sections, identifying the physical and biological linkages and areas that are critical for maintaining landscape processes and wetland functions.

Geography

Climate

Geologically Hazardous Areas

Watersheds

Wetlands

Streams

Groundwater

Aquifer Recharge Areas

Fish and Wildlife

Overview of Existing Conditions – Built Environment

Note: This section describes the human-made conditions and land uses currently present in the jurisdiction.

Residential Development

Commercial Development

Overview of Existing Conditions – Resource Lands

Note: This section describes the resources that humans use for economic purposes.

Agriculture

Forest Land

Mining

Goal and Policies/Principles of the Built Environment

Note: This section outlines the overriding intent and values of the jurisdiction for the built environment. Each subsection below contains the policies or principles that create the framework on which subsequent community plans and/or regulations are developed.

Framework of the Plan

General Land Use

Neighborhood Service Centers

Light Manufacturing

Residential Open Space

Environment

Sample Table of Contents for a Land Use Element (continued)

Goals and Policies/Principles of the Natural Environment

Note: This section outlines the intent and values of the jurisdiction for the natural environment.

- Fish and Wildlife Policies
- Aquatic Resources
- Frequently Flooded Areas
- Geologically Hazardous Areas
- Atmospheric Conditions
- Greenways

Goals and Policies/Principles of Natural Resource Lands

Note: This section outlines the intent and values of the jurisdiction for managed natural resource lands.

- Agricultural Lands
- Forest Lands
- Mining

The **Introduction** to the Land Use Element provides an overview of the Land Use Element and how information was obtained. If landscape analysis, or other environmental data, Green Infrastructure planning, or Alternative Futures analysis are incorporated, there should be a brief description of the methods used to generate the information.

The **Overview of Existing Conditions - Natural Environment** is where the results of a landscape analysis can be presented. It can also be where the criteria for establishing priorities for proposed land uses are described. The existing condition and the criteria for priorities set the stage for the future and would benefit from incorporating information about natural resources at all geographic scales. This would also be the location to describe the findings of Green Infrastructure planning or Alternative Futures analysis (discussed in Chapter 6), particularly in reference to establishing priorities. In this section it would be reasonable to present the conclusions from any public process used to create criteria or priorities for land use designations, as well as recommendations for preservation or restoration.

The **Overview of Existing Conditions - Built Environment** provides a summary of the relevant conditions of the developed lands within the jurisdiction. The character and extent of housing and lands zoned for various levels of residential use are described and contrasted with expected demands. Depending upon the jurisdiction, the section may contain descriptions of commercial and industrial lands, infrastructure (e.g., domestic water and public sanitary sewer systems), and transportation in sufficient detail on which to base the planning process. The overview of infrastructure and capital facilities is usually brief to illustrate existing conditions; detailed discussions are contained in the appropriate elements of the comprehensive plan. This section may include a description

and discussion of existing housing stock and residential zoning designations. If the results of a Green Infrastructure planning or Alternative Futures analysis include recommendations or criteria for housing considerations, this is the location for those findings.

The **Overview of Existing Conditions - Resource Lands** focuses on lands used for commodities: agricultural lands, commercial timberlands, and mining and mineral extraction. Depending upon the jurisdiction, the overview may or may not describe lands zoned for commercial resource use. The results of Green Infrastructure planning or Alternative Futures analysis may identify some of these lands as critical hubs or links from the perspective of maintaining or restoring landscape processes. It is appropriate to discuss those findings in this section.

The next sections of the Land Use Element present examples of policies for the Natural Environment, Built Environment, and Resource Lands. Polices are statements that guide more detailed planning documents conducted at a management scale, such as community plans, basin plans, or neighborhood plans, as well as Green Infrastructure or Alternative Futures plans. These policies also form the basis for a jurisdiction's regulations. The policies must reflect the priorities for the jurisdiction. The policies should reflect the findings of a landscape analysis (or any environmental analysis) and the priorities of the community.

7.3.1.3 Landscape Analysis in the Policy Language of the Land Use Element

Policies can be modified to reflect the need for analyzing and protecting landscape processes that are necessary for the long-term protection of wetlands and the functions they provide. Specifically, a statement in the Introduction or opening section of the Land Use Element can provide the foundation for subsequent policies and regulations.

A policy statement can be created that directs the jurisdiction to use landscape analysis to identify lands that are critical to maintaining landscape processes, then to use this information in determining land use designations. Example policy statements include:

- A landscape analysis shall be conducted for each [subarea/planning area/sub-basin] to identify lands that are critical for the maintenance or restoration of the landscape processes that maintain wetland functions and minimize cumulative impacts

- Green Infrastructure planning or an Alternative Futures analysis will be conducted within each [subarea/planning area/sub-basin] to establish criteria and set priorities for land-use designations and protection of the landscape processes that maintain wetland functions

Below are two examples of typical policy statements that have been modified to include landscape analysis (new language is shown in *italics* and deleted words are indicated by ~~strikethrough~~):

- ~~Identified~~ Critical areas, *critical habitats,* shorelands, aquatic resource areas and natural resource lands *identified through a landscape analysis* shall be protected by restricting conversion *or rezoning to a buildable designation*; encroachment by incompatible uses shall be prevented by maintenance of adequate buffering between conflicting uses *and habitat function shall be maintained by establishing connective linkages between critical habitats identified in the landscape analysis*

- Open space corridors within and between urban growth areas shall be identified *based on the landscape analysis of critical habitats and linkages*; these areas shall include lands useful for recreation, fish and wildlife habitat *including corridors for movement between habitats,* trails, and connection of critical areas *to essential habitats to avoid future fragmentation*

Many existing policies in typical planning documents already include language that suggests identification and protection of environmentally sensitive lands. Examples of policy language that could be used to revise the Land Use Element of a comprehensive plan follow. These are only examples; there are many ways that the intent of these examples can be incorporated into a Land Use Element.

General Land Use

General Land Use goals and policies provide more detailed guiding principles for overall land use within a jurisdiction. The general goals for land use listed below have been revised (new text is in *italics*) to show that little modification may be required to incorporate protection of landscape processes and wetland functions based on the results of landscape analysis.

- Support land-use development patterns which protect public, health, safety and welfare, *and the long-term protection of the environmental processes at all geographic scales that support the functions of critical areas, including wetlands*

- Encourage dedication of open space *that is identified as critical for maintaining environmental processes or for providing habitat linkages based on a landscape analysis,* preserve *existing upland forest to the extent feasible,* and encourage the restoration of trees and vegetation to maintain the feel of the community

- Guide future development into concentrated urban growth areas where adequate public facilities, utilities and services can be provided

- *Use appropriate development techniques to minimize impervious surface and maximize infiltration of surface runoff*

- Protect and conserve long-term, commercially viable forest, agricultural, and mineral natural resource lands

- Retain rural landscape features and lifestyles
- Maintain open space, recreation, fish and wildlife habitat, scenic and significant historic archeological cultural lands *by identifying, through a landscape analysis, the critical habitat areas and linkages across the landscape to ensure their protection*
- Enhance the community character, natural beauty, and environmental quality *by ensuring protection of critical areas and linkages through appropriate land-use designations*
- Help preserve rural economies
- Foster opportunities for rural-based employment, self-employment, and economic diversification
- Permit the operation of rural commercial businesses, natural resource related industries, recreation and tourism activities, cottage industries and small-scale businesses, and home occupations that are consistent with existing and planned land use patterns and are of an appropriate size and scale to maintain rural character

Residential Open Space

The Residential Open Space section can be the location for a goal that creates flexibility in lot configurations or density through such mechanisms as transfer of development rights (TDR), discussed in Chapter 9. The following are examples from typical policies for Residential Open Space that have been modified (in *italics* or ~~strikethrough~~) to incorporate landscape analysis:

- Protect open space, *assure the long-term protection of* critical areas *and the environmental processes that sustain them at all geographic scales*, and *assure sustainable* agricultural uses through public and private initiatives, including open space tax incentives, cluster development, planned unit development (PUD), transfer and purchase of development rights, public land acquisition, greenways, conservation easements, landowner compacts, down-zoning, limiting the amount of lot coverage, and other techniques
- *Encourage preservation of key habitat linkages between critical areas, allow* the aggregation of nonconforming lots of record and undeveloped subdivisions and short plats, so as to achieve ~~consistent with goals of the Plan~~, a development pattern that provides affordable housing, preserves open space, protects *critical areas and landscape linkages*, and protects water resources
- *Establish and maintain* vegetated buffers *around critical areas* to preserve the community's rural character *and maintain upland habitat adjacent to aquatic resources; to assure the presence of forest buffers over the long term, require the*

planting of native conifer seedlings within the margins of forested buffers left when adjacent upland forest is cleared for the creation of lot

- New development should be responsive to the natural landscape conditions and should *reflect the results of a landscape analysis* so as to have the least environmental impact on the community's landscape

- *Forested steep slopes,* particularly ridge lines, shall be protected for their visual, aesthetic, *and habitat-linkage* benefits, *including* their functions as wildlife habitat, and *for control of* erosion and *sedimentation*

- A Flexible Lot Design Subdivision process will be created to encourage more creative development *that has the flexibility to reflect site conditions including the results of a landscape analysis.* Flexible lot design *can* integrate use of open space and placement of buildings and infrastructure to reflect site conditions. It will include a cluster zoning requirement in the subdivision process and ensures that the approval process is timely and efficient. The following criteria shall be considered for flexible lot design:

  – Suitable soils for individual, on-site septic systems *or the presence of a community treatment facility*

  – *The findings from the landscape analysis to identify key habitats, and appropriate habitat linkages across the landscape; flexible lot design shall incorporate a perimeter buffer to the development which also provides visual screening of the site from public roadways, and maintains public viewsheds*

  – *Where feasible, grading should be minimized and trees should be maintained as much as possible throughout the project area*

  – Land that is designated as permanent open spaces within Flexible Lot Design Subdivisions shall be used either for recreational, conservation, or *ongoing* agricultural uses; *lands designated for conservation shall not be used for active recreation or initiating agricultural uses;* recreation or agricultural lands shall *be* dedicated to the community, or to a private, non-profit organization

  – Revise the PUD section of the zoning ordinance to provide greater flexibility in design and provide density bonuses for imaginative design, preservation *of identified* environmentally sensitive areas *including aquifer recharge, floodplain, critical wetlands and habitat linkages identified through a landscape analysis*, and include a broad range of housing alternatives

Environment

Within the Environment Element, a variety of goals and policies can be established to implement the intent of the guiding policies. For example, the following three goals are stated in the opening text of the Environment Element of the City of Olympia comprehensive plan (http://www.trpc.org/resources/olycompplan03_ch2_environment.pdf):

- *Long-term economic progress and environmental protection are mutually dependent*

- *Future generations have a right to an environment which has greater environmental assets than today*

- *A healthy environment contributes to the economy no less than do roads and other public services*

Examples of typical Environment policies that have been modified (new text in *italics*) to include recommendations from this volume are:

- Whenever there is *a proposed rezoning* or subdivision of land, the community *shall use the information from a landscape analysis to help assess and* consider the impact of the proposed project on critical areas

- *Identification and prioritization of lands for protection or reduced zoning shall be based on the results of a landscape analysis, or a process like that found in the Green Infrastructure plan*

- The number and design of lots shall be based on minimizing impact to critical areas and protecting natural systems; development shall *incorporate the findings of the landscape analysis during development of the* objectives of the Critical Areas policies rather than maximizing the number of lots; in order to protect critical areas, the full density permitted under the zoning ordinance may not be achieved

- Creative solutions (e.g., flexible lot design, TDRs, and *purchase of development rights* [PDRs]), which may allow the maximum number of lots while protecting critical areas, should be explored

Fish and Wildlife Policies and Aquatic Resources

Policy language for fish and wildlife and aquatic resources may be the easiest to modify. Modifications to typical policy language may simply incorporate the requirement for conducting the landscape analysis, prioritizing lands for protection based on clearly identified criteria, and directing zoning to result in lower impact on high-priority habitats and critical areas. The following are examples of modifications (in *italics* or ~~strikethrough~~) of existing policy language:

- The protection, ~~and~~ enhancement, *or restoration* of wildlife habitat shall be an integral component of the land-use planning process

- The protection, ~~or~~ enhancement, *or restoration* of critical wildlife habitat *and linkages identified through landscape analysis* shall be ~~one of the criteria~~ *a primary criterion* used when evaluating the preservation of open space as part of development techniques, such as clustering, Flexible Lot Design Subdivisions, and creation of TDRs

- Protect critical wildlife habitat and limit fragmentation of habitat that isolates wildlife populations (physically and genetically) by developing an interconnected system of corridors which link critical wildlife habitat *based on a landscape analysis*

- Evaluate wildlife habitat and *linkages based on a landscape analysis, and* develop a classification system which will identify ~~priority~~ habitat to be preserved; the *analysis* shall consider watercourse areas, wetlands, shoreline, riparian areas, tidelands, public open space, forested areas, topography, *aquifer recharge areas, Washington Department of Fish and Wildlife Priority Habitats and Species data,* and intensity of adjacent development

- Structure regulatory processes and permitting decisions so that they reasonably balance natural values with the use of the land *by utilizing a landscape analysis to prioritize lands for protection or special management*

- Collect and analyze information relevant to the function of natural systems *by conducting a landscape analysis as well as collecting information at individual sites*

- Develop a community-wide program to educate the public about alternatives to using and disposing of herbicides, pesticides, and other household chemicals to reduce impacts *to aquatic resources* and other environmentally sensitive areas

- New development, using flexible lot design, should include any *aquatic resources, prioritized habitats and linkages, and regulated buffers* in separate tracts or easements to remain in common ownership

Frequently Flooded Areas and Geologically Hazardous Areas

Through the landscape analysis, frequently flooded areas (FFAs) and geologically hazardous areas can be identified as lands requiring particular zoning limitations in order to protect public health and safety. Policy statements that are "standard" for these types of lands are appropriate to use.

However, FFAs and the processes that occur in these areas such as sediment transport, recruitment of large woody debris, nutrient cycling, and habitat linkages are protected under GMA. *Diehl V. Mason County* (95-2-0073) states, "An FFA designation must be clearly mapped and must include buffers sufficient to protect critical area functions and values." These areas can also function as wetlands and wildlife habitat and provide linkages between landscape processes. Therefore, policy language can be modified to protect the processes and functions of FFAs and geologically hazardous areas, and the wetlands that occur within them, based on landscape analysis.

Natural Resource Lands

Natural resource lands are designated for resource production and may include wetlands and other critical areas, as well as areas in which important landscape processes occur.

Development regulations should require buffers to protect the critical areas within these resource lands.

Typically these areas have already been designated; however, a landscape analysis may identify the linkage between these areas and landscape processes as well as the role that wetlands (and/or restored wetlands) play. For example, protection of shellfish areas is often related to water quality upstream of these resource lands. Wetlands and/or restored wetlands can provide important improvements in water quality. Shellfish growing areas are candidates for designated agricultural lands.

7.3.2 Capital Facilities Plan Element

A Capital Facilities Plan Element includes the analysis and planning for public water, sewer, transportation, and recreation facilities. A jurisdiction has the responsibility to provide water and sewer services, parks and recreation, public safety, transportation facilities such as adequate streets and roads, plus other basic public services and facilities. The Capital Facilities Plan Element includes a requirement to reassess the Land Use Element if funding falls short of meeting existing needs for public services and utilities.

The Capital Facilities Plan Element can address regional water drainage needs, planned parks and recreation facilities, and other capital expenses needed for critical areas protection. Funds to support open space tax assessments, transfers of development rights, conservation easements, and similar needs can be identified in the Capital Facilities Plan Element.

In addition, policies in the Capital Facilities Plan Element can provide guidance on the appropriate conditions and geologic settings in which to use low impact development (LID) practices, referencing such policies in the Land Use Element. The Capital Facilities Plan would state the costs to implement the policies over time, along with alternatives that offer potential cost savings through measures such as LID. LID practices address the control of stormwater and surface water runoff, which is important in protecting wetland hydrology. Traditional and regional stormwater management facilities can also be assessed through the landscape analysis to identify how to minimize adverse impacts of runoff.

Policy language for the Capital Facilities Plan Element in a comprehensive plan can be readily modified to reflect these issues. For example (new language below is in *italics*):

- Designate utility corridors *using landscape analysis to ensure that placement of facilities does not result in permanent impacts to critical areas, their buffers, or habitat linkages*

- Promote the placement of underground utility distribution lines *using information from a landscape analysis to minimize or eliminate permanent or temporary impacts to critical areas*

7.3.3 Rural Lands Element

The Rural Lands Element in county comprehensive plans addresses lands that are not designated for urban growth or lands used for agriculture, forest practices, or mining. It implies lower density land uses with the intention of maintaining the locally defined rural character of unincorporated areas. Measures used to protect and manage rural lands include clustering, density transfer, design guidelines, conservation easements, and other innovative techniques designed to accommodate appropriate rural population densities and land uses.

One of the most significant impacts in rural zones is the increasing tendency to clear residential lots for pastures or viewsheds. The removal of forest cover, as discussed in Chapter 3 of Volume 1, has a significant effect on hydrologic patterns within the contributing landscape. Thus, guidance and policy language within the Rural Lands Element of a comprehensive plan can address site clearing and provide recommendations or requirements for retaining forest cover on lots of certain dimensions.

Typical examples of modified policies for Rural Lands are provided below (new text is in *italics* and deleted words are indicated by ~~strikethrough~~). Note that many of these examples of policies from existing comprehensive plans already incorporate many of the goals in Chapters 5 and 6 of this volume:

- Land use regulations and development standards shall protect and enhance the following components of the Rural Area
  - The natural environment, particularly ~~as evidenced by the health of~~ wildlife and fisheries (especially salmon and trout), *shellfish resources, habitat areas including linkages between habitats as identified as a result of landscape analysis*, aquifers used for potable water, surface water bodies, *wetlands and* natural drainage systems and their riparian corridors
  - Commercial and non-commercial farming, forestry, fisheries *including shellfish aquaculture*, mining, and *home-based and* cottage industries
  - Historic resources, historical character, and continuity including archaeological and cultural sites important to tribes
  - Community small-town atmosphere, safety, and locally-owned small businesses
  - Economically and fiscally healthy rural cities and unincorporated towns and neighborhoods with clearly defined identities compatible with adjacent rural, agricultural, forestry, and mining uses
  - Regionally significant parks, trails, and open space *including corridor linkages identified through landscape analysis*
  - A variety of low-density housing choices compatible with adjacent farming, forestry, mining, *and open spaces,* and not needing urban facilities and services

- The Rural Area designations include areas that are rural in character and meet one or more of the following criteria
  - Opportunities exist for significant commercial or non-commercial farming and forestry (large-scale farms *or more intensive small-scale farms* and forest lands are *usually* designated as Natural Resource Lands)
  - The area will help buffer nearby Natural Resource Lands from conflicting urban uses
  - The area is contiguous to other lands in the Rural Area, Natural Resource Lands, *wetlands, aquifer recharge areas* or *lands identified as critical habitats, habitat linkages or aquatic resources based on a landscape analysis*
  - There are major physical barriers to providing urban services at reasonable cost, or such areas will help define the outer limits for providing urban public services and infrastructure
  - Significant environmental constraints make the area generally unsuitable for intensive urban development

7.3.4 Transportation Element

The Transportation Element is focused on implementing the Land Use Element and addressing intergovernmental coordination of regional transportation facilities and strategies. It is important that the environmental impacts of existing and planned transportation strategies and facilities be addressed in a comprehensive way.

By using the results of a landscape analysis, additions or revisions to existing transportation facilities can be planned to avoid or minimize additional impacts to critical areas and areas that support environmental processes at all geographic scales. Addressing regional transportation issues within the context of landscape information can 1) identify areas that should be avoided, 2) limit habitat fragmentation, and/or 3) facilitate linkages along rights-of-way.

In addition, an Alternative Futures analysis can identify the logical consequences of configuring transportation corridors in various ways. It is possible to anticipate long-range impacts and plan for the compensation for unavoidable effects in advance of the impacts. Jurisdictions can use this approach to identify opportunities to implement Low Impact Development techniques to decrease impervious surfaces by requiring surface parking lots (including retrofits) to be pervious and infiltrate precipitation and water run-off as appropriate to the soil and geology in the area." (For the January 2005 Puget Sound Action Team *Low Impact Development Technical Guidance Manual for Puget Sound* see http://www.psat.wa.gov/Publications/LID_tech_manual05/lid_index.htm.)

One of the requirements for the Transportation Element is financial planning. The Transportation Element has to ensure that, when combined with the Capital Facilities Plan Element, the true costs of planned public works are known in advance of rezoning and commitments to build. This type of analysis can be conducted through an

Alternative Futures assessment, where various costs (economic, community, as well as ecological costs) are determined and compared to help a community make informed choices.

7.3.5 Parks and Recreation Element

This element addresses active parks and recreation opportunities within the community and must be consistent with the Capital Facilities Plan. It may incorporate assessment of the need for organized sports fields, athletic fields, pools, beaches, skateboard parks, etc. It can incorporate passive recreation such as photography or bird watching, as well as other types of recreation such as hiking or mountain biking, or those elements can be contained within a separate Recreation Element.

7.3.6 Economic Development Element

Many jurisdictions are including an Economic Development Element. Some communities are drawing the links between a healthy environment and attracting tourist recreation spending, or building on the "watchable wildlife" program of the Department of Fish and Wildlife.

7.4 Optional Elements of Comprehensive Plans

7.4.1 Conservation Element

As noted in the beginning of this chapter, a jurisdiction may choose to add optional elements to its comprehensive plan that go beyond the mandatory elements, in order to more fully reflect the values and goals of the community. The GMA is open regarding potential elements that can be included as optional.

One optional element that can address the protection of critical areas is a Conservation Element. It can provide an alternative for jurisdictions that are not able to approach all of their comprehensive planning from the foundation of a Green Infrastructure plan or Alternative Futures analysis (discussed in Chapter 6). This can be an element within a comprehensive plan or it can take the form of an independent Conservation Plan. Unlike an Open Space Plan that protects resources through acquisition, the Conservation Element or Plan establishes a method or mechanism to protect and/or restore resource lands through incentives (such as tax credits). Programs such as the U.S. Department of Agriculture's Wetland Reserve Program, the Natural Resources Conservation Service's Conservation Reserve Program, as well as options offered through local land trusts, can also be used in relation to a Conservation Element. Whenever possible, lands to be managed in this way should be identified through landscape analysis or a Green Infrastructure plan.

A Conservation Element is different from the open space approach traditionally used in local planning. The difference is that Open Space Plans typically focus on protecting lands that are valued for aesthetic, recreational, and habitat features primarily through the acquisition of properties by the local parks department. The open space approach can fall short by 1) not including a broader definition of important features worthy of preservation for their contributions to landscape processes, and 2) not including sites that could be restored or enhanced to return processes and improved functions to the landscape.

During the development of a Conservation Element or Plan, sites for both potential acquisition and restoration can be identified. Appropriate sites, such as wetlands in key locations that have a high performance of functions or that support landscape processes, can be located using information generated during landscape analysis. Specific sites can be assessed using tools such as the Washington State wetland rating systems (Hruby 2004 a,b) and the Washington State wetland function assessment methods (Hruby et al. 1999, 2000).

A Conservation Plan should be implemented through both regulatory and non-regulatory components of a program to preserve and restore landscape features identified within the plan. Together, Conservation Plans and non-regulatory components of a program are important additions to comprehensive planning and regulations in providing protection for wetlands and other important landscape features. The tools a local jurisdiction needs to consider using for developing and implementing the non-regulatory component are discussed in Chapter 9.

7.4.1.1 Natural Setting Element Used in Yakima County

Yakima County has a Natural Setting Element that could be considered as part of a Conservation Element or Plan. The text below is taken from Yakima County's Natural Element (http://www.co.yakima.wa.us/planning/pdf/plan2015.pdf). The text has been modified to incorporate the recommendations of this volume (edits are shown in *italics* and ~~strikethrough~~):

- The Natural Setting Element serves ~~two~~ *three* purposes. The first is to clarify the relationship between the natural environment and our built-out surroundings. The second is to secure a balanced or sustainable approach to future development. *The third is to ensure that balanced and sustained economic growth is planned to ensure the existence of long-term landscape processes that sustain the natural environment and help define our community.* To help complete these purposes, the following guiding principles and assumptions were used:
  - Our cultural landscape "where we work, live and play" is shaped by our natural surroundings; *therefore, our future landscape must include the space and configurations needed to sustain the natural surroundings*
  - Our economic base of agriculture and forest products is dependent upon the County's natural setting and its resources

- In order to protect the long-term capacity of the environment to support growth, we need to understand the limits of natural systems *and we need to understand how our choices influence the processes that control those natural systems*
- Responsible growth requires us to work with and within our natural setting; we must work with nature rather than against it; *thus we must analyze, at a landscape scale, the processes that sustain the natural system and plan our future growth by working with nature*
- We must recognize our limits; humankind's problems, especially in regards to the natural setting, cannot always be solved with better science or a technological fix

7.4.2 Subarea Plans

RCW 36.70A.080 allows for the development of subarea plans as optional elements of a comprehensive plan. Subarea plans are essentially more detailed land-use plans for a specific area and must be consistent with the comprehensive plan. One benefit of subarea plans is that citizens typically have increased opportunities for participation.

Some jurisdictions have adopted subarea plans that emphasize elements of the comprehensive plan that are important to that specific area, whether for reasons of economic development or environmental protection. They provide local governments the opportunity to fully incorporate Smart Growth and the results of landscape analysis (e.g., Green Infrastructure or Alternative Futures) into the comprehensive plan. For example, Alternative Futures analysis in Kitsap County's Chico Creek (discussed in Chapter 6) resulted in a detailed subarea plan that addressed many of the issues covered in this chapter.

For jurisdictions that are not currently amending comprehensive plans to reflect the recommendations in this volume, it may be timelier and equally effective to incorporate the recommendations within subarea plans. This is particularly true for areas within the jurisdiction with a high density of critical areas. Planning only for a subarea does, however, reduce the geographic area that is included in landscape analysis. Therefore, it is advisable to have at least a cursory understanding of the landscape and its processes beyond the subarea as well as within its boundaries.

Plans and policies (discussed in this chapter as well as Chapter 6) are only some of the solutions that can be identified and developed as a part of Step 2, Prescribing Solutions. Regulatory and non-regulatory tools are identified and developed as common solutions. Chapters 8 and 9 discuss these tools in detail.

Chapter 8

Prescribing Solutions: Regulatory Tools

8.1 Introduction

This chapter describes the regulatory tools that can be used to protect and manage wetlands. It is intended to assist local governments in developing these tools. As with plans and policies described in Chapters 6 and 7, developing regulations is an important part of Step 2, Prescribing Solutions, in the four-step framework in a program to protect wetlands (Figure 8-1).

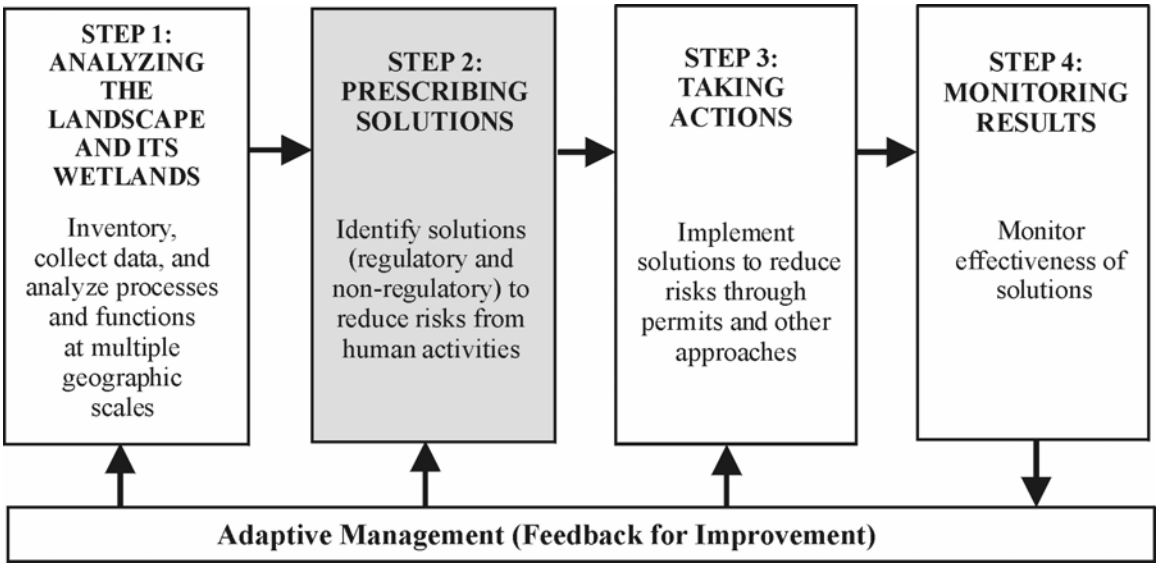


Figure 8-1. Developing regulations is part of Step 2 in the four-step framework discussed in this volume (shaded box).

Although, regulatory tools are only one part of the package of solutions recommended to protect wetland functions and values from future human impacts, they are usually the "backbone" of any wetland protection program implemented by local government.

As described in Chapter 2, the Washington State Growth Management Act (GMA) specifically requires that local governments adopt development regulations that include the best available science to protect the functions and values of critical areas (RCW 36.70A.172). These regulations are one of the primary means of implementing the goals and policies in the land-use plans of local governments.

Historically, most local governments have relied upon regulation as the sole means of protecting wetlands. A regulatory permitting component can, in fact, be very effective at limiting some of the adverse impacts associated with new development (if based on an

understanding of the scientific literature in Volume 1). However, the synthesis of the science makes it clear that reliance upon a regulatory approach using case-by-case decision-making at the site scale as the sole means of protecting wetlands will result in loss of wetland functions. Wetland regulations are most effective in preventing direct physical loss of wetland area and functions resulting from a change in land use, but regulations that focus on the site scale are not effective in addressing the indirect and cumulative impacts from larger-scale changes in landscape processes.

Using the information generated by landscape analysis described in previous chapters can help in developing regulations that protect not only the functions of individual wetlands, but protect some landscape processes as well. Although beneficial at larger scales, this is best done at a sub-basin or subarea scale, where specific regulations can be developed to prevent degradation of landscape processes and to target protection of connected habitats.

Section 8.2 of this chapter discusses several factors that should be considered when establishing regulations, such as balancing predictability with flexibility, the expertise of in-house staff to review wetland reports and permits, the assessment of risk, and the use of a separate permit for critical areas vs. incorporating provisions for critical areas throughout a jurisdiction's code. Section 8.3 discusses the specific elements that need to be addressed in local regulations, such as identifying wetlands, the applicability of regulations and permitting schemes, regulated activities and exemptions, wetland ratings, buffers, etc. The last section of this chapter (Section 8.4) briefly describes how to monitor the regulatory aspects of a protection program.

Regulations target site-scale activities (e.g. clearing vegetation, disturbing the soil, changing the movement of surface water and groundwater, and development together with its supporting infrastructure) that can impact adjacent and nearby wetlands (see Volume 1, Chapters 2 through 4). As discussed below and in Chapter 5 of this volume, such activities also have the potential for altering landscape processes and impacting wetlands not in the immediate vicinity of the alterations.

Important information is provided in appendices

Supporting information and additional detail on the topics discussed in this chapter are provided in a series of appendices (8-A through 8-H), listed in the shaded box on the next page. They contain examples of implementing language (e.g., for regulations, buffers, wetland ratings, criteria for technical experts, etc.) and other information. ***Chapter 8 and all of these appendices should be reviewed before a local jurisdiction decides to use any of the recommendations in this document in its critical area regulations.***

Appendix 8-A. An Overview of Ways to Protect and Manage Wetlands synthesizes the information available on what is needed to protect or replace wetland functions. The discussion is organized by the three major groups of functions (water quality, hydrologic, wildlife habitat) and by the different types of wetlands with other characteristics used in the Washington State wetland rating systems (e.g., bogs, Natural Heritage wetlands, etc.).

Appendix 8-B. Recommendations for Wetland Language in a Critical Areas Ordinance contains specific recommendations for ordinance language in a format similar to that used in many local critical area ordinances. This appendix revises the wetlands regulatory code language found in Appendix A of *Critical Areas Assistance Handbook* published by the state's Department of Community, Trade, and Economic Development (November 2003).

Appendix 8-C. Guidance on Widths of Buffers and Ratios for Compensatory Mitigation for Use with the Western Washington Wetland Rating System provides detailed guidance on buffers, ratios for compensatory mitigation, and other measures for protecting wetlands that are linked to the *Washington State Wetlands Rating System for Western Washington-Revised* (Hruby 2004b).

Appendix 8-D. Guidance on Widths of Buffers and Ratios for Compensatory Mitigation for Use with the Eastern Washington Wetland Rating System provides detailed guidance on buffers, ratios for compensatory mitigation, and other measures for protecting wetlands that are linked to the *Washington State Wetlands Rating System for Eastern Washington-Revised* (Hruby 2004a).

Appendix 8-E. Rationale for the Guidance on Recommended Widths of Buffers and Other Methods for Protecting Wetlands explains the rationale for the recommendations about buffers presented in Appendices 8-C and 8-D. It discusses why buffers of certain widths are recommended for wetlands that perform functions at different levels or for specific wetland types (e.g., bogs, etc).

Appendix 8-F. Rationale for the Guidance on Recommended Ratios for Compensatory Mitigation to be Used with the Wetland Rating Systems explains the rationale for the recommendations about compensatory mitigation ratios presented in Appendices 8-C and 8-D. It describes how mitigation ratios should be established based on risk of failure and temporal loss of functions, and can be further refined to reflect the category and type of wetland.

Appendix 8-G. Widths of Buffers Needed to Protect Some Threatened/Endangered/ Sensitive Wildlife Species Associated with Wetlands lists the widths of buffers needed to protect some of the wildlife species associated with wetlands. The species listed are the Federal Candidate, Federal Threatened, Federal Endangered species, State Sensitive, State Threatened, and State Endangered species found in Washington as of February 4, 2005.

Appendix 8-H. Hiring a Qualified Wetland Professional provides guidance on hiring a professional to provide wetlands services such as delineations, functions assessments, permit preparation, etc. It discusses the basic qualifications that should be considered by local governments and provides suggestions for locating a professional.

8.2 Issues in Establishing Regulations

Some of the key questions a local government should ask when establishing regulations that protect and manage wetlands and their functions include:

- Has a landscape analysis been conducted and have plans, policies, and zoning regulations been revised to reflect that information at the landscape scale?
- Are regulations the sole means of protecting wetlands, or are there (will there be) non-regulatory approaches that will help in protecting wetland functions?
- How much is known about the types and extent of wetlands in the jurisdiction and how they function?
- How well do the current zoning and critical area inventory maps incorporate reliable information on where wetlands and other critical areas are located?

Generally, a regulatory program should aim to prevent any further loss or degradation of wetland area or functions, thereby helping to maintain landscape processes as well. However, realistically even a very stringent regulatory program will not completely prevent all impacts to wetlands because some impacts occur as a result of land-use changes distant from wetlands. As discussed in Chapter 2, Section 2.3.4, of this volume, local government regulations may result in localized impacts upon, or even the loss of, some critical areas. However, the overall plan for the resources should result in no net loss of the value and functions of these resources within a watershed, etc. Thus, as previously mentioned, it is important to complement a regulatory permitting approach with planning based on landscape analysis as well as non-regulatory elements (these are discussed in Chapters 6, 7, and 9 of this volume). The following issues should be considered when establishing wetland regulations.

8.2.1 Balancing Predictability with Flexibility

One of the more common complaints about regulations is that they are either too unpredictable or too inflexible. Generally, these two characteristics are at odds with one another. A very predictable (prescriptive) approach provides clear, consistent standards that applicants can rely on. However, such an approach may not allow for flexibility to address site-specific or unique situations from the perspective of the resource or from that of the landowner. On the other hand, a more flexible approach may fail to provide the degree of specificity that allows applicants to have some certainty of the outcome early in the process.

In developing or revising regulations, one must consider how to balance these two competing needs. A balanced approach may set "sideboards" with criteria for selecting within the range of allowable options or a general standard with criteria for deviating from the standard. A more flexible approach implies more discretion on the part of local staff and managers.

8.2.2 Staff Expertise and the Role of Third-Party Review

As just mentioned, an important consideration in determining the appropriate regulations is the capacity of local staff to exercise independent judgment in applying protection standards, especially with a more flexible, less prescriptive approach. Flexibility requires time on the part of staff that are well versed in wetland ecology and management in order to make consistent and defensible decisions based on site- or situation-specific factors (see Chapter 11 for more discussion). Many local jurisdictions cannot afford to have this expertise on their staff and rely upon third-party review by a wetland professional who is retained by the local jurisdiction (usually at the applicant's expense), or through technical assistance from state or federal agencies (see Appendix 8-H on hiring a wetland professional).

8.2.3 Separate Critical Area Permit vs. Provisions Throughout the Code

Although critical areas ordinances are most often used as the sole regulation for wetlands and other critical areas, other code provisions may be directly relevant to the protection and management of critical areas. Some jurisdictions adopt critical areas provisions that establish a distinct permit that is required for any proposed activity within that type of critical area or its buffer. Other jurisdictions place provisions for critical areas and their buffers throughout their code, wherever consideration of impacts on critical areas is appropriate. For example, language addressing wetland/buffer protection may be adopted into clearing and grading regulations. (See Section 8.3.2 for more discussion.)

If a local jurisdiction decides to link wetland protection to other existing regulations and permits (e.g., clearing and grading regulations), it should bear in mind the issues described in the following sections (especially 8.3 and 8.3.2), as applicable.

8.2.4 Risk Management for Wetland Resources

In the end, the primary decision regarding the appropriate type and stringency of regulations for protecting wetlands is one of risk management. The key question is: *How much risk of loss or degradation of wetland functions and values is reasonable given; 1) what is known about the types of wetlands and their functions, 2) the types of land uses and their impacts, and 3) what othe, complementary components of protection, including planning based on landscape analysis and non-regulatory programs, are in place or will be implemented?* The scientific literature does not and cannot say what the appropriate level of risk should be; it can only assess the potential consequences of this type of decision. The final determination of the level of risk that is appropriate is made by government at the local level. (Risk assessment is discussed in greater detail in Chapter 10 of this volume.)

8.3 Important Elements of the Regulatory Component of a Protection Program

The current general approach to wetland regulation at the local level can be summarized as: *Avoid - Buffer - Compensate*. This means:

- **Avoid** direct impacts to a wetland or its buffer to the extent practicable by allowing impacts only when there is no reasonable alternative
- **Buffer** wetlands from indirect impacts through the retention of adjacent vegetated upland
- **Compensate** for unavoidable impacts by requiring the replacement of wetland and/or buffer area and function through the restoration, creation, enhancement, and/or preservation of wetlands and/or their buffers

This approach has been used in areas of the Puget Sound lowlands since 1984 and throughout Washington for the past 10 years. With appropriate protection standards and consistent implementation, such provisions can go a long way toward protecting wetland functions and values that are not strongly linked to landscape processes. For those that are affected by landscape processes, however, the review of the science in Volume 1 indicates that site-specific regulations alone will not protect all wetland functions.

Following is a discussion of the recommended key elements that should be addressed in the regulatory component of any local government's wetland program. For examples of recommended code language for each of these elements, please refer to Appendix 8-B.

8.3.1 Designating, Identifying, and Mapping Wetlands

The GMA requires that local governments designate and protect critical areas including wetlands (RCW 36.70A.170 and 172). The first step in regulating wetlands is to define what is being regulated and specify how these areas will be identified. The GMA provides the definition of wetlands and specifies how to identify and delineate them.

In designating wetlands for regulatory purposes, counties and cities are required to use the definition of wetlands in RCW 36.70A.030 (20):

> *"Wetland" or "wetlands" means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands*

may include those artificial wetlands intentionally created from non-wetland areas created to mitigate conversion of wetlands.

Wetlands are subject to a local government's regulatory authority if they meet the criteria in this definition. The GMA does not allow flexibility in adopting a modified definition of wetlands.

State legislation (RCW 36.70A.175) also requires local governments to use the *Washington State Wetlands Identification and Delineation Manual* (WAC 173-22-080) in implementing the GMA. The manual is used to identify the actual boundary of a wetland. The manual is based on the 1987 Corps of Engineers wetlands delineation manual and incorporates changes made by the Corps since 1987. Since the Washington State manual and the Corps manual rely upon the same criteria and indicators for hydrology, soils, and vegetation, proper use of either manual should result in the same wetland boundary.

Having reliable information about the location and extent of wetlands in a local jurisdiction is helpful to landowners and to regulatory staff. Reliable information provides greater predictability for landowners and helps ensure that wetlands are accurately identified for regulatory purposes. However, many local governments do not have accurate maps of wetlands within their jurisdiction. Inventory maps that have been checked on the ground can be time consuming and expensive to produce. Although field inventories conducted by local governments are recommended, existing information can be used to produce a useable, if less accurate, map of wetland locations.

Many local governments use a Geographic Information System (GIS) for decisions about planning and land uses and can generate a useful wetland map by combining several digital layers. The National Wetlands Inventory (NWI) can be combined with local soil surveys to produce a map that shows the approximate location, extent, and distribution of many (but usually not all) wetlands in the jurisdiction. The NWI was completed by the U.S. Fish and Wildlife Service and the soil surveys by the Natural Resources Conservation Service (formerly called the Soil Conservation Service). For many areas of the state, the NWI and hydric soil maps are available in digital format.

Two other layers of information that are also useful are 1) the maps of Priority Habitat and Species (PHS), generated from a database established and maintained by the Washington Department of Fish and Wildlife, and 2) the Flood Insurance Rate Maps (FIRMs), developed by the Federal Emergency Management Agency (FEMA). PHS data help identify fish and wildlife issues associated with wetlands that might arise. The FIRMs, although sometimes out-of-date, can be useful when used with other data, particularly when seasonal or forested wetlands may not have been mapped in the National Wetlands Inventory. Few FIRMs are currently digitized, but FEMA is in the process of digitizing all FIRMs for use with GIS.

Paper copies of FIRMs are available by calling toll-free 1-800-358-9616 or through the FEMA website: www.fema.gov (click on "FEMA flood map store"). Digitized FIRMs should be completed by around 2010 for the entire state but by 2008 for the urban centers. At this time, there are only two jurisdictions in the state (Whatcom County and the City of Anacortes) that have digital FIRMs that meet the current standards (i.e., GIS-based digital maps).

When superimposed, all of these maps can serve as a useful starting point for identifying the general location of areas that are likely to be wetlands in a planning area. However, as already mentioned, local field-based maps are superior because of the potential inaccuracy of the NWI and soil surveys, which are based on interpretation of aerial photographs (some 15 to 20 years old). This makes the existence of some wetlands as well as the extent of others hard to identify. Typically, the hydric soils maps have more field verification than the NWI maps, although aerial photography is the main source of information for both. In addition, wetland maps cannot replace the need for site- or parcel-scale delineations when activities are proposed that might affect wetlands.

To ensure the protection of wetlands, the regulatory code should contain language that clearly states that wetlands are to be regulated as they are defined in code and designated on site, not as they are mapped during inventories. In other words, areas that meet the regulatory definition of a wetland are regulated even if they are not mapped.

It is also important to understand how wetlands function and how they interact with landscape processes when applying local regulations. See the discussions later in this chapter and its appendices regarding wetland rating systems, as well as Chapter 5 for information on landscape analysis.

8.3.2 Applicability of Regulations

The applicability section of a code clarifies what types of activities the code is intended to regulate. There are two general ways in which protection measures for wetlands and other critical areas can be triggered through codes: 1) wetland provisions are integrated throughout various elements of the development code as applicable; or 2) a distinct permit for a specific critical area (e.g., wetland) is required for activities that may influence them. These two approaches are discussed below, along with a discussion of code language that address applicability and the pros and cons of each. Regardless of the approach selected to trigger the wetland protection, the code should, as mentioned previously, require that a site reconnaissance be conducted to evaluate the presence/absence of wetlands and their extent and to collect other information. This is particularly important given the limitations of wetland inventory maps as discussed above.

8.3.2.1 Protection of Wetlands Triggered by Various Development Permits

Measures used to protect wetlands or other critical areas can be initiated when any development permit (e.g., a grading, rezone, building, subdivision, short-plat permit, etc.) is required by the local jurisdiction. The code can be written to automatically allow the wetland provisions of the code to be applied to a permit when the applicant submits it. Thus, the law can be written such that the submittal of each development permit allows staff to review and condition the application with the regulatory standards for wetlands from the code.

Applicability language

Using this approach, the applicability section of the code should state that the critical areas provisions of the jurisdiction apply to "any permitted activity if a wetland or its buffer is present on the subject property, or the proposed actions could result in adverse impacts to offsite wetlands and/or their buffers." The language can specify that "all development permits" are included, or the code can specify which development permits trigger the critical area provisions. Such language makes it clear that any action within the jurisdiction that requires a permit (e.g., grading, rezoning, building permit, subdivision, etc.) will be subject to the protection measures in the critical areas code.

For example, some jurisdictions apply critical area provisions to all newly formed lots created **after** the critical area provisions have been implemented or revised (i.e., the applicability language cites the date of the adoption of the new provisions). The jurisdiction can require that all short-plats and subdivisions abide by the new wetland protection standards, **and** they may exempt single-family building permits from wetland review for such new lots. This means that the new lots will have the required critical area setbacks and buffers embedded into them, so the review of building permits for single-family homes is not necessary to assure that they meet the provisions of the code.

This also means that lots that were created **prior to** implementation of the current critical area standards (i.e., "grandfathered in") **may not** be subject to the new provisions (e.g., wetland rating, buffers, and setbacks, etc.) if it would deny all reasonable use of the parcel. This is one means to address reasonable-use provisions when new standards could possibly influence the use of an existing lot that was created under less restrictive standards. Although this may seem like a lessening of regulatory standards, it is a pragmatic approach to deal with the issue of reasonable use. This language also makes it implicit that any proposal to create new lots (e.g., a short-plat or long subdivision) requires implementation of the new standards.

Applicability language for development permits can also be modified to reduce the threshold that triggers a permit (such as a certain acreage) to zero for actions that pose a risk to wetlands and/or their buffers. For example, clearing of vegetation that falls below a minimum square footage (threshold) established for a clearing and grading permit would not trigger the requirement for the provisions for wetlands in the clearing and grading permit. However, the applicability section of the clearing and grading code can

readily be amended to note that, "There is a zero threshold for any activity which may pose an adverse impact to wetlands and/or their regulated buffers; such activities will trigger the requirements of a clearing and grading permit." By this means, existing code language can simply be modified to extend the provisions for wetland review and conditioning to actions that would otherwise not trigger the underlying permit requirements.

Pros and Con

A benefit of this approach is that no new permitting mechanism needs to be established; review and conditioning for critical areas is linked directly to existing permit processes that applicants are already familiar with. Many jurisdictions are already employing this method in their codes, and thus major code revisions and changes in processes used to review permits would not be required. Some development permits (e.g., subdivisions and some rezones) trigger State Environmental Policy Act (SEPA) determinations that may provide a mechanism for greater analysis and public input in the decision-making process than a permit process that is for wetlands only.

Initiating critical area provisions through development permits requires coordination between wetlands staff and the staff who condition and issue development permits (if they are different people). Such coordination is needed to ensure consistency in the provisions of approval for permits. The option of not having a separate wetland permit may require additional review fees for fee-supported staff (as would a distinct wetland-only permit), and may or may not require additional review time compared to a distinct wetland-only permit. There is a risk that the timing of approving multiple permits may lengthen the time required to process an applicant's permit.

For an application to be subject to wetland review and conditioning, some type of development permit (e.g., clearing, grading, filling, etc.) must be triggered. If no development permit is required for an action, no wetland review process can be legally initiated, unless the applicability language is modified as noted above.

8.3.2.2 Separate Critical Area Permit

A separate process for critical areas permits means that an applicant would be required to obtain a separate and distinct wetland (or critical areas) permit whenever a wetland or its buffer is located on the site of a proposed action. This is a distinct permit that would be required **in addition** to any other development permit for a parcel. The applicability of this permit is linked to the presence of the critical area or its buffer on a site. The standards for when a permit would be required should be the same as the provisions for the development-related permits, including zero thresholds for actions such as grading, clearing of vegetation, or other physical alterations.

Applicability language

Code language can be drafted for a wetland permit that identifies the activities that trigger the need to obtain the permit. The language would have to specify actions, development

permits, and/or thresholds of actions that would trigger a review according to the provisions of obtaining a permit. Unlike the previous option, this applicability section would have to include **all** actions or thresholds that would trigger the wetland permit: In the previous option, the applicability language of each existing development permit/action is modified to include wetland provisions. A discussion and description of suggested regulated and exempted activities follows in the Section 8.3.3.

Pros and Cons

Using a distinct wetland or critical areas permit involves many of the same issues described for the first option. The advantage of a wetland-specific permit is that it allows staff to clarify conditions of approval and perhaps, if the mechanism is established, to provide clarity for monitoring and enforcement with wetland permits. If the jurisdiction sets up a monitoring program, which is staffed to ensure that approved wetland permits are tracked and the conditions implemented, then a wetland-specific permit could facilitate such tracking and response**.**

A wetland-specific permit requires wetland staff to coordinate all conditions from all development permits for a particular project to ensure consistency for wetland protection. A wetland-specific permit could possibly result in higher permit and review fees. It should be assumed that a jurisdiction would either hire technical staff to implement a distinct permit program, or require an applicant to pay for review/conditioning of a permit by a third-party professional. The fee structure of the jurisdiction would determine whether fees would be higher for processing a wetland-specific permit compared to that needed to cover processing of multiple permits when protecting wetlands through the previous option.

There is a risk that the timing of approving multiple permits may lengthen the time required to process an applicant's permit. However, in a worst-case scenario, it is also possible that wetland staff may get backlogged in the case of wetland-only permits, in which case other development permits may be approved and issued before it. (The state law requires a 120-day "clock" for local permit review.)

8.3.3 Exempted Activities, Allowed Activities, and Exceptions

Critical areas ordinances are adopted to protect wetlands and their functions from the many types of activities that can adversely impact them as described in Volume 1. Therefore, local governments should regulate all activities with a potential to affect the functions of a wetland and its buffer. At a minimum, it is important to regulate all activities that would directly impact a wetland and its buffer such as filling, draining, excavating, clearing, flooding, and tilling. Other activities that should be included are herbicide application, stormwater discharges, and water diversions and withdrawals.

However, some activities pose little threat to wetlands and can be exempt from regulatory review or can trigger a lower level of review. Exempt activities should be limited to

those that will not have a significant impact on a wetland's structure and function (including its water, soil, or vegetation) and those which are expected to be very short term. Local governments should, however, also consider the cumulative impacts from exempted activities.

The scope, coverage, and applicability of a critical areas ordinance should capture the full range of activities that are detrimental to wetland functions. Therefore, exemptions should be supported by the scientific literature and be carefully crafted to minimize the potential for adverse impacts. Likewise, a local government should not assume that an exemption is appropriate in the absence of science to refute the exemption. The language should clearly state whether a given exemption is from applicable standards in the code or whether it is exempt from needing a permit but still must comply with the code.

The types of activities that are excluded from wetland regulation are grouped in to three categories in the example code provided in the *Critical Areas Assistance Handbook,* Appendix A (Department of Community, Trade, and Economic Development (CTED) 2003). They are *exempted activities, allowed activities, and exceptions.* These three categories allow varying degrees of activities or uses either without review, or in a way that avoids the regulations associated with critical areas, as explained in the following paragraphs.

The first category, exempted activities, are those activities that are excluded from critical areas regulations on the premise that they would have little or no effect, or that the activity is an emergency and delay of the action could result in threats to public health or safety. In addition to emergencies, these activities can include passive outdoor activities, forest practices regulated by the state, as well as specific operation, maintenance, or repair activities.

Allowed activities comprise the second category and are those activities that, due to other regulations or previous reviews, are unlikely to result in critical areas impacts. Since these activities are not exempt, the wetland standards continue to apply and the underlying permit could be conditioned to ensure that the activity complies with critical areas protection.

The third category, exceptions, are granted in limited circumstances where a reasonable use permit is issued to only allow the minimum "reasonable" use of the property and avoid a constitutional taking. Refer to Section X.10.150 of CTED's example code provisions for additional guidance on reasonable use exceptions.

The section below discusses the types of activities that are often considered as exemptions in critical area regulations and how they may apply to different types of wetlands. For each, we discuss the relevant scientific findings and provide recommendations for how they should be treated.

- Wetland size
- Size of minimum wetland impact

- Isolated wetlands
- Wetlands that are designated as prior converted croplands
- Irrigation-induced wetlands
- Clearing, grading, and placement of fill
- Ongoing agriculture
- Conversion of wetlands to new agriculture
- Conversion of agricultural lands to other uses
- Removal of noxious weeds
- Forest practices and conversions
- Removal of hazard trees
- Non-compensatory restoration and enhancement
- Stormwater management and wetlands
- Emergency activities

8.3.3.1 Wetland Size

While recognizing that local governments have to make difficult choices about where to expend their efforts, we do not believe it is appropriate to recommend a general threshold for exempting small wetlands in Washington because the scientific literature does not provide support for such a general exemption. Volume 1 (Chapter 5) documents the relationship between the lower levels of protection afforded to small wetlands and the resulting fragmentation and increase in distance between wetlands on the landscape as well as the important functions provided by small wetlands. The loss of small wetlands is one of the most common cumulative impacts on wetlands and wildlife in Washington.

If a local government, however, wants to consider exempting some wetlands under a certain size, this should be done with an understanding of the potential cumulative impacts (e.g., how many acres of wetlands would be affected, what functions would be most affected, how such impacts would be compensated, etc.). Considering and documenting the potential implications is critical to protecting wetland functions. The decision, therefore, is best made after reviewing the information generated from a landscape analysis (as outlined in Chapter 5 of this volume) for the geographic area that would be affected by the exemption.

Limiting the exemption to certain areas (such as Urban Growth Areas or specific sub-basins) and to certain wetland types (e.g., Category IV wetlands, those with non-native species, non-riparian wetlands) will help minimize the risk of losing important functions.

Additionally, it may be important to limit the total acreage of wetlands exempted on a project basis or within a sub-basin.

A more appropriate way to deal with small wetlands would be to exempt projects from the need to avoid small wetlands. This type of exemption should still require that the loss of wetlands be compensated either directly or through an in-lieu fee program.

8.3.3.2 Size of Minimum Wetland Impact

As with exempting a certain wetland size, there is no scientific basis for exempting wetland impacts under any particular size without an analysis of the cumulative effects of the exemption. A study of the management area is needed in order to measure the net result of the exemption as applied over time. If a local government chooses to move forward with an exemption for small area impacts, a restoration program and/or in-lieu fees program should be created to offset the net impacts.

Given the potential for cumulative impacts from exempting small wetlands and small impacts to wetlands, local governments should monitor and report the effectiveness of their wetland provisions or critical areas ordinances to achieve "no net loss." This is discussed further in Section 8.4 of this chapter.

8.3.3.3 Isolated Wetlands

There is no scientific justification for exempting isolated wetlands from regulation (See Chapter 5 in Volume 1). Isolated wetlands are generally defined as those wetlands that are hydrologically isolated from other aquatic features. Hydrologic isolation is not a determinant factor in the function of wetlands. Isolated wetlands in Washington perform many of the same important functions as other wetlands, including recharging aquifers, storing flood waters, filtering pollutants from water, and providing habitat for a host of plants and animals. Many wildlife species, including amphibians and waterfowl, are particularly dependent on isolated wetlands for breeding and foraging.

The current lack of regulation of many isolated wetlands by federal agencies is the result of very different statutory language in the federal Clean Water Act that ties federal regulation to navigable waters and interstate commerce. No such restriction exists under the GMA or any other state laws.

8.3.3.4 Wetlands that are Prior Converted Croplands

There is also no scientific basis for exempting wetlands that are prior converted croplands (PCC) from wetland regulation under the GMA. Wetlands that are designated as PCC provide the same functions as other similarly degraded wetlands. The scientific information on wetlands designated as PCC is briefly discussed below, following a description of these wetlands, and is also addressed in Chapter 5 of Volume 1.

Prior converted croplands are defined in federal law as administered by the U.S. Army Corps of Engineers. PCC are those wetlands that were drained, dredged, filled, leveled, or otherwise manipulated, including the removal of woody vegetation, before December 23, 1985, to enable production of an agricultural commodity, and that:

1. Have had an agricultural commodity planted or produced at least once prior to December 23, 1985

2. Do not have standing water (ponding) for more than 14 consecutive days during the growing season

3. Have not since been abandoned

However, many of the wetlands meeting these criteria are still *biological* wetlands (i.e., they still meet the three criteria for hydrology, soils, and vegetation) and provide important functions.

Local governments cannot exempt wetlands that are designated as PCC in their regulations and rely on the federal exemption to satisfy the best available science requirement in the GMA. Although activities in these wetlands are not regulated under Swampbuster provisions of the federal Farm Bill or Section 404 of the federal Clean Water Act, the GMA requires local governments to regulate wetlands that meet its definition. This definition of wetlands includes PCCs that meet the three criteria in the *Washington State Wetland Identification and Delineation Manual*. It therefore does not distinguish wetlands designated as PCC from other wetlands.

The original assumption behind exempting PCCs from federal regulation was the belief that these wetlands had been so altered they were no longer wetlands or no longer provided important wetland functions. In some cases, PCC have been significantly altered so they provide functions at a level that is minimal. However, in many cases, PCC provide hydrologic and water quality functions (e.g., recharging aquifers, storing flood waters, filtering pollutants from water, etc.) and may provide wildlife habitat or important linkages between habitats. For example, in western Washington, many PCC used for agriculture are ponded during the winter, when overwintering waterfowl are highly dependent upon flooded areas for resting and feeding. Overwintering bald eagles and other raptors, in turn, depend on the waterfowl attracted to these flooded areas.

Local governments that rely on the Corps of Engineers to verify wetland delineations need to ensure that wetland delineations are conducted and verified using the state wetland delineation manual to determine if they are wetlands regulated under the GMA. Once these wetlands are delineated properly, a function assessment can be conducted to analyze the functions being provided by the wetlands. Most wetlands designated as PCC will be Category III or IV wetlands under the state wetland rating systems. The departments of Ecology and Fish and Wildlife recommend that wetlands designated as PCC be regulated similarly to other wetlands (i.e., commensurate with the functions they provide).

8.3.3.5 Irrigation-Induced Wetlands

Some confusion exists as to whether wetlands that have expanded or have been formed due to the influence of irrigation are considered *artificial* and whether they are, therefore, *jurisdictional* (i.e., that is, regulated under federal, state, or local laws). Many of the habitat types with deep soils in eastern Washington have been converted to agriculture. A large portion of this land, particularly in the Columbia Basin, is under irrigation. Additionally, some agricultural areas in western Washington are also irrigated. In many irrigated areas, the groundwater table is higher than it was prior to implementation of irrigation. Many wetlands have expanded or formed adjacent to irrigation conveyance systems and in low-lying areas where irrigation occurs and downslope of irrigated lands.

The definition of wetlands comes into play when trying to clarify the situation. Artificial wetlands are addressed in definitions of wetlands used in the three state laws that regulate wetlands. These laws include the Growth Management Act (RCW 36.0A.030 (20)); the Shoreline Management Act (RCW 90.58.030 2(h)); and the Water Pollution Control Act (WAC 173-201A.020). This definition reads:

> *Wetlands means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas created to mitigate conversion of wetlands,*

Basically, this definition means:

1. A wetland must have indicators of three features: water (wetland hydrology), plants (hydrophytic vegetation), and soils (hydric soils). It must have enough water to support water-dependent plants, so the water must be present during the growing season. The presence of water creates low-oxygen conditions that support those specialized plants and also creates unique soil characteristics.

2. That, for a wetland to be non-jurisdictional (artificial) it must meet both of the following characteristics:

    a. Be intentionally created

    b. Be located in a formerly non-wetland (upland) site

The term *intentionally created* and the examples given in the definition require that the artificial wetland not be the result of an accident or an unexpected byproduct of some other intentional act. Therefore, artificial, non-jurisdictional wetlands result from someone intentionally creating a water feature such as a ditch or pond in an area that is non-wetland. The only situation where an artificial, non-jurisdictional wetland results from an unintentional action is when construction of a road (after July 1, 1990) inadvertently creates a new wetland.

The term *non-wetland* means an area where wetland characteristics are lacking—that is, an upland area. Thus, if someone intentionally creates a new water feature, such as a ditch or pond, in an area that was already wetland, the "new" water feature is still under jurisdiction as a wetland.

The following examples may help illustrate real-world situations:

1. A ranch pond was built on a dry hillside to supply water to livestock, and wetland conditions have formed over time. Clearly, the pond meets both criteria for being an artificial, non-jurisdictional wetland: It is an intentionally created water feature in an upland site.

2. Wetland vegetation is found along the edge of an irrigation canal. The canal is an intentionally created water feature. If the canal was dug through uplands, then the wetland within the canal is non-jurisdictional per GMA (though it may be subject to federal regulation). If the canal was dug through an existing wetland, then the wetlands within the canal are jurisdictional.

3. A wetland is found downgradient of a leaking irrigation canal or pipe. The wetland is jurisdictional because it is an unintentional result of digging the canal. However, the canal (or a leaking irrigation pipe) can be repaired or lined to improve water conservation. If the wetland disappears as a result of the improvement, the loss of the wetland is not regulated. If wetland conditions persist, then the wetland cannot be further altered without a permit.

4. A wetland is found within a field that is irrigated. The wetland is jurisdictional because it was not intentionally created. Although filling the wetland would be regulated, changes in irrigation practices (such as changing from flood to drip irrigation) that would dry up the wetland would not be regulated.

5. A wetland is found in a field that is not irrigated, but irrigation water from a field higher up has raised the groundwater table. The wetland is jurisdictional because it was not intentionally created as part of a water feature.

6. Wetland indicators (water, plants, and soils) are found within a stormwater pond. The wetland is not jurisdictional if the stormwater pond was created in an upland. However, if the stormwater pond was created within a wetland, then it is jurisdictional.

8.3.3.6 Clearing, Grading, and Placement of Fill

The scientific literature does not support blanket exemptions for clearing, grading, and placement of fill in wetlands or their buffers without first understanding the direct and cumulative effects of such an exemption. Critical area regulations should be crafted to address these activities because of their significant and direct impacts to wetlands and their functions.

If a local jurisdiction believes it is important to exempt small amounts or areas of filling or grading in wetlands or their buffers, they should provide some analysis to document the potential cumulative impacts of such an exemption and provide some means of offsetting the expected cumulative impacts. This could include in-lieu fee and/or non-regulatory restoration programs to restore wetlands or increase wetland functions, provided that non-regulatory programs are evaluated to ensure that the no net loss goal is met.

To address cumulative effects of multiple small fills or clearings in the same wetland, the threshold for clearing, grading, or filling a critical area or its buffer should be reduced to zero.

8.3.3.7 Ongoing Agriculture

The literature synthesized in Chapters 2, 3, and 4 in Volume 1 demonstrated that agricultural activities can negatively affect wetlands. One of the goals of the GMA is to protect wetlands and other critical areas. Equally important, the GMA seeks to maintain and enhance industries that rely on natural resources, encourage the conservation of productive agricultural lands, and discourage incompatible uses. Designated agricultural lands are one of the three types of natural resource lands defined in GMA for which local governments need to plan.

The purpose of this volume is not to further evaluate or frame the issue of agricultural impacts. It is important, however, to recognize that different types of agricultural practices result in different types of potential impacts. Local governments should consider the types of agriculture being practiced in their watersheds and craft their critical area protection programs to address impacts from agriculture accordingly.

However, given that existing, ongoing agricultural activities take place in already drained and/or actively manipulated wetlands (such as grazed wetlands), impacts from bona fide ongoing agricultural activities are most effectively managed through best management practices.

The departments of Ecology and Fish and Wildlife recommend the use of best management practices (BMPs) and/or conservation plans for ongoing agricultural activities in wetlands.

There are two basic approaches that local governments should consider:

1. **Voluntary use of BMPs with monitoring.** This encourages the voluntary use of BMPs, farm conservation plans, and incentive-based programs to improve agricultural practices in and near wetlands. Local governments work with Conservation Districts or county staff with agricultural expertise regarding technical assistance to willing landowners. They should set up and implement a monitoring program to determine if the voluntary approach is effective. If problems are detected, the jurisdiction should require the use of specific BMPs and the approval of farm conservation plans in order to correct identified problems; OR

2. **Required BMPs and/or farm conservation plans.** These could be approved by an agency or organization with expertise in agricultural practices (such as a Conservation District), with appropriate local government oversight and monitoring. This type of approach is outlined in the *Critical Areas Assistance Handbook* (CTED 2003) where it describes how Whatcom County has approached this issue:

   Some agricultural uses are regulated by state or local government, usually because of a particular environmental concern related to ground or surface water or air quality. For example, Whatcom County regulates pre-existing agricultural activities that impact wetlands, fish and wildlife habitat conservation areas, and aquifer recharge areas or their buffers in conformance with an adopted conservation program. The conservation program is developed to be consistent with the Whatcom Conservation District's best management practice manual and requires the containment of livestock waste. The plan is then filed with both the conservation district and the county, to ensure that the agricultural practices are being implemented. Periodic monitoring of farm activities ensures that the management objectives are being met.

The CTED handbook acknowledges that while regulations provide certainty, they can be difficult and costly for agricultural activities, particularly without the understanding and cooperation of the landowners.

8.3.3.8 Conversion of Wetlands to New Agriculture

Conversion of wetlands that are not currently in agricultural use to a new agricultural use should be regulated by the same regulations as any new development. The scientific literature does not support the conversion of wetlands to new agricultural uses without review and conditioning through a critical areas ordinance.

8.3.3.9 Conversion of Agricultural Lands to Other Uses

A change in use from agriculture to non-agricultural uses should trigger review under the critical areas ordinance. Exemptions and special considerations for wetlands (i.e.,

targeted implementation of best management practices) crafted for agricultural activities should not be "grandfathered" when the land use changes from agriculture to another form of development. A change in use from one type of agricultural activity to another type of agricultural activity should be addressed through best management practices and farm plans.

Of particular concern is that a change in land use may be preceded by an activity that may be exempted by a local government because alterations may occur to the wetland before adequate review takes place. A common example is the exemption in many critical areas ordinances for the maintenance of existing drain tiles and ditches on drained agricultural lands. Ditches and drain tiles require maintenance from time to time in order to keep the water table low enough during the growing season for agricultural production. As long as the lands are being maintained for ongoing agricultural use, the maintenance exemption makes sense, provided that the original depth and dimension of ditches and tiles is maintained.

A critical areas ordinance should specify what constitutes "maintenance," what does not, and what documentation is necessary to prevent inappropriate or unlawful wetland draining activities. A conflict can arise when ditch and tile systems are enlarged or upgraded to effectively drain farmed wetlands so they no longer meet the definition of a wetland. This is a change in management and is the point where the local government has an interest in reviewing this change in use because new areas are being affected by the upgrade to drainage systems. Many agricultural areas often provide important habitat and other hydrologic functions (previously discussed in Section 8.3.3.4 on Wetlands that are Prior Converted Croplands).

Local governments are encouraged to work with agricultural landowners to implement the GMA's goal of protecting and enhancing agricultural lands, as well as provide notice of their authority to regulate converting wetlands, or expanding the extent of conversion, to non-wetlands for agricultural uses. This recommendation is reflected in the language in Appendix 8-B.

8.3.3.10 Removal of Noxious Weeds

Many current regulations that protect critical areas do not require a permit for the control and removal of noxious weeds in wetlands and buffers (as well as other critical areas), provided that the control is done by hand or with light equipment and does not involve the use of hazardous substances. Local governments should retain some oversight authority when more extensive control methods are proposed to make sure that wetland functions are adequately protected.

8.3.3.11 Forest Practices and Conversions

The state's Forest Practices Act (RCW 76.09 and WAC 222) regulates commercial woodlots and forest lands and contains provisions for protecting wetlands. The Act contains less stringent standards for wetland protection for commercial forestry than those required by local governments for non-forest lands through the GMA. The Forest

Practices Act does not protect forested wetlands from harvest and has weaker standards for avoidance, buffers, and mitigation than most local regulations. It provides standards for buffer protection for certain non-forested wetlands and bogs. The assumption in the Forest Practices Act is that many of the affected functions performed by forested wetlands recover during the time they regenerate trees old enough for another cycle of timber harvest.

However, the GMA requires that local governments protect the functions provided by forested wetlands. It is important for local governments to recognize and address the gap in wetland protection between the GMA and the Forest Practices Act. They should provide a framework to ensure compliance with their standards when forest lands are converted to residential, commercial, or other non-forestry uses. The jurisdiction should regulate the conversion of lands when they will no longer be regulated under the rules of forest practices. The regulations should provide guidance on how this issue will be managed in jurisdictions that contain commercial forest lands. It is important to note that the provisions should only apply when forest lands regulated by the Forest Practices Act are converted to other uses. It should not be the intent of the local jurisdiction to make the Forest Practices Act consistent with local government's more stringent requirements for forested wetlands.

8.3.3.12 Removing Hazard Trees

Provisions for the trimming or removal of hazard trees in buffers are legitimately addressed through an exemption to regulations protecting critical areas. Considering public safety is important in balancing exemptions with the goal of protecting critical areas. The needs for limits on the exemption are obvious: The exemption should be limited to situations where the "offending" tree is clearly a hazard, and removing the tree would not adversely affect the functions of a wetland or its buffer. One option is for the local government to involve a qualified arborist who has an understanding of the functions of wetlands and buffers to evaluate a request to remove a hazard tree.

The qualified arborist should establish that the hazard tree presents an imminent hazard and is threatening a structure. Some local governments use the definition in the Forest Practice Rules (WAC 222-21-010(4)) which define a *danger tree* as "any qualifying timber reasonably perceived to pose an imminent danger to life or improved property." This applies to any tree within 1.5 tree-lengths of the structure. The Washington Department of Natural Resources (WDNR) is not, however, charged with administering the requirements in the GMA. Therefore, a local government should not defer the determination of what constitutes a hazard tree, or the review of hazard tree cutting proposals, to WDNR or WDNR standards. Trees removed as hazards should be replaced either in kind or with species that are underrepresented in the community.

The exemption process should not allow for the creation of "view corridors" and the removal of healthy trees in a buffer under the pretext of control of hazard trees. When trees are removed, a restoration plan should be required. In some instances, pruning (not topping) of trees to maintain (not create) a limited view corridor may be considered by a jurisdiction as appropriate. A management plan for a view corridor, prepared by a

certified arborist, should be required by the jurisdiction. The plan should also be reviewed by qualified staff or an arborist paid by the applicant. This approach is recommended to reduce the cases of illegal clearing to create a view, leaving the jurisdiction to deal with an enforcement action.

8.3.3.13 Non-Compensatory Restoration and Enhancement

Provisions for non-compensatory restoration and/or enhancement may legitimately be addressed as exemptions through critical areas regulations. Limits, however, should be defined so that proposals narrowly focused on or managing for a single function are not allowed to occur at the expense of other wetland functions.

Restoration and enhancement activities are considered non-compensatory when they improve wetland functions (and/or increase wetland acreage) and are not meant to compensate for impacts caused by development. Many restoration activities are by definition "self-mitigating" in that they may cause temporary impacts (during construction) that are ameliorated by the significant increase in function resulting from the activity.

Some non-compensatory activities are not beneficial from a landscape perspective because they are narrowly focused or do not fit the hydrogeomorphic setting in which they are carried out. Narrowly focused activities are those that provide benefits to single species at the expense of other wetland functions. For example, in the past some waterfowl management projects have been constructed to significantly increase waterfowl production, while reducing habitat for non-waterfowl species. An extreme example would be the clearing of a forested wetland for the construction of an impoundment to attract waterfowl.

Local governments should not assume that restoration activities supported by other agencies will result in an appropriate tradeoff of functions and should carefully look at the merits of the proposal. Beneficial projects should be encouraged as a means to offset net losses in the regulatory arena, provided that they result in wetlands of the appropriate hydrogeomorphic class and are supported by landscape processes.

Local governments may also consider relaxing some of the procedural requirements typically reserved for compensatory mitigation projects. For example, a requirement for a restriction on an easement or deed for a "native growth protection area" may only serve to needlessly frustrate the proponent of a project that is non-compensatory in nature. It may be appropriate for a local government to set up a separate review process for non-compensatory projects that is focused on facilitating projects while still complying with requirements of their local protection program.

8.3.3.14 Stormwater Management

The use of wetlands for stormwater management should be included in the list of regulated activities. Most wetlands are adversely affected when they are modified to treat and/or detain urban stormwater. The literature, much of it based on research done in the

Puget Sound area, suggests that there are very narrow circumstances under which wetlands can be managed to meet the stormwater requirements of new (and retrofitted) development. While it may be appropriate in some situations to allow a wetland performing at low levels to be used as part of a system for managing stormwater, local review and permitting should be required.

Ecology has published a manual to provide local jurisdictions with technical standards and guidance on stormwater management based on the current state of the science and the best technical information available. The 2001 revision to the *Stormwater Management Manual for Western Washington* includes practices to minimize stormwater impacts on receiving waters, including wetlands, in areas west of the crest of the Cascade Mountains. The manual is used to address the effects of changes in water quality and water quantity on receiving waters such as wetlands. The 2001 Ecology manual should be used by local governments in western Washington to include best available science in developing or revising protection programs for wetlands.

In the manual, Ecology states that stormwater discharges to wetlands "shall maintain the hydrologic conditions, hydrophytic vegetation, and substrate characteristics necessary to support existing and designated uses." To accomplish this, Ecology recommends use of the amended *Wetlands and Stormwater Management Guidelines* published in Appendix I-D of the manual.

Achieving the goal of maintaining hydrologic conditions requires the use of continuous modeling and spreadsheets to track events that exceed recommended water levels in the wetland receiving the run-off. The modeling tools, such as the Western Washington Hydrology Model (WWHM) provided in the appendices of the manual, are available but applying them is difficult. As a result, Ecology intends to add a spreadsheet to the WWHM, to help with tracking these events. The model can be used to develop strategies to protect wetlands and their hydrology from the negative effects of stormwater run-off if it is calibrated for the specific drainage area. Refer to the manual for more details.

Ecology also published a stormwater management manual for eastern Washington (Ecology 2004). The manual is more limited in scope (when compared to the western Washington manual) with respect to wetland management and does not include the management guidelines for wetlands and stormwater contained in the western Washington manual.

Ecology's manual for stormwater management

Details about changes to and requirements of the stormwater manual for western Washington are available on the internet at:
http://www.ecy.wa.gov/programs/wq/stormwater/manual.html.

The manual for eastern Washington is available at
http://www.ecy.wa.gov/programs/wq/stormwater/eastern_manual/index.html.

8.3.3.15 Emergency Activities

Local codes typically include provisions for emergency activities. These are intended to provide relief from procedural requirements of the code, namely from the time delays associated with having to obtain a permit prior to responding to an emergency. Local regulations should clearly differentiate between the need to quickly permit the emergency activity and providing any compensation needed for the emergency activity after-the-fact. There is no scientific justification for exempting emergency activities from having to provide compensatory mitigation after-the-fact when the emergency action results in adverse impacts to wetlands (or other critical areas).

8.3.4 Wetland Rating

A wetland rating system is a useful tool for dividing wetlands into groups that have similar needs for protection. The scientific literature makes it clear that wetlands in Washington are very diverse (see Volume 1, Chapter 2). Wetlands occur in a wide variety of locations as a result of very different influences (e.g., geomorphology, geology, water source, etc.) and have a wide range of characteristics that contribute to different types and degrees of functions.

Wetland rating systems allow tailoring of regulations to the protection needs of different types of wetlands or degrees of function. They offer a scientifically defensible approach to assigning protection standards as well as providing a significant degree of predictability for applicants. For example, the widths of buffers and ratios for compensatory mitigation can be determined based upon a wetland rating, in addition to other factors.

A rating system for wetlands should divide them into categories based on understanding how wetlands function and how they are affected by human activities. A rating system should use clear criteria for each wetland category and include methods for determining which category a wetland is in. Without detailed methods, it is not possible to consistently apply rating criteria. The primary factors that should be used to rate wetlands are:

- The **rarity** of the wetland type
- The **irreplaceability** of the wetland type
- The **sensitivity** of the wetland type to adjacent human disturbances
- The **functions** performed by the wetland type

Ecology has revised the wetland rating systems that were previously developed for eastern and western Washington based on current wetland science. The revisions to the rating systems were determined by interdisciplinary teams that included local planners and biologists and have been field tested across the state. If a local government wants to revise one of these updated rating systems or develop its own, it should do so based on

the best available science and should include a detailed method for making site-specific decisions about categorization.

Approaches for applying protection measures by incorporating the wetland rating are discussed in Appendices 8-C through 8-F. The Washington State wetland rating systems are available at http://www.ecy.wa.gov/programs/sea/wetlan.html.

8.3.5 Requirements for Wetland Reports

Local regulations should specify when a wetland report is needed, in regard to requesting a development permit, and what should be included in the report. The Department of Community, Trade and Economic Development (CTED) provides guidance, in Appendix A of their handbook (CTED 2003), regarding what should be included in a wetland report for projects that will likely cause impacts to a wetland and require mitigation. Based on this guidance, such requirements for the preparation of wetland reports include, but are not limited to:

1. Preparation by a qualified professional
2. Use of scientifically valid methods and studies in the preparation of the report
3. Minimum contents for the report, which set the threshold for determining whether it is complete
4. Geographic limits of the study
5. Requirements for compensation, performance standards, construction plans, monitoring and maintenance, contingency plans, financial guarantees, and other details

Some projects may result in minor or "de minimus" impacts which may not require a full wetland report. In such cases, some jurisdictions may choose to implement a two-tiered process to segregate projects with de minimus impacts from those requiring more in-depth review and analysis, thereby limiting the need for comprehensive review of all permits that are submitted. To implement a tiered approach, a local jurisdiction would need to collect all information that is readily available about the site of the project and the wetland to complete an initial analysis to determine if a full wetland report is needed (e.g.. the likelihood of project to have more than de minimus impacts). Appendix F of CTED's handbook includes a "critical area identification form outline" that lists a series of indicators and information that can be used for such an analysis. In most circumstances, a jurisdiction would, at a minimum, need to have a wetland inventory that has included some field verification to determine the accuracy of the inventory.

The departments of Ecology and Fish and Wildlife recommend that the requirements for wetland reports, as outlined in the CTED handbook, be included in a local jurisdiction's critical areas code or the administrative rules adopted for implementing the code. Issues

regarding the technical ability of local staff in reviewing wetland reports are covered in Section 8.2.2 of this chapter.

8.3.6 Mitigation Sequencing

Mitigation is a series of actions that requires addressing each action, or step, in a particular order. This sequence of steps is used to reduce the severity of negative impacts from activities that potentially affect wetlands and to determine what types of impacts may be permitted and what types of compensatory mitigation may be appropriate (see the following section for a discussion of compensatory mitigation).

According to the rules implementing the Washington State Environmental Policy Act, mitigation involves the following (WAC 197.11.768):

1. *Avoiding the impact altogether by not taking a certain action or parts of an action;*

2. *Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;*

3. *Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;*

4. *Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;*

5. *Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or*

6. *Monitoring the impact and taking appropriate corrective measures.*

The primary decision to be made with respect to avoidance is one of risk management. For example, using the state's system for wetland rating, impacts to Category I wetlands (which are rare, sensitive to disturbance, irreplaceable, or perform a high level of functions) are higher risk and should have to pass a higher avoidance threshold than impacts to a Category IV wetland. Category IV wetlands are usually significantly degraded, provide a low level of functions, and may be more successfully replaced. If the goal is to protect existing functions, it makes sense to apply more stringent protection to those wetlands that have a higher rating. See Appendices 8-A through 8-F for further discussion of incorporating wetland rating into regulations.

8.3.7 Compensatory Mitigation Requirements

Local regulations need to address how best to compensate for wetland area and the functions and values that will be lost due to the proposed impacts. This is called compensatory mitigation. The term mitigation is defined legally as the six-step

sequencing process described in the previous section, of which compensation is step five. Wetland impacts can be significantly reduced or avoided altogether by following the first four steps in the sequence (i.e., avoiding, minimizing, rectifying, and reducing or eliminating impacts). When wetland impacts are unavoidable, the fifth and sixth steps in the sequence are engaged (i.e., compensating for impacts and monitoring the impact and taking appropriate corrective measures).

Step five, compensating for the impact, requires considerable attention to detail because the issues are complex and the current record for compensatory mitigation is variable (see Volume 1, Chapter 6). Based on the review of the scientific literature in Volume 1, regulations addressing compensatory mitigation need to include the following:

- Standards for the type, location, amount, and timing of the compensatory actions
- Clear guidance on the design considerations and reporting requirements for compensation plans

The last requirement allows the local agency to make a decision about the adequacy of the proposed compensatory mitigation.

Ecology reports on compensatory mitigation

A two-part report on compensatory mitigation was published jointly by Ecology, the U.S. Army Corps of Engineers, and the U.S. Environmental Protection Agency. It is titled *Guidance on Wetland Mitigation in Washington State: Part 1 - Laws, Rules, Policies, and Guidance Related to Wetland Mitigation* (Ecology Publication 04-06-013a, April 2004); and *Part 2 – Guidelines for Developing Wetland Mitigation Plans and Proposals* (Ecology Publication 04-06-013b, April 2004). Access them on the internet at http://www.ecy.wa.gov/programs/sea/wet-updatedocs.htm. (The document is currently being revised).

Part 1 of this document outlines the general policies and requirements of federal and state agencies for compensatory mitigation. Part 2 provides detail on what information should be included in a compensatory mitigation plan.

Local governments are encouraged to adopt mitigation policies consistent with Part 1. This will help ensure consistency between levels of government and streamline the permitting process for applicants. The language in Appendix 8-B of this document is consistent with Part 1. Local governments should reference Part 2 as the standard for what should be included in a mitigation plan.

8.3.7.1 Standards for Compensatory Mitigation

The review of the scientific literature makes clear that compensatory mitigation has frequently failed to adequately replace wetland area and functions (see Volume 1, Chapter 6). The reasons for failure, among others, include:

- Poor site selection

- Poor site design
- Inappropriate or inadequate goals, objectives, and performance measures
- Lack of sufficient water
- Inappropriate water regime
- Poor implementation
- Inadequate maintenance
- Lack of regulatory follow-up

The reasons listed above point to a need for rigorous standards to address the type, amount, and location of mitigation projects that are permitted, and the type and extent of information that must be provided in a mitigation proposal. An adequately trained and funded regulatory staff is also vital for performing permit review, compliance monitoring, and enforcement.

Standards for compensatory mitigation should specifically address the following issues.

Goals of Compensatory Mitigation

The standards need to include a statement about the primary intent of compensatory mitigation. Is it to replace the functions being lost by the permitted impact? Is it to achieve greater area or functions? Are tradeoffs in functions allowed (i.e., allowing replacement with different functions than the functions being lost)? Generally, the goal of compensatory mitigation should be to achieve equivalent or greater area and functions.

Types of Mitigation Actions

Compensatory mitigation typically includes five basic types of activities:

- Creation or establishment of new wetlands where none previously existed
- Restoration of new wetland area and functions where wetlands previously existed (also called re-establishment)
- Restoration of wetland functions in an existing wetland area that is significantly degraded (also called rehabilitation)
- Enhancement of some wetland functions in an existing wetland that may reduce other functions
- Preservation (also called protection/maintenance) of an existing wetland that is otherwise likely to experience degradation (because it is not currently well protected by existing laws)

Standards for compensatory mitigation should specify whether any of these types of activities are preferred over others. Generally restoration (re-establishment and rehabilitation) is preferred because it is the most likely to succeed. Enhancement

typically provides the least gain in functions, and preservation always results in a net loss of wetland area; thus, these types are usually the least preferred.

Replacement of Function vs. Area

Standards should address whether wetland area and function must be replaced on an individual project basis and to what extent tradeoffs in functions can be made. *Tradeoffs* means exchanging some functions in favor of others. It is a good idea to require a minimum of 1:1 replacement of wetland area except in unique circumstances, such as when it can be clearly demonstrated that a lesser area of wetland can provide greater functions than are being lost. It is reasonable to require that compensatory mitigation replace the same functions as those lost except when tradeoffs in functions are identified as desirable in a regional plan. As a general rule, replacement of the same functions on a project basis will help ensure that significant tradeoffs are not made on the scale of a landscape or basin without fitting into clearly identified regional priorities.

Tradeoffs in functions need to be evaluated at the site and basin scale. If a function is effectively being performed in a wetland or in a sub-basin, then it may be appropriate to prioritize a function that is currently lacking or being performed at a low level. For example, a project may affect a degraded pasture near a stream that has been diked. The pasture may provide water quality improvement and limited wildlife habitat (e,g,, small mammals and raptors) but is no longer seasonally flooded, therefore diminishing its hydrologic functions. Extensive diking in the basin may have also significantly decreased the flood attenuation and desynchronization functions once provided by the wetland. Suitable mitigation, therefore, may involve removal of a dike thereby increasing hydrologic functions. This would result in a tradeoff with habitat for small mammals, which would be lost. In addition, as discussed in the next section, the removal of the dike would be off-site in relation to the wetland impact.

A real-life example is the Snohomish Estuary Wetland Integration Plan (SEWIP) (Stanley et al. 1997). The SEWIP allows a tradeoff in the types of functions provided by depressional wetlands behind dikes to those provided by restored estuarine tidal wetlands.

Location of Mitigation

Historically, most regulatory agencies required that mitigation activities be performed on-site (i.e., on or very near the same parcel where the impact occurred). This was based on the belief that the closer the mitigation was to the impact site, the better chance it would have of replacing the functions that were lost. However, recent studies have concluded that this requirement too often has forced applicants to try to fit a mitigation project into an area that makes little ecological sense and is not sustainable (Johnson et al. 2002, Johnson et al. 2000).

Mitigation standards should emphasize that mitigation activities must occur in a location where the targeted functions can reasonably be performed and sustained. For example, the site needs to have an appropriate source of water and allow for control of invasive species, and adjacent land uses need to be compatible with the long-term functioning of

the site. It is difficult to design a wetland for amphibian habitat in a location that is surrounded by dense, urban development and expect it to be sustainable.

Compensatory mitigation should not result in the creation, restoration, or enhancement of an atypical wetland. An atypical wetland refers to a compensation wetland (e.g., created or enhanced) that does not match the type of existing wetland that would be found in the geomorphic setting of the site (i.e., the water source(s) and hydroperiod proposed for the mitigation site are not typical for the geomorphic setting). Likewise, a compensation wetland should not provide exaggerated morphology or require a berm or other engineered structures to hold back water. Excavating a permanently inundated pond in an existing seasonally saturated or inundated wetland is one example of an enhancement that could result in an atypical wetland. Another example would be excavating depressions in an existing wetland on a slope, which requires the construction of berms to hold the water.

Amount of Mitigation

The acreage that should be required as compensation for lost wetland area is one of the most important and most contentious aspects of compensatory mitigation. The review of the science in Chapter 6 of Volume 1 indicates that compensatory mitigation frequently fails to produce the targeted wetland area and/or function, and it can take as long as 20 years to more than 100 years for a newly created or restored wetland to perform some functions.

The acreage of compensation required is usually expressed as mitigation ratios that are commonly used as tools to equalize the tradeoffs between the wetland lost and wetland used for compensation. While the overall goal is to replace lost functions with equivalent new functions, the reality is that it generally takes greater acreage and considerable time to provide equivalent functions. Additionally, some types of compensatory mitigation actions (e.g., enhancement, preservation) provide no new area and only a few new functions. The ratios help address the inherent disparities and act as a kind of "interest rate" to address the temporal loss of functions; there is almost always a significant time lag between when the permitted wetland impact occurs and when the compensatory wetland is fully functioning.

However, every mitigation project is unique, and it is possible to create or restore a wetland and provide greater functions than those that are being lost if the project impact is to a significantly degraded wetland. Additionally, some mitigation projects are more likely to succeed than others, particularly if good hydrologic information is available. Thus, mitigation ratios need to be flexible to address the wide range of situations that are encountered.

The recommended approach is to establish general mitigation ratios based on the wetland category and the type of mitigation activity, and then adjust the ratio on a case-by-case basis to account for project-specific factors. Criteria for increasing or reducing ratios should be specified in the standards used to protect wetlands. This provides some degree of predictability for applicants while retaining the flexibility to make site-specific adjustments.

Suggested code language for mitigation ratios is provided in Appendix 8-B. Guidance on compensatory mitigation ratios for use with the western and eastern Washington wetland rating systems is provided in Appendices 8-C and 8-D, respectively. Appendix 8-F provides the rationale behind these mitigation ratios.

Timing of Mitigation

Generally, mitigation actions are conducted concurrently with or soon after the wetland impact occurs. Standard ratios are typically established based on this assumption. If mitigation is conducted in advance of the impacts, then the risk and temporal loss are reduced and the ratio should be reduced commensurately. If the mitigation is conducted well after the impact, the ratio should be increased.

8.3.7.2 Special Types of Compensatory Mitigation

In addition to addressing the more common mitigation actions (e.g., creation, restoration, and enhancement), local jurisdictions should consider including language in their regulations specifying the circumstances under which special types of compensatory mitigation may be used, such as preservation, mitigation banks, in-lieu fee programs, and programmatic mitigation areas. These types of programs are discussed below.

Preservation

The preservation of existing wetlands as a means of compensating for wetland impacts is highly controversial because it always results in a net loss of wetland area and is perceived as trading one wetland for another one that is already protected. The reality is that some wetland types are not adequately protected under existing laws and can benefit from being placed in public ownership or protected by a conservation easement.

For example, many forested wetlands can be logged under current state laws, and wetlands with significant habitat value are very difficult to protect without large buffers and corridors to connect them to other habitats. Preservation of large tracts of wetlands and uplands can provide benefits that are impossible to achieve using typical regulatory approaches. One way to think about the issue of "net loss" with respect to preservation is that some wetlands are going to experience unmitigated impacts unless they are preserved. In that sense, preservation provides a "net gain" over what would otherwise occur.

Preservation has the following basic advantages as a compensatory mitigation tool:

- Larger mitigation areas can be set aside due to the higher mitigation ratios required for preservation
- Preservation can ensure protection for high-quality, highly functioning aquatic systems that are critical for the health of the watershed and aquatic resources that may otherwise be adversely affected

- Preservation of an existing system removes the uncertainty of success that is inherent in a restoration, creation, or enhancement project

Generally, the use of preservation to compensate for impacts is appropriate only in very limited circumstances. The preservation of a *high-quality* wetland in the same watershed or basin where a wetland loss has occurred, however, is often an acceptable form of compensation when done in combination with other forms of compensation such as re-establishment or creation. See Appendix 8-B for features indicative of high-quality sites.

Note that the use of preservation of wetlands as compensatory mitigation should not allow applicants to circumvent the standard mitigation sequence of avoiding and minimizing impacts first, followed by compensating for unavoidable losses. Additionally, preservation projects should be subject to the same requirements as other types of wetland mitigation (e.g., monitoring and long-term protection). Preservation of wetlands generally requires significantly higher ratios to offset impacts than wetland restoration or creation (see Appendix 8-C and D).

Generally, the preservation of at-risk, high-quality wetlands and habitat may be considered an acceptable part of a mitigation plan when the following criteria are met:

1. Preservation is used as a form of compensation only after the standard sequencing of mitigation (avoid, minimize, and then compensate)

2. Restoration (re-establishment and rehabilitation), creation, and enhancement opportunities have also been considered, and preservation is proposed by the applicant and approved by the permitting agencies as the best option for compensation

3. The preservation site is determined to be under imminent threat; that is, the site has the potential to experience a high rate of undesirable ecological change due to on-site or off-site activities that are not regulated (e.g., logging of forested wetlands). This potential includes permitted, planned, or likely actions

4. The area proposed for preservation is of high quality or critical for the health of the watershed or sub-basin due to its location

In addition, please refer to Appendices 8-B, 8-C, and 8-D for additional criteria and further guidance on the use of wetland preservation in compensatory mitigation.

Mitigation Banks

Mitigation banks offer an opportunity to implement compensatory mitigation at a regional scale and provide larger, better-connected habitat in advance of impacts. Mitigation banking involves the generation of "credits" through restoring, creating, enhancing and, in exceptional circumstances, preserving wetlands and other natural resources. These credits can then be sold to permit applicants who need to offset the adverse environmental impacts of projects that would occur within the *service area* of the bank. A bank's service area is akin to its "market area" or the geographic area in which

credits may be sold or used. Projects that use bank credits as compensation are called *debit projects*.

Wetland mitigation banks have two basic components as follows:

- **Bank site**. The bank is located at the physical site where credits for mitigation are generated by restoring, creating, enhancing, and/or preserving wetlands and associated natural resources.

- **Bank sponsor**. An organization operating under the provisions of a mitigation banking instrument that markets and sells credits, maintains a bank ledger, monitors and reports on the development of the bank site, and provides perpetual protection, management, and other services for the bank site.

Bank sites are normally protected in perpetuity by a legally binding protective covenant such as a conservation easement held by a long-term manager. Bank sponsors must also provide one or more temporary financial assurances to ensure the successful ecological development of the bank and an endowment to fund long-term management of the bank site(s).

Once released for sale, wetland bank credits are sold to permit applicants to compensate for wetland impacts that occur within the service area of the bank. As credits are sold, bankers debit them from the bank's ledger so they cannot be resold. Once all credits in a bank have been sold, the bank is closed.

Mitigation banks benefit the aquatic environment by consolidating numerous small wetland mitigation projects into larger, potentially more ecologically valuable projects. This results in economies of scale that benefit the regulated public, regulatory agencies, and the environment.

Another important feature of mitigation banks is that they are developed in advance of the adverse impacts for which they compensate, which ensures that the bank is ecologically successful before it is used to offset adverse impacts at other sites. Mitigation banks that are properly implemented offer improved ecological performance, lower mitigation costs to permit applicants, and a more streamlined permit process.

To date, few mitigation banks have been approved in Washington. However, as the regulatory agencies develop and implement the process to review and approve banks and gain experience in evaluating proposals, mitigation banks are likely to become more common in Washington.

As with any form of compensatory mitigation, the use of mitigation bank credits to offset impacts to the natural resources should not be considered prior to completing the two mitigation sequencing steps of avoidance and minimization. Then, the regulatory agency must determine whether purchasing credits from a particular bank would provide appropriate and practicable compensation for a proposed impact. In making its determination, the regulatory agency should consider whether any opportunity for mitigation that is environmentally preferable (e.g., on-site mitigation) is available, how

closely a bank's credits correlate with the particular wetland functions that would be altered by a proposed action, and whether using a bank to compensate for a proposed action would be in the best interest of the natural resource, particularly the affected watershed.

Current information on the Ecology's Wetland Mitigation Banking Program is available at http://www.ecy.wa.gov/programs/sea/wetmitig/index.html.

In-Lieu Fee Programs

Mitigation using in-lieu fees (ILF) occurs when a permittee pays a fee to a third party in lieu of conducting project-specific compensatory mitigation, purchasing credits from a mitigation bank, or conducting some other form of compensatory mitigation. This fee represents the expected costs to a third party to replace the wetland functions that would be lost or impaired as a result of the permittee's project. ILFs are typically held in trust by a non-profit conservation organization until they can be combined with other ILFs to finance a project that replaces the lost and impaired functions represented by those ILFs. The entity operating the trust is typically an organization with demonstrated competence in natural resource management, such as a local land trust, private conservation group, or government agency that manages natural resources.

ILF mitigation is used primarily to compensate for minor adverse impacts to the aquatic resources when more preferable forms of compensation are not available, practicable, or in the best interest of the environment. Compensation for projects that result in more substantial adverse impacts is usually provided by project-specific mitigation or a mitigation bank. ILF mitigation may be appropriate when:

- The amount of compensatory mitigation required for a project is too small to justify the cost of designing and implementing project-specific mitigation
- Practicable opportunities to conduct appropriate project-specific mitigation or purchase credits from an approved mitigation bank are not available
- Project-specific mitigation that could be implemented would likely result in a low-performing aquatic system, have a high risk of failure, be incompatible with adjacent land uses, or fail to address the needs of the watershed
- A minor amount of additional mitigation is needed to supplement project-specific mitigation that would not, by itself, fully compensate for a project's adverse environmental impact
- The permit process does not adequately compensate for cumulative effects from a project

ILF mitigation and mitigation banking share many similarities. For example, both types of mitigation allow permittees to fulfill their compensatory mitigation responsibilities by paying a fee to a third party who will accept responsibility for the required mitigation.

Also, mitigation banks and ILF-funded projects must both fully comply with existing federal mitigation guidance and policy, including a requirement for a written implementing agreement that normally includes construction plans, performance standards, monitoring and reporting provisions, a long-term management plan, financial assurances, a protective real estate agreement (e.g., conservation easement), and other measures, as appropriate, to ensure the ecological success of each project.

The fundamental difference between mitigation banking and ILF mitigation is the relative timing of the activities that offset the adverse environmental impacts for which they compensate. With mitigation banks, the environment-enhancing activities are conducted in advance of the adverse impacts, whereas with ILF mitigation, those activities normally are not conducted in advance of the adverse impacts. While specific ILF-funded mitigation projects may not always be identified in advance of project-related impacts, quickly expending collected ILFs to fund mitigation projects should be a high priority for any ILF program. However, regulatory agencies may adjust the size of ILFs to compensate for anticipated delays in expending them.

Local governments interested in developing an ILF program should evaluate the potential for cumulative and unmitigated impacts to hydrologic and water quality functions that may result from the program. Local governments should consider the use of stormwater controls (such as over-sizing ponds and swales) as a way to replace wetland hydrologic and water quality functions on-site and reduce cumulative effects from an ILF program.

Programmatic Mitigation Areas at the Local Level

Another approach for consolidating compensatory wetland mitigation involves directing compensation projects to a *programmatic mitigation area*. Simply defined, a programmatic mitigation area is a site (or series of sites) that have been identified by the local jurisdiction or a state or federal agency as a preferable site(s) for wetland compensation. Wetland compensation projects are constructed separately on the site but are all part of a common design. The programmatic mitigation sites are subject to the same minimum requirements as other compensation sites such as permanent protection, monitoring, restrictions on other activities on the site, etc.

The goal of a program for programmatic mitigation areas to allow the restoration of larger wetland areas that are important to the functioning of a stream basin or watershed because of their position in the landscape. Since many projects require relatively small areas of compensatory wetland mitigation, the programmatic mitigation area program allows the consolidation of these small compensation sites into a larger project.

The following is a summary of how a programmatic mitigation areas work?:

1. The lead regulatory entity (county or city jurisdiction, state or federal agency) identifies an area or areas as priority restoration areas

2. The regulatory entity develops a site development plan for the entire site and may either purchase the site or purchase an easement on the site

3. As projects needing compensation arise, the applicants are directed to perform either certain activities on the site (to aid in the completion of the plan) or directed to implement the site design on specific areas within the overall site

This approach has not been used much in Washington. The closest example available is Kitsap County's work along Clear Creek where several mitigation projects have been completed adjacent and complementary to each other. The county has actively directed compensation projects to the Clear Creek area. Another example is along Mill Creek in Auburn where the Emerald Green Race Track and Washington State Department of Transportation located their compensation sites in an area identified in the draft Mill Creek Special Area Management Plan or SAMP (U.S. Army Corps of Engineers 1997).

8.3.7.3 Impacts to buffers

Impacts to buffers should be handled similarly as impacts to wetlands. Applicants should be required to use all available means of modifying their development proposal, as well as using existing provisions for buffer averaging, before they are allowed to build in buffers. Where buffer impacts are unavoidable, compensation should be required in the form of wetland and/or upland restoration or enhancement.

8.3.8 Buffers

Buffers are defined in many ways (see Chapter 5 in Volume 1) but generally include relatively undisturbed, vegetated areas adjacent to critical areas such as wetlands and streams. The review of the scientific literature in Chapter 5 of Volume 1 indicates that the protection of buffers around wetlands is necessary to protect wetland functions. The scientific literature also provides considerable guidance on buffer characteristics, including widths, which are necessary to protect specific wetland functions. The literature does not provide clear direction on how to structure buffer protection and management programs. However, in addition to providing technical information on buffer effectiveness, the literature provides information that should help guide the development of buffer protection policies and regulations. This information can be summarized as follows:

- Four primary factors should be considered in determining the appropriate width and character of buffers, no matter what the physical setting is:
  - The quality, sensitivity, and functions of the aquatic resource
  - The nature of adjacent land use activity and its potential for impacts on the aquatic resource
  - The character of the existing buffer area (including soils, slope, vegetation, etc.)
  - The intended functions of the buffer

- Site-specific information is needed to determine the characteristics and width of the buffer that will make it effective
- It is important to manage surface water discharges to wetland buffers to ensure effective treatment of pollutants
- Generally, buffer widths "shrink" over time as a result of infringement from adjacent activities

Ideally, this guidance should be incorporated into any local government's buffer regulations. There are, however, many different ways to incorporate this information into a protection program for buffers. The challenge for local governments in Washington is to develop approaches to buffer protection and management that include the best available science and provide a reasonable and defensible means of establishing and maintaining effective wetland buffers.

Suggested code language for buffers is provided in Appendix 8-B. Guidance on buffers for use with the western and eastern Washington wetland rating systems is provided in Appendices 8-C and 8-D, respectively. Appendix 8-E provides the rationale behind the recommended buffer widths.

8.3.8.1 Issues Regarding the Regulation of Wetland Buffers

Regulations for the protection of wetland buffers should address a number of issues:

1. Standards for buffer characteristics and width
2. Criteria and procedures for varying from a standard
3. Allowable uses within buffers
4. Best management practices to enhance and ensure effective buffer function
5. Provisions for the delineation and demarcation of buffers and their maintenance over time

In most cases, the primary concern will be "how wide does the buffer need to be?" This issue dominates any discussion of buffer regulation and generates the most conflict. However, before determining appropriate standards for buffer widths, a local government needs to decide how best to balance the need for a predictable and cost-effective approach with the desire for an approach that is both flexible and responsive to specific situations.

The options for regulatory approaches to buffers range from variable-width buffers that are determined case-by-case based on multiple site-specific factors, to fixed-width buffer standards. Between these two extremes, there are many intermediate options that combine some elements of each.

Variable-Width Approach

The case-by-case, variable-width approach is probably the most consistent with what a review of the scientific literature reveals about buffer effectiveness (see Chapter 5 in Volume 1). This approach usually requires the development of a detailed formula and methodology for considering site-specific factors such as wetland type, adjacent land use, vegetation, soils, and slope. By considering all relevant site-specific factors prior to determining the appropriate width of the buffer width, this approach helps ensure that the buffer is adequate to protect wetland functions without being any larger than is necessary.

However, this approach is time-consuming, costly to implement, and provides a less predictable outcome. It requires either that the applicant hire a consultant to conduct the necessary analysis, or that the government agency staff conduct the analysis. In either event, the local government staff must have appropriate training and expertise to conduct or review the report produced. In addition, this approach initially requires considerable effort when the formula and methodology for site-evaluation is developed. This approach also does not provide any predictability for applicants. They have no idea how large a buffer may be required until considerable time and money are invested in the analysis. Using a case-by-case, variable-width approach can also result in attempts to manipulate the site-specific data, lead to frequent haggling with applicants, and create the perception that buffer widths are determined in an arbitrary and capricious manner.

Fixed-Width Approach

By contrast, a fixed-width approach provides predictability and is relatively inexpensive to administer. The downside of this "one-size-fits-all" approach is that it results in some buffers being too small to adequately protect wetland functions and some buffers being larger than necessary to protect wetland functions. Over time, this inequity may erode public and political support for the buffer program. Frustrated landowners can point to the "over-regulation" of those buffers that are larger than necessary, while environmentally-minded citizens can point to those buffers that are smaller than needed to protect wetland functions.

It also is difficult to determine an appropriate standard width, because no single-size buffer can be demonstrated to protect all wetland types adequately in all situations unless that standard width is very large. Furthermore, it is difficult to argue that an approach using fixed widths includes the best available science since the scientific literature clearly recommends different buffer widths based on a variety of different factors. While no local governments in Washington currently use a single, fixed-width approach, there are several states that do (e.g., California, New Hampshire, New Jersey).

Combining the Fixed-Width Approach with Site-Specific Variables

There are several ways to modify an approach using standard, fixed widths to incorporate some of the factors that contribute to the effectiveness of buffers. Some drawbacks of the fixed-width approach can be rectified by using a wetland rating system that divides wetlands into different categories based on specific characteristics. Then, different

standards for buffer width can be assigned to each category. This approach provides predictable widths, yet allows some tailoring of buffer widths to wetland functions.

For example, as previously mentioned, the Washington State wetlands rating systems divide wetlands into four categories based on rarity, sensitivity to disturbance, irreplaceability, and functions. This hierarchical rating allows one to establish larger standard buffer widths for those in higher categories wetlands and smaller standard buffers for those in lower ones. Most local governments in Washington currently designate buffer widths based on the state wetland rating systems or a rating that is similar.

Another way to address site-specific factors while using fixed widths is to have different widths based on the type of adjacent land use, thus incorporating the four factors, discussed earlier, that are known to influence the effectiveness of buffers. A buffer regulation could require a larger buffer width for adjacent land uses with intense impacts and a smaller buffer width if the impacts from adjacent land uses are low. This strategy can be combined with a wetland rating system to provide a more scientific and defensible approach.

Other critical factors, such as the characteristics of the buffer itself and the functions of the buffer that are desired, can be addressed by establishing criteria and procedures for varying from a standard width. This approach allows for some site-specific tailoring of the standard widths on a case-by-case basis without the need for developing a detailed formula or methodology for determining the widths. In this approach, criteria for increases or reductions from the standard buffer width are developed, and the applicant or any other interested party is given the option of "making a case" as to why the standard buffer width should be increased or decreased. Agency staff then evaluate the proposal against the criteria and decide if such a deviation is warranted.

The criteria for allowing a deviation from the standard buffer width should include the various buffer characteristics that in the scientific literature have been determined to be most important. These include slope, soil type, vegetative cover, and/or the habitat needs of particular wildlife species. For reducing standard buffer widths, an applicant should have to demonstrate that a smaller buffer will protect the functions and values of the wetland. This will generally require hiring a qualified expert and preparing a site-specific report for the local government's review and approval. It is also important to have a minimum buffer width below which the buffer cannot be reduced.

Protecting wildlife species that are threatened, endangered and sensitive

Threatened, endangered, and sensitive (T/E/S) species need specific protection, but this protection cannot be accomplished using the protection measures linked with wetland rating systems. If a T/E/S species is found living in or using a wetland, the appropriate state or federal agency should be consulted to determine what is necessary to protect that species. This information can be considered an "overlay" on the wetland rating. A wetland containing T/E/S species should be protected to meet the requirements of the species as well as the measures associated with its rating category. The T/E/S species using the wetland may need larger buffers or other considerations (e.g., no disturbance during the nesting season).

For example, a Category II riverine wetland that provides overwintering habitat for endangered Coho may need larger buffers than those recommended for a Category II wetland that would protect fish that are not T/E/S species.

For these reasons, it is important that wetland rating forms be used in conjunction with detailed guidance on using the rating forms**. Inadequate protection for listed species may result if rating systems are misapplied.** See Appendix 8-G for buffer widths for some threatened, endangered, or sensitive wildlife species associated with wetlands.

8.3.8.2 Reasonable Use Criteria

Another situation in which standard buffer widths may need to be reduced on a case-by-case basis is when protection of the buffer will result in a property owner being denied reasonable use of his/her land. For example, if a landowner has a one-acre parcel that was zoned for one single-family residence and a wetland covers 80% of the parcel, protection of a buffer around the wetland might mean that the parcel is rendered undevelopable. In this case, the landowner would have a strong case that protection of the wetland and buffer would deny him/her all reasonable use of the property. However, if the buffer were reduced, it may be possible to construct a single house on the property and avoid a "takings" claim.

Thus, critical area regulations should include a provision allowing for buffer reduction in situations where reasonable use would be denied. Such a provision should include requirements that the applicant demonstrate that there are no feasible alternatives to reducing the buffer such as revising the development design, that critical wetland functions or public health and safety will not be impaired, and that the inability to derive reasonable economic use of the property is not the result of the applicant's own actions. For example, a landowner may divide the property in a way that created an unbuildable lot after the adoption of critical area regulations.

Reduction of wetland buffers increases the risk that the remaining buffer will be degraded and encroached upon over time. The allowance for the reduction should be coupled with

requirements for permanent fencing and revegetation. Periodic monitoring may also be necessary. Significant reductions in buffers may require off-site mitigation for the reduced buffer.

8.3.8.3 Buffer Averaging

Buffer averaging is a tool for balancing buffer protection with specific site needs for development, or for tailoring a buffer to maximize protection of natural features in the wetland or surrounding upland. It allows a buffer to vary in width around a given wetland. For example, if the standard width for a buffer around a wetland is 100 feet, buffer averaging would allow the width to vary between a minimum and a maximum width but require that the buffer area average 100 feet in width. Typically this is done to allow development to occur closer than usual to the wetland in order to fit a particular development "footprint" onto a given site. However, it can also be used to protect a natural feature (e.g., a stand of trees or snags) that otherwise would fall outside of the standard buffer. Buffer averaging can also be used to provide connections with adjacent habitats or to address those situations where pre-existing development has reduced a buffer area to a width less than the required standard.

Criteria for averaging buffer widths typically require a minimum buffer width (either a designated width or a percentage of the standard buffer width) and documentation to ensure that the averaging of the buffer will improve, or at least, not impair overall buffer functions. Ideally, buffer widths should be narrowed in an area where it will cause the least disturbance and widened in an area where it will benefit the wetland the most.

8.3.8.4 Uses Within Buffers

Another critical issue that buffer regulations need to address is the type of uses that are allowed within buffers. Generally, buffers should be maintained in vegetation. However, uses that could be considered are some stormwater treatment facilities (e.g., bioswales) or trails to provide for some form of recreational use. In addition, over time, residents adjacent to the buffer might want to use it for some activity. Thus, it is essential that buffer regulations address which uses are allowed in buffers.

Generally, any use that results in the creation of impervious areas, clearing of vegetation, or compaction of soils will be incompatible with buffer functions. Typically, buffers need to be densely vegetated with appropriate native vegetation to perform water quality and habitat-related functions. In most cases, this requirement precludes any human uses of the buffer. However, it may be necessary in some situations to use the outer area of the buffer for initial treatment of surface water runoff, via the construction of biofiltration swales or water-spreading devices to ensure sheet flow.

In other situations, it may be desirable to allow some focused use of the buffer for educational and recreational activities and to prevent widespread disturbance of the buffer. If it appears inevitable that adjacent residents will use the buffer to gain access to a wetland for aesthetic or recreational enjoyment, then it may be preferable to concentrate that use in a smaller area and minimize disturbance of the soil, vegetation, and habitat by

constructing trails, viewing platforms, or similar facilities. Additionally, providing some educational or recreational developments in buffers may enhance the general public's understanding and appreciation of wetlands and their functions and values.

Many regulations include criteria for evaluating proposals for use of buffers. These criteria typically include general language about prohibited uses but allow for variances if certain conditions are met. Care should be taken to ensure that low-impact trails are not later upgraded to paved trails that encourage activities with greater impacts. Construction of trails can allow greater access for pets to the wetland or wetland buffer and increase predation on fish and wildlife species. Regulations should minimize the impacts from trails and interpretive facilities to the extent practicable.

8.3.8.5 Enhancement and Restoration of Buffer Areas

Frequently, upland areas adjacent to wetlands have been altered by previous land-use practices. In many cases, the vegetation has been cleared or significantly degraded and the soil has been disturbed. Also, it is not uncommon to find that the existing buffer area is composed of non-native vegetation. In these situations, simply "protecting" a buffer with a set width may fail to provide the necessary characteristics to protect a wetland's functions. It is usually desirable, therefore, to restore the buffer to a more naturally vegetated condition.

In other cases, a buffer area may be in relatively good condition but still be sparsely vegetated with trees and shrubs. It may be desirable in this case to improve the screening and habitat value of the buffer by planting additional trees and shrubs or other vegetation appropriate to the ecological setting.

Buffer regulations should be designed to ensure that buffers provide adequate protection of wetland functions. Standard buffer widths should be set based on an assumption that the buffer is well vegetated. In cases where the buffer is not well vegetated, it is necessary to either increase the buffer width or require that the standard buffer width be revegetated. Generally, a well-vegetated buffer will function substantially better than a poorly vegetated buffer. Regulations can essentially give the applicant the option of revegetating the existing buffer in order to have the standard width or foregoing buffer restoration and providing a wider but poorly vegetated buffer.

Requirements for re-vegetating buffers should specify that the buffer be vegetated to a condition that is comparable to an undisturbed plant community in the ecoregion. Buffer enhancement and restoration requires the same diligence as wetland enhancement and restoration and requires monitoring and follow-up to ensure success.

8.3.8.6 Best Management Practices to Enhance or Ensure Effective Functions of Buffers

Water Quality Protection

A buffer's effectiveness at improving water quality is largely a factor of how polluted water travels across and through the buffer. The scientific literature has many references to pretreatment practices that enhance a buffer's effectiveness at removing pollutants, thereby reducing the width of buffer necessary.

In areas with agricultural or silvicultural land uses, the primary pollutants of concern are sediments, nutrients, and pesticides. Narrow (15- to 30-foot-wide) grass filter strips have been shown to be effective at removing coarse sediments and adsorbed pollutants as well as helping encourage sheetflow and infiltration of surface runoff, thus enhancing a buffer's effectiveness at removing remaining pollutants. Therefore, requiring or encouraging the construction of a narrow grass filter strip between agricultural or silvicultural areas and wetlands and their buffers is strongly advised.

In urban areas, the pollutants of concern are primarily sediments and metals from roads, parking lots, and construction sites. Adequate treatment of stormwater runoff is critical to remove most of the pollutants and to reduce peak flows prior to discharge to a wetland or its buffer (see below for more discussion of stormwater). To encourage sheetflow and infiltration, stormwater should be dispersed through a shallow infiltration trench at the outer edge of the buffer (i.e., farthest from the wetland).

In residential areas, the pollutants of concern include sediments, metals, nutrients, and pesticides (from lawns). A combination of appropriate stormwater treatment and the use of a grass filter strip or grassy swale is recommended to pretreat and disperse surface runoff prior to introduction into a buffer.

In rural residential areas, the primary concern is pollutants such as nutrients and fecal coliform from animals. Many hobby farms in rural areas house livestock that should be kept out of wetlands and their buffers.

Stormwater Management

In addition to the introduction of pollutants, development adjacent to or upgradient from a wetland can alter the quantity and timing of surface water and/or groundwater inputs to the wetland. Considerable research has documented the adverse impacts from changes in wetland hydroperiod. The scientific literature also shows that upland buffers around wetlands do little to ameliorate these impacts except in wetlands with small contributing basins. (See Chapter 4 in Volume 1 for further discussion.)

Thus, it is imperative that adequate stormwater management practices be applied to any project adjacent to or upgradient from a wetland. This includes such practices as the construction of settling/detention facilities as well as treatment with a grassy swale. Inadequately detained and treated stormwater will overwhelm a buffer's ability to filter and treat pollutants. Direct surface discharges to buffers usually result in surface flow

that is channeled, which significantly reduces pollutant removal and can erode buffers. (Refer to Chapter 3 in Volume 1 for additional information on disturbances caused by urbanization.)

Wildlife Habitat

The two primary actions that can be taken to reduce impacts to wildlife habitat are to 1) ensure that the wetland and its buffer are connected to other habitat areas, and 2) reduce the intrusion of noise, light, people, and pets.

Ensuring connectivity is usually an issue of site design. Some wetlands are already isolated from other habitat areas, and it will not be possible to provide connectivity. On sites where wetlands are currently connected to other habitat areas, it is important to maintain that connectivity through corridors. While the scientific literature indicates that wildlife travel corridors should be as wide as 500 feet, it may be beneficial to provide a corridor of any size. Generally, corridors of less than 100 feet will only provide the cover needed for small mammals and less-sensitive birds.

Local wildlife experts should be consulted to determine the appropriate corridor design for a given site. Buffer averaging can be a useful tool to help ensure connectivity with adjacent habitat areas without unduly burdening the landowner.

Reducing the intrusion of noise, light, people, and pets can be accomplished in many ways. Buffers vegetated with dense trees and shrubs are effective at reducing intrusion of noise and light. Additionally, projects can be designed to reduce noise and light intrusion by locating noisy areas such as parking lots, playgrounds, and loading docks away from the edge of the buffer. Lighting can be designed and located so it points away from the wetland and its buffer. Fences or berms can be constructed to block noise and light. Fences can also be used to limit human and pet intrusion. Dense shrubs, particularly those with thorns, can be planted along the edge of a development to block noise and light and limit intrusion.

With forethought and careful planning, projects can be designed to reduce impacts to wildlife habitat. When combined with adequately vegetated buffers of sufficient width, these measures can help ensure that disturbance to wildlife use of a wetland is minimized.

8.3.8.7 Issues in Managing Buffers

Many steps need to be considered to ensure that, once established, buffers continue to provide the functions for which they were protected. These steps frequently are overlooked or given scant attention by local governments, resulting in the degradation of buffers over time.

Ownership of the Buffer

The issue of who owns the area included within a buffer is an important one. There are basically two options:

- The buffer area can be included in a separate tract or lot and held in common ownership by a homeowners association, agency, or non-profit organization
- The buffer can be included in lots owned by adjacent landowners

The second option is often pursued by a developer who wants to divide the buffer among individual lots in order to achieve a required minimum lot size. However, a study by Cooke (in Castelle et al. 1992) of buffer areas in two counties in western Washington showed that buffers that were owned by many different lot owners were more likely to be degraded over time. Even with easement language on each lot owner's deed specifying the buffer protection provisions, owners tend to clear buffer vegetation over time to expand lawns, build storage sheds, or serve other uses.

If the buffer area is not held in some kind of common ownership, it is much more difficult to take enforcement action against those landowners who encroach upon its boundaries. Therefore, when feasible, wetlands and their buffer areas should be placed in a separate, non-buildable tract that is owned and maintained by an organization that is dedicated to protecting the buffer. The boundaries of the tract should be clearly marked to help prevent unintentional encroachments.

Buffer Delineation, Recording, and Signage

Clearly delineating and marking a buffer area helps ensure that it is not degraded over time. Following project approval, and prior to site construction, the buffer should be measured, recorded on applicable legal documents, and clearly marked on the ground. During the construction phase, constructing a temporary sediment fence or "clearing limits" fence helps to ensure that the boundary is seen by equipment operators and that the wetland and buffer are protected from erosion during construction. Following construction, a fence may still be desirable to demarcate the boundary and to limit human and pet access and reduce the intrusion of noise and light.

Placement of signs along the buffer boundary is important for two reasons: to help mark the boundary, and to help educate landowners about the purpose and value of protecting buffer areas. In areas with high potential for human intrusion and degradation of the buffer, more extensive signage explaining the value of the buffer may be necessary to develop support for protecting the buffer. In addition to signs, brochures can be developed and distributed to adjacent landowners to explain the reasons why buffers and wetlands are protected and what human activities are allowed. Typically, applicants are responsible for developing and constructing fences and signs and for distributing educational materials. However, local jurisdictions can develop standards for fences, signs, and educational materials to ensure consistency and effectiveness. Maintenance of fences and signs is typically the responsibility of the adjacent landowner or a homeowners association, if applicable, or lies with the local jurisdiction.

Maintenance of Buffers

In cases where enhancement or restoration of a buffer is required, monitoring and maintaining the buffer area is essential. A monitoring/maintenance program should include evaluation of the success of plantings and provide for contingency measures if vegetation survival standards are not met. Responsibility for this is usually borne by the developer or landowner. It is also important to monitor buffer areas when human use is allowed or expected. Adverse effects of human access such as vegetation trampling, littering, and soil compaction or erosion should be monitored and corrected if found. Local jurisdictions can develop and implement a buffer maintenance and monitoring program but few have done so. Alternatively, applicants can be required to monitor and maintain buffers and submit regular reports to the local jurisdiction.

Enforcement

Simply designating and marking the boundaries of buffer areas is not sufficient to protect buffers in all cases. Regular observation of buffer areas is critical to determine whether vegetation and soils are being damaged and to ensure that adjacent development does not encroach on the buffer over time. Where illegal activities occur, enforcement actions to restore the buffer may be necessary. Local jurisdictions should establish a program to observe the buffer over time and take enforcement actions when necessary, similar to programs for private stormwater or wastewater facilities.

8.3.8.8 Buffers in Urban Areas

A frequent concern about buffers is their applicability to urban and urbanizing areas. The concerns generally fall into two categories: 1) the science on buffers comes largely from agricultural and forestry settings and is perceived to be irrelevant to urban areas; and 2) the need to maximize density of development in urban areas is in direct conflict with the protection of large upland areas around wetlands (and streams).

The concern over the relevancy of the literature on buffers to urban areas is largely unfounded. While most of the studies of buffer effectiveness occur in non-urban settings, the principles are the same. Buffers do not function any differently in urban settings than in rural settings. The same processes of sediment, nutrient, and toxics removal operate similarly in urban areas as they do in rural settings. However, a good stormwater management program can reduce the need for buffers to perform filtration functions, with the exception of lawns and landscaped areas which drain into wetlands rather than into stormwater collection areas.

The role of buffers in providing needed upland habitat for wetland species and in screening adjacent noise and light is also performed similarly. In fact, a case can be made that buffers in urban areas are even more important from a habitat standpoint because there is little other upland habitat available. The factors that may be different in urban areas are that urban wetlands may perform some functions at a lower level because of degradation, and the range of wildlife species utilizing urban wetlands may be smaller. However, remaining wetlands (and adjacent upland areas) in urban areas may, in fact,

function as habitat islands and be critical to many species. Generally, the protection of wildlife habitat functions of wetlands requires larger buffers than protection of water quality functions, particularly when state-of-the-art stormwater management is employed.

However, the best way to address the issue of buffers in urban areas is to conduct a landscape analysis and develop a subarea plan that identifies, prioritizes, and protects the most important wetland, riparian, and upland habitats (see Chapters 5 through 7 of this volume for additional discussion). Maintaining and restoring connections between wetland, riparian, and upland habitats is key to protecting wildlife. A landscape analysis can help identify existing connections that should be protected as well as areas where connectivity can be restored. Combined with standards for low impact development and state-of-the-art stormwater management, this kind of approach could result in smaller buffers around the other critical areas that are not providing vital habitat. The studies should always be confirmed on the ground during project review.

The issue of balancing wetland protection with competing mandates in the GMA is a legitimate one that can be addressed in a number of ways. A buildable lands survey with a good wetlands inventory can provide important information on the actual conflicts that may exist (rather than a perceived conflict). Provisions to allow density trading from buffers to adjacent or nearby developable lands can help.

8.4 Monitoring the Effectiveness of the Regulatory Component of a Protection Program

A local government should be able to track the effects of decisions made in the implementation of its critical areas ordinance and produce regular status reports for the public to review. This is an important step to demonstrate that the goals and requirements of the GMA are being met. The following are examples of questions that should be answered:

- How many wetlands have been affected by permit decisions?
- How many acres have been filled?
- How much and what type of mitigation was required?
- How many requests for buffer reductions have been granted? (Associated questions include: how many projects included buffer increases, how narrow/wide was the buffer reduction/increase, how many acres of buffers were involved in buffer reduction/increases, and was off-site mitigation required as part of the buffer reduction?)
- How many projects included provisions for wildlife corridors to connect adjacent wetlands? (An associated question is: how many acres of upland buffers were affected by these buffer considerations?)

- How well have the mitigation projects succeeded in replacing wetland acreage and function?
- How many variances have been issued? (Associated questions include: how many exemptions have been granted, and how many violations have occurred?)
- How many emergency waivers have been issued? (An associated question is how many required after-the-fact mitigation?)
- How much non-compensatory restoration is being done?
- How many acres of impacts have been avoided, by basin?

Without the collection of these data, a local government cannot evaluate how well it is doing in moving toward a goal of "no net loss goal" for its regulation. Furthermore, these data are an integral part of a local government's adaptive management approach because they allow decision-makers to improve the regulations based on real data.

Monitoring does not have to be complicated but should be linked to the goals established for the regulations (discussed in Section 8.2). A regulation with rigid requirements will not require as much data collection as one that relies on case-by-case flexible implementation. Flexible programs by design represent a higher risk to wetlands because case-by-case decision-making can lead to greater cumulative effects than more rigid regulatory programs. (See Balancing Predictability with Flexibility in Section 8.2.1). Many of these data can be collected as part of follow-up work for permit compliance.

This chapter has not outlined the minimum features to include for monitoring because they are entirely dependent on what language is adopted in code. See Chapter 12 of this volume for additional information on monitoring and adaptive management.

Chapter 9

Prescribing Solutions: Non-Regulatory Tools

9.1 Introduction

Non-regulatory tools, discussed in this chapter, provide important solutions to protecting and managing wetlands, and they comprise a key component of any wetland protection program. Developing non-regulatory approaches is a part of Step 2, Prescribing Solutions, in the four-step framework discussed in this volume (Figure 9-1).

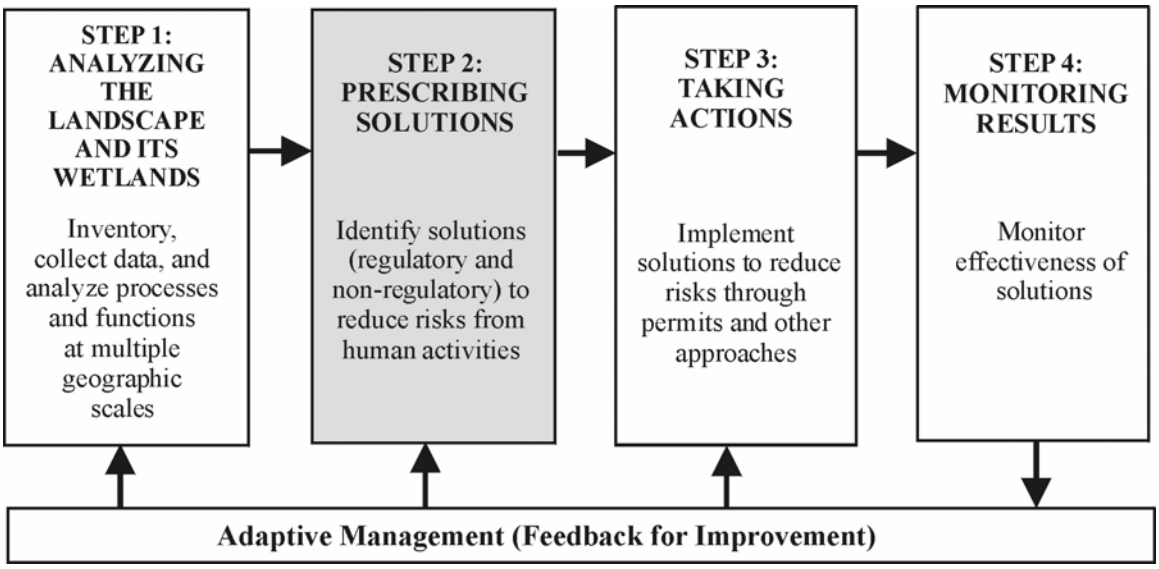


Figure 9-1. Developing non-regulatory tools is part of Step 2 in the four-step framework for protecting and managing wetlands (shaded box).

Non-regulatory activities are voluntary in nature and complement land-use regulations used to protect and manage wetlands. As mentioned in Chapter 8, regulations alone cannot adequately protect wetlands. For example, regulatory tools, such as buffers and compensatory mitigation, establish standards for protecting and managing resources when a land-use action is proposed on a specific site. Non-regulatory approaches, including preservation, conservation, restoration, and incentives, can be used on both a site-specific basis and can be applied to an entire management area.

In addition, non-regulatory activities, as a part of a wetland protection program, are important because they:

- Reduce risk of loss and/or degradation of critical wetlands (*Critical* in this context means those wetlands that provide essential contributions to the landscape or to society)

- Provide options for landowners and governments in the early stages of making decisions about the conservation of landscape processes and wetlands (see Section 9.2 for a description of "conservation")
- Can address large areas of the landscape and thus be effective in protecting landscape processes and wetland functions
- Meet the needs of those landowners who prefer a voluntary option
- Provide a proactive approach to improve landscape conditions that incorporates willing landowner and community participation
- Help to achieve no net loss and make eventual gains in wetland function and acreage
- Have financial and tax benefits

Therefore, the goal of protecting wetland functions and values, and associated landscape processes, is best accomplished when using wide range of activities: An effective protection program needs to include both regulatory and non-regulatory components.

Developing and incorporating non-regulatory tools can occur at any stage of a jurisdiction's planning process. However, non-regulatory efforts will be most effective if they are integrated in the early stages of planning; for example, during the formation of a Green Infrastructure plan (Chapter 6). During these early stages, the information from a landscape analysis (Chapter 5) can be used to help the jurisdiction assess options for maintaining landscape processes into the future and to decide which options provide the most desirable outcome. The non-regulatory component of a wetland protection program can then be used as a means to help achieve this outcome.

9.2 Three Categories of Non-Regulatory Actions to Consider

Non-regulatory actions fall into three general categories:

- **Preservation** provides a way to set lands aside so that they are not actively used for human activities
- **Conservation** allows for human activities but limits their impacts by applying best management practices and other measures to protect resource functions
- **Restoration** serves to return the land to a condition in which it performs functions and contributes to landscape processes in a manner similar to past conditions. For wetlands, the key step is re-establishing the appropriate water regime

Preservation, conservation, and restoration are actions that are used in both regulatory and non-regulatory contexts. In the regulatory context, these terms may represent actions that are more limited in scope. For example, preservation may be defined narrowly. As described in the recent regulatory guidance by Ecology and the U.S. Army Corps of Engineers (April 2004), preservation can be used only under specific conditions such as preserving a wetland that is under immediate threat. Comparatively, in a non-regulatory context, preservation can be applied whenever a particular wetland is considered of high importance thus warranting permanent protection to remove any future threats.

As previously mentioned, conducting a landscape analysis (see Chapter 5) is very helpful in determining how each of these types of non-regulatory actions can supplement regulatory tools to ensure that landscape processes are maintained. Generally, all three may be desirable for maintaining landscape processes. However, some jurisdictions may find that only one or two of these actions will be the primary focus, while others may incorporate all three.

Each of these non-regulatory actions can be used at various locations within a jurisdiction, and a landscape analysis clarifies which non-regulatory action is most relevant to respective locations. For example, a particular sub-basin may be dominated by agriculture and have water quality problems but have a high potential for water quality improvement if wetlands were restored. In this case, the focus of non-regulatory efforts could be improving *conservation* through application of best management practices in agricultural areas while initiating *restoration* of wetlands where landowners are willing. In another sub-basin with high growth rates, the need might be to use *preservation* of wetlands that provide high habitat functions at the fringe of an urban growth area.

Understanding the landscape processes therefore helps with the design of non-regulatory actions and implementation through non-regulatory tools. Appropriate tools can then be applied broadly throughout the entire management area or selectively in the areas in which they are most relevant.

A brief overview of preservation, conservation, and restoration in the non-regulatory context is provided below. The specific tools that can be used to implement these non-regulatory actions are discussed in more detail later in this chapter and in the chapter on implementation (see Chapter 11).

9.2.1 Preservation

In their paper on *Conservation of Biodiversity in a World of Use*, Redford and Richter (1999) state:

> *(1) different degrees of human use or alteration result in differential conservation of biodiversity components, (2) some components and attributes of biodiversity are more sensitive to human use than others, and (3) only extremely limited use or virtually no alteration will protect all components.*

Thus, a key role for preservation is to permanently protect those areas that are so highly sensitive to use, so rare or irreplaceable, or so critical to landscape processes that their degradation or loss cannot be afforded.

Preservation employs the permanent protection of land through either:

- Full-fee, title ownership of all property rights
- Partial ownership of the development and/or use rights to the land through a conservation easement

Conservation easements serve to protect the land into the future (often in perpetuity) by restricting the property deed with conditions for preservation. A "holder" of the conservation easement (such as a land trust) is designated to enforce the terms of the easement through time. Short of full-fee purchase, conservation easements are the strongest legal protections available for land preservation.

9.2.2 Conservation

As previously mentioned, conservation allows for the active use of the land while maintaining landscape processes over time. Conservation applies to areas used for resource production. For example, owners of land used for agriculture and forestry are encouraged to apply best management practices such as riparian and wetland buffers.

Conservation also applies to urbanizing areas where changes in land use might adversely impact a resource. Conservation of wetlands is a concern in urbanizing settings where adjacent use by humans affects wetlands and buffers. Improved management practices on the part of homeowner associations, private landowners, and land developers can help to reduce impacts. Education and outreach are vital in promoting the use of appropriate conservation tools.

9.2.3 Restoration

Restoration provides a method for recovering landscape processes and wetland functions that have been lost or degraded. While mitigation actions in a regulatory context compensate for the loss of acreage or functions as a result of a current development activity, they are not designed to recover wetland acreage or functions that have been lost in the past. However, voluntary (non-compensatory) restoration can restore acreage and functions lost as a result of past land uses.

Some types of wetlands have been more altered than others due to the relative ease of draining and converting them to other uses, as well as other factors. The net result has been a homogenization (i.e., reduction in diversity) of the remaining wetlands and a shift in the relative proportion of habitat types and functions performed (see Chapter 4 in Volume 1). Wetlands have also been affected in terms of their distance from each other, the connectivity of habitat between them, and their location, distribution, and position in the landscape. This affects the dispersal of animals and plants between wetlands and how wetlands affect water quality, flood attenuation, and hydrologic processes (Bedford 1999,

citing Brinson 1993). These and other factors need to be considered as part of non-regulatory, wetland restoration efforts.

9.3 Fiscal Benefits of Using Non-Regulatory Tools

One of the most important considerations in using non-regulatory actions and tools in a wetland protection program is fiscal savings. Fiscal savings fall into two categories: 1) the efficiencies resulting from the maintenance of services performed by "green infrastructure", and 2) the savings gained by implementing actions at the optimal geographic location to effectively address problems in the landscape or watershed.

As discussed in Chapter 6, landscapes and their wetlands provide an array of green infrastructure services (e.g., flood attenuation, improvement in water quality, the recharge of water, etc.) Studies have indicated that protecting existing green infrastructure, instead of having to engineer and build "grey infrastructure" to replace the green infrastructure, actually saves money (see Chapter 6). For example, despite the common perception that non-regulatory programs are too expensive, money spent to purchase land for permanent preservation and thus protect its functions and services can result in a significant financial savings over the long term. Therefore, when considering the goals of non-regulatory efforts, the jurisdiction should understand these financial implications.

Cost efficiencies are increased when the non-regulatory actions and the funds to implement such actions are targeted to the ideal or optimal locations, such as "problem" areas within sub-basins or watersheds which have been identified using a landscape analysis. (The analysis can also help identify the appropriate non-regulatory actions to use to help correct the problems.) Thus, targeting the right action in the right place is a wise and effective use of funds. Also, prioritizing which locations need attention first helps to minimize further loss of landscape processes, thereby retaining existing green infrastructure.

An active education initiative that includes fiscal benefits is essential. As previously mentioned, it is important that citizens and political leaders are aware of fiscal benefits. They should understand that short-term costs to preserve land, and any loss of tax revenues on that land, will be offset over the long term by savings from the functions and services the land provides. In addition, it is also important to know that the cost of providing built infrastructure can out pace tax revenues generated by new development. Conveying this information to local leaders and citizens increases understanding and promotes support for non-regulatory programs.

Jurisdictions in several parts of the country have conducted fiscal analyses to document the cost savings that a non-regulatory approach can provide. Further information on these savings can be found in Chapter 6 and Appendix 6-A.

9.4 Important Considerations When Incorporating Non-Regulatory Tools

When establishing the non-regulatory components of a wetland program, developing the overall vision and the goals to be accomplished should be the first step. A clear foundation on which to build the non-regulatory effort will already have been laid if a Green Infrastructure plan has been prepared or the community has engaged in an Alternative Futures analysis (see Chapter 6). From there, the identification of the locations and type of actions (conservation, preservation, and restoration) for specific sites can readily be determined.

In addition to the vision and goals, several practical considerations must be addressed to initiate the non-regulatory components. The following are some essential parts of an effective non-regulatory effort:

- Staffing (e.g., coordinator, support staff, staff for site management, etc.)
- Identifying, mapping, and prioritizing where non-regulatory tools will be applied
- Creating partnerships with organization, government agencies, and others to help sponsor local projects
- Identifying a recipient to hold and manage land
- Obtaining funding for local actions
- Providing incentives to encourage participation by landowners
- Educating and involving the public and providing technical outreach to the public and landowners
- Monitoring project sites and the overall success of the non-regulatory actions

Most of these are discussed in the implementation portion of this document (see Chapter 11). However, an overview of key funding mechanisms and landowner incentives are provided in Section 9.4.1 in this chapter.

For more details on funding and incentives, as well as complete coverage of landowner conservation tools, please refer to the *Exploring Wetlands Stewardship Guide: A Reference Guide for Assisting Washington Landowners and Communities* (Rubey 2004). http://www.ecy.wa.gov/biblio/96120.html or http://www.ecy.wa.gov/pubs/96120.pdf

9.4.1 Funding Mechanisms

Purchasing land to preserve it, whether in *full-fee title* or *less-than-fee development rights*, requires some form of local revenue. Full-fee title (also *fee-simple, full purchase, or full-interest*) is the acquisition of all rights to a parcel of land, including development rights, mining rights, timber rights, etc. *Less-than-fee title* (or *partial-interest purchase*) is the acquisition of some of the rights to a parcel of land but not all (for example, the acquisition of development rights only).

Common forms of financing for preservation (and other conservation measures) include property taxes, sales or use taxes, real estate transfer taxes, impact fees, special assessment districts, general obligation bonds, and revenue bonds. The ability to raise local revenue for conservation allows the money to be used as a match to obtain additional funds through state or federal grants, thus enhancing the potential for funding local conservation.

In *Local Greenprinting for Growth*, the Trust for Public Lands and National Association of County Officials (2002) provide the following table which summarizes common sources of conservation financing with a list of pros and cons for each.

Table 9-1. Common sources of financing for conservation.

Financing Source	Definition	Pros	Cons
Property tax	Tax on real property paid by commercial and residential property owners	Steady source of revenue Relatively easily administered Tax burden is distributed Small increases create substantial funding Popular with voters when focuses on compelling needs of land conservation	Competition for other public uses Overall concern among taxpayers about higher rates
Sales & use tax	Tax in sales of goods and services	Relatively easy to administer Low reporting costs Can generate large sums, even at small tax levels May be paid in part by out-of-town visitors Can tap into tourism profits generated by open space amenities May include exemptions such as food & medicine	Revenues can drop when economy slows Considered regressive

Financing Source	Definition	Pros	Cons
Real estate tax	Tax on the sales of property paid by either the buyer or seller at time of transfer	Funds can be substantial Connection between taxing new development and protecting open space	Initial opposition from real estate/development interests can make passage difficult Less predictable revenue stream
Impact fees	One-time fee paid by developer to offset costs of infrastructure needed for new development	Connection between taxing new development and protecting open space	Parks and open space projects might require direct link to new development
Special assessment district	Special tax district for area that benefits from an open space area	Users finance acquisition and management Predictable revenue stream Accountability in government spending Sense of ownership of and responsibility for area parks and services Can establish in small increments May be able to set own election date and process	Possibly time consuming to implement Overall concern among taxpayers about high rates
General obligation bond	Loan taken out by a city or county against the value of the taxable property	Allows for immediate purchase of open space, locking in land at current prices Distributes the cost of acquisition over time	Extra costs associated with the interest accrued through borrowing Voter approval required, sometimes by supermajority levels
Revenue bond	Loan paid from proceeds of a tax levied for the use of a specific public project or with proceeds of fees charged to those who use the financed facility	Not constrained by the debt ceilings of general obligation bonds Voter approval rarely required	More expensive than general obligation bonds
Source: Trust for Public Lands and National Association of County Officials (2002).			

9.4.1.1 Common Forms of Conservation Revenue in Washington

In Washington, one of the most common forms of conservation revenue comes from the Conservation Futures Levy. RCW 84.34.200 and RCW 84.34.230 established the authorization for any Washington county to administer a real property tax in the amount of $0.0625 per $1000 of assessed valuation. This provision for conservation fund-raising at the local level is quite unique in the country and presents an opportunity for local communities to acquire and preserve wetlands and other areas that provide green infrastructure services. However, it is currently used by only a third of the counties in the state. Those counties that are using it have been quite successful, over the years, in preserving important lands within their communities.

General obligation bonds and impact fees have also been frequently used by local jurisdictions in Washington for conservation purposes. General obligation bonds are generated by local governments, and the revenue can be used to finance conservation activities, with the principle repaid over time. Impact fees are charged when a site is developed, and the fees can be dedicated to finance conservation of open space to compensate for losses caused by the development.

9.4.1.2 Land Banking

Land banking is a tool that raises funds from land acquisition by placing a tax on real estate sales within the jurisdiction. It was first initiated in Massachusetts in 1984. In 1990, Washington State authorized a real estate excise tax under RCW 82.46.070 for the establishment of land banks. This authority allows counties to impose a property transfer tax where tax proceeds are used exclusively for fee-simple or less-than-fee acquisition and/or maintenance of conservation areas. Initiated either by resolution of the county legislators or by the public through a petition, the excise tax is approved by citizen vote.

Only one Washington jurisdiction, San Juan County, has established this form of tax revenue. The San Juan County Land Bank, established in 1990, has successfully completed conservation easements on 17,000 acres and fee purchase on approximately 900 acres. To date, they have received between $18 million and $19 million in revenue. After its original authorization period of 12 years, the program was extended following active campaigning by local real estate agents. The land bank was reauthorized with a 74% approval by county residents (Shaffer, San Juan County Land Bank, personal communication 2003).

Communities in Cape Cod are also moving toward establishing land banks to address growth while protecting their resources. This is discussed in a paper by Cummiskey (2001) in which the author describes the development of a land bank in Cape Cod during the late 1990s. Cummiskey states that despite the existence of numerous tools such as building restrictions, zoning bylaws, subdivision regulations, and historic district designations, accelerating development continued to threaten shorelines and other resources. This necessitated the addition of other management tools to protect the

lifestyle and natural qualities of Cape Cod. The author points out that more cities and towns in Massachusetts and other states are considering land banks as growth management tools to address coastal development, as well as urban, suburban, and rural sprawl.

9.4.2 Landowner Incentives

It is important to have a broad range of tools available to address the needs of each individual landowner. Tools that incorporate some form of market-based incentive help to motivate conservation. With this in mind, local governments can conduct full-interest and partial-interest land purchases (conservation easements), and/or they can establish tax-based incentives and incentive zoning with tradable development rights and cluster or higher density alternatives. As previously mentioned, it is best to institute these tools early in the planning process to allow for their optimum use. A few are discussed in this section as well as Section 9.4.3, Incentive Zoning and Regulation.

9.4.2.1 Incentive-based Tools: Open Space Current Use Taxation

"Land taxes often act as a disincentive to landowners wishing to conserve natural areas" (Edwards 1994). In *Developing America's Natural Areas Market*, Edwards states that government can assist in conservation by removing existing disincentives to private protection of land and by assisting in developing a market for areas that are maintained as "natural areas" rather than relying on private conservation programs alone.

Washington's Open Space Current Use Taxation (CUT) Program (RCW 84.34) removes such disincentives. It allows local governments to offer landowners voluntary enrollment of undeveloped property in their county's program. The open space element of the CUT program provides reductions in property tax for the conservation of features of natural resources considered of value to the community at large. The optional Public Benefit Rating System (PBRS) allows the local jurisdiction to identify which "features" of natural resources that will be considered in the program, targeting those that are deemed most beneficial to the community. In the PBRS, the specific criteria related to these features are clearly defined and are used to score a property. These criteria assess its eligibility for enrollment in the CUT program and determine the level of tax reduction. The PBRS therefore allows flexibility to shape the CUT Program to protect landscape processes by targeting features that help maintain those processes.

Applying the Public Benefit Rating System as a Watershed Action Tool (Rubey 1999) provides guidance for local jurisdictions who wish to use the PBRS more strategically. The guidance includes specific criteria to identify properties containing natural resource features that will help ameliorate water quality problems, flooding, habitat loss, etc.

Using the PBRS criteria can even be tailored to address the needs of different sub-basins within the overall jurisdiction. A tailored PBRS is an ideal tool when implementing Alternative Futures or Green Infrastructure plans.

9.4.2.2 Other Incentive-Based Tools

There are other incentive-based options, listed below and discussed briefly, from which landowners can benefit by protecting and enhancing ecosystems including wetlands:

- Transferring property title with compensation
- Retaining ownership and managing the property
- Conservation in the context of development (see Section 9.4.3)

The reader is referred to *Exploring Wetlands Stewardship, A Reference Guide for Assisting Washington Landowners and Communities* (Rubey 2004) for a detailed discussion of these options, as well as the other conservation and stewardship issues. For example, Rubey (2004) covers the grant programs available to assist implementing preservation and restoration projects. The document also includes a complete listing of state and federal programs, with many local programs, as a resource to correspond non-regulatory wetland projects with potential funding.

Transferring Property Title with Compensation

Transfer of property title <u>with</u> compensation is used in the context of funding mechanisms for the purchase of property title. There are numerous non-regulatory tools available which can be employed to bring a purchase of land to closure. These include bargain sales, installment sales, land exchanges, options to buy, reserved life estate, right of first refusal, self finance, and tax deferred exchange. *Transfers of title <u>without</u> compensation* would include different forms of donations such as bequest, leaseback, outright, and reserved life estate or remainder interest.

Retaining Ownership and Managing the Property

A landowner can retain ownership and management of the property while providing conservation through a *conservation lease.* When purchase of property and/or a conservation easement (which provide permanent protection) are not available or acceptable to a private landowner, another less-permanent option is a conservation lease (also called a *resource conservation agreement*). The conservation lease offers tax relief or a conservation management payment as the incentive for conservation.

Conservation leases are often a preferred approach for agricultural or timber landowners. Main et al. (1999) point out that the system of taxation in the United States discourages agricultural landowners letting lands remain fallow when they are marginal for agriculture (e.g., wetlands), thus fueling the conversion of wetland habitats and resulting in loss or fragmentation. A conservation lease can offer some compensation to these landowners for conserving lands, rather than using them as marginal farmed lands.

Other options for retaining ownership with conservation are mutual covenants, open space current use classification, and undivided interest. As mentioned previously, more details on all of these tools are provided in *Exploring Wetlands Stewardship, A Reference Guide for Assisting Washington Landowners and Communities* (Rubey 2004).

9.4.3 Incentive Zoning and Regulation

There are also some tools that provide conservation incentives to landowners within the context of regulating development. *Incentive zoning* operates within the regulatory component of an existing protection program to influence development toward preservation of open space. One example is clustered development. Clustered development requires that development be placed on a small portion of the parcel, thereby retaining the balance as open space. Incentives for denser development of up to 20% have been allowed in some communities where a larger number of lots than usually allowed are exchanged for dedicating additional open space (Smart Growth Network 2002).

The transfer of development rights (TDR) is also frequently considered. Basically, TDR moves the allowed rights of development from a less desirable site (with higher resource functions or values) to a less sensitive site (more suited to development). A strong real estate market is necessary to fuel the transfer, and very abundant and uncontroversial sites for the transfer (receiving sites) must exist. Also, the zone proposed for preservation must have comparatively lower activity in regard to the real estate market. For example, McGilvray et al. (1985) found that saltmarsh lagoons in coastal communities were hard to preserve using TDR because of the high property values associated with ocean views.

Brabec and Smith (2002) studied TDR, purchase of development rights (PDR), and cluster development in the eastern United States in regard to fragmentation in agricultural lands. They found that TDR and PDR worked best for maintaining viable agricultural practices and preventing isolation and reduction in size. Because the area they studied had a strong transfer market, the TDR tool performed well. The TDR resulted in the aggregation of 91% of the parcels into protected areas with an average size of 465 acres. The PDR programs aggregated 75 to 88% in the various communities studied. With the cluster program, 36% of the sites were aggregated (64% isolated) and averaged only 30 acres in size.

Avoiding fragmentation is a key aspect of any conservation strategy, so this study provides valuable insights regarding the potential of these tools for wetland applications. The analysis and comparison of these three incentive-based, regulatory tools reinforces the importance of using and coordinating a variety of non-regulatory and regulatory tools to achieve optimal results (Brabec and Smith 2002).

Chapter 10

Prescribing Solutions: Characterization of Risks

10.1 Introduction

This chapter builds on previous chapters by discussing the importance of characterizing the risks that are inherent in the solutions developed in Step 2 of the framework of a wetland protection program (Figure 10-1). The scientific information available indicates that as human populations grow, we increasingly impact the environmental processes that maintain the functions of our natural resources (Dale et al. 2000). We have not yet found the ways by which we can completely eliminate impacts in the face of our growing population. Therefore, the goal for protecting and managing our natural resources, including wetlands, should be to minimize the risk to resources from our activities, thereby, also reducing cumulative impacts (Cairns 1997).

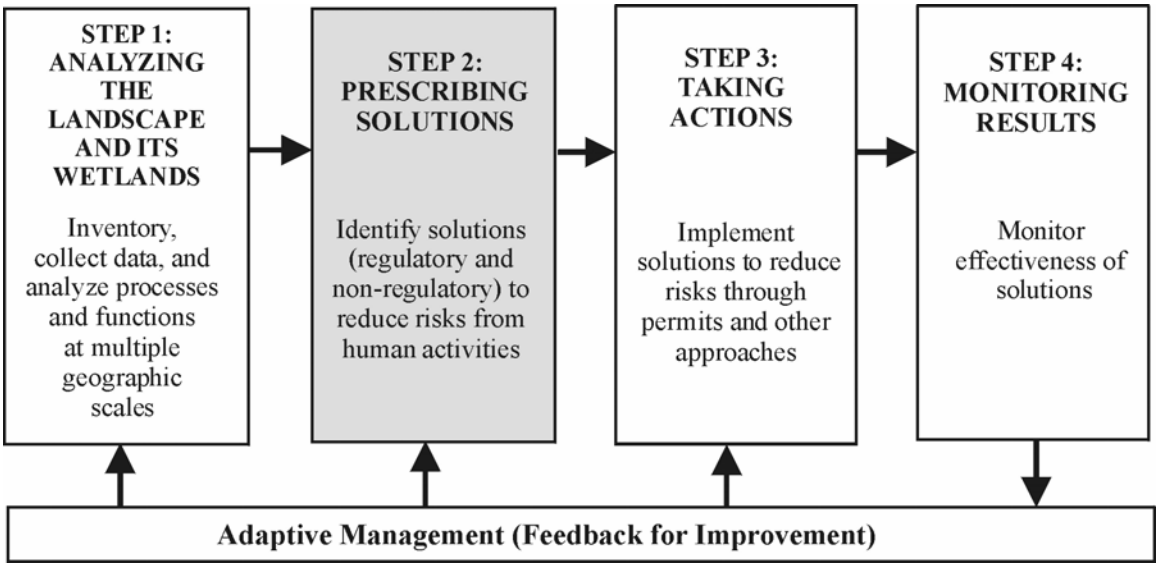


Figure 10-1. Characterizing risks is part of Step 2, Prescribing Solutions, within the four-step framework recommended for protecting and managing wetlands (shaded box).

Risks are minimized by first understanding the risks inherent in actions taken and then developing a program that minimizes those risks. The first step, developing an understanding of risks, is called a *characterization of risks* or *risk assessment.* A characterization of risks considers the impacts and benefits that result from actions that are proposed to be taken. A characterization provides a way to develop, organize, and present scientific information so that it is useful in making decisions about future land

uses. The characterization can provide a basis for comparing different options for protecting and managing wetlands, and it should enable decision-makers and the public to make more informed decisions about wetland resources.

In a characterization of risks, local jurisdictions should consider whether the plans, policies, and regulations they are developing will minimize the risk of cumulative impacts to the functions and values of natural resources including wetlands. If the risk to the wetland resource is still high with the proposed actions in place, the jurisdiction should identify additional measures that can be taken to reduce the risk.

The descriptions of impacts and benefits used for a characterization of risks may range from qualitative judgments to numeric estimates of probability. The guidance for characterizing risks described in this chapter can be applied to both qualitative and quantitative approaches. Local governments are encouraged to characterize the risks of each policy, zoning plan, regulation, exemption, incentive, restoration program, etc. based on the impacts or benefits it poses to landscape processes and the wetland resource.

For example, a regulation that represents a relatively low risk to wetlands is to set a standard 300-foot buffer around every wetland. This is not necessarily recommended because it does not take into account differences among wetlands, but it would significantly reduce the risk to wetlands from human activities in the immediate vicinity. Such a standard could be characterized as having "low risk." On another extreme, a local government may apply a 30-foot buffer around all their wetlands, which could be characterized as "high risk." The review of the literature indicates that a 30-foot buffer alone is not large enough to protect most functions of a wetland. By consistently applying a 30-foot buffer around all wetlands, the functions of wetlands in the jurisdiction will be degraded and result in cumulative impacts such as "space crowding" and "fragmentation" (see Chapter 7 in Volume 1).

There are no simple, unambiguous methods to characterize the risks of different actions that can be taken by local jurisdictions to protect wetlands. The methods are being developed and are still quite subjective. The departments of Ecology and Fish and Wildlife recommend, however, that local jurisdictions try to characterize the risks of their actions. A subjective characterization is better than none at all if the choices and decisions made are documented. The following section outlines one type of process by which the risks can be characterized and documented.

10.2 Risk and the Growth Management Act

A characterization of risks of proposed solutions for protecting and managing wetlands is not a statutory requirement of the Growth Management Act. However, the procedural guidelines (WAC 365-195) adopted by the department of Community, Trade, and Economic Development (CTED) in 2001 recommend that risks to critical areas resulting from the adoption of policies and development regulations be identified. The risks should be identified if the policies and regulations depart from the best available science

established in the record or where adequate scientific information is lacking. Following are relevant excerpts from WAC 365-195.

The following section describes the process that should be used when a local jurisdiction determines that it cannot, for some reason, include the best available science in its development policies and regulations. In these cases, the clear identification of risks to the functions and values of critical areas is essential (see bolded language below).

WAC 365-195-915 Criteria for including the best available science in developing policies and development regulations.

(1) To demonstrate that the best available science has been included in the development of critical areas policies and regulations, counties and cities should address each of the following on the record:

(a) The specific policies and development regulations adopted to protect the functions and values of the critical areas at issue.

(b) The relevant sources of best available scientific information included in the decision-making.

(c) Any nonscientific information -- including legal, social, cultural, economic, and political information -- used as a basis for critical area policies and regulations that depart from recommendations derived from the best available science. A county or city departing from science-based recommendations should:

(i) Identify the information in the record that supports its decision to depart from science-based recommendations;

(ii) Explain its rationale for departing from science-based recommendations; and

(iii) Identify potential risks to the functions and values of the critical area or areas at issue and any additional measures chosen to limit such risks. State Environmental Policy Act (SEPA) review often provides an opportunity to establish and publish the record of this assessment.

(2) Counties and cities should include the best available science in determining whether to grant applications for administrative variances and exemptions from generally applicable provisions in policies and development regulations adopted to protect the functions and values of critical areas. Counties and cities should adopt procedures and criteria to ensure that the best available science is included in every review of an application for an administrative variance or exemption.

In addition, the WAC addresses situations where there is a lack of adequate scientific information upon which to base development policies and regulations.

WAC 365-195-920 Criteria for addressing inadequate scientific information.

Where there is an absence of valid scientific information or incomplete scientific information relating to a county's or city's critical areas, leading to uncertainty about which development and land uses could lead to harm of critical areas or uncertainty about the risk to critical area function of permitting development, counties and cities should use the following approach:

(1) A "precautionary or a no-risk approach," in which development and land use activities are strictly limited until the uncertainty is sufficiently resolved; and

(2) As an interim approach, an effective adaptive management program that relies on scientific methods to evaluate how well regulatory and non-regulatory actions achieve their objectives. Management, policy, and regulatory actions are treated as experiments that are purposefully monitored and evaluated to determine whether they are effective and, if not, how they should be improved to increase their effectiveness. An adaptive management program is a formal and deliberate scientific approach to taking action and obtaining information in the face of uncertainty. To effectively implement an adaptive management program, counties and cities should be willing to:

(a) Address funding for the research component of the adaptive management program;

(b) Change course based on the results and interpretation of new information that resolves uncertainties; and

(c) Commit to the appropriate timeframe and scale necessary to reliably evaluate regulatory and non-regulatory actions affecting critical areas protection and anadromous fisheries.

10.3 A Process for Characterizing Risks

Ideally, local jurisdictions will be taking steps to protect and manage wetlands at the different geographic scales discussed in previous chapters. The goal is to reduce risks to natural resources to levels that can be considered acceptable. Please note however, that this document does not try to establish what might be considered an “acceptable risk” to the wetland resources. This has to be determined by each jurisdiction based on the laws and policies they are trying to implement and the functions and values of the resources they are trying to protect.

Whether planning is done at the scale of the management area or the site itself, the risks can be characterized by answering a series of questions about the actions being proposed:

- What disturbances or benefits will result from a proposed action (e.g., change in land use through zoning, regulations that affect how land is used, restoration plan, etc.)?
- What risks do these disturbances pose to the functions and values of wetlands?
- What measures are proposed to minimize the risks or replace the resource at risk?

10.3.1 Identifying the Environmental Disturbances or Benefits that Result from Proposed Actions

Chapter 3 in Volume 1 summarized the different types of environmental disturbances that can occur as humans modify ecosystems to meet their needs. The plans, regulations, restoration actions, etc. taken by local jurisdictions to direct and control the use of land can also be characterized in terms of the disturbances they may allow or rectify. The first step in characterizing the risk, therefore, is to identify how a specific type of land-use activity may cause an environmental disturbance or benefit.

The characterization of risks should start with a thorough list of the different actions being proposed to protect and manage wetlands (e.g., zoning categories, regulations, exemptions, ordinances, etc.). Each of these has the potential to cause an environmental disturbance by allowing certain land uses to occur or by changing the current land use to some other one.

The types of environmental disturbances identified in Volume 1 include:

- Changing the physical structure within a wetland (e.g., filling, removing vegetation, tilling soils, compacting soils)
- Changing the amount of water (increasing or decreasing the amount)
- Changing the fluctuation of water levels (frequency, amplitude, direction of flow)
- Changing the amount of sediment (increasing or decreasing the amount)
- Increasing the amount of nutrients
- Increasing the amount of toxic contaminants
- Changing the acidity (acidification)
- Increasing the concentration of salt (salinization)
- Fragmentation of habitats
- Other disturbances (noise, etc.)

For example, a jurisdiction may be revising their zoning ordinance and zone an area that was previously rural as urban to accommodate growth. The potential disturbances that may result from this action include changing the patterns of water flow, increasing the input of nutrients and toxic compounds, and causing fragmentation of habitat on the landscape. Another area may be re-zoned from low- to high-density residential. This would result in changes in the patterns of water flow, introduction of toxics from lawn care, and increase the disturbance to wildlife by introducing more predation by pets.

An example of disturbances caused by management actions at the site scale is allowing single-family residences, as an exemption, in the buffers of wetlands. Such an action

would allow disturbances such as the introduction of nutrients and toxics from lawn care and pets, and possibly a change in water regime to occur.

Table 10-1 provides an example of how the environmental disturbances and risks associated with various management actions could be summarized.

Table 10-1. An example of a table summarizing risks associated with common land-use actions.

Action	Disturbance Caused by Allowing Action	Risk of Disturbance to Wetland Functions and Values
Urban zoning in a recharge area	Change in water regime, increased surface runoff, and less infiltration	High for wetlands fed by groundwater and for those that will receive the direct runoff from paved surfaces
Permit fill of wetlands	Change in structure of wetland and loss of wetland area	High for functions within wetland
300-ft buffers for wetlands with a high habitat score	Minimal	Low
200- to 300-ft buffers for high habitat score	Will allow some disturbance of wildlife and limit upland zones suitable for amphibians	Moderate
< 200-ft buffers for high habitat score	Significant disturbance of wildlife	High

10.3.2 Identifying the Risks of Disturbances to the Functions and Values of Wetlands

Not all human-caused disturbances will result in significant impacts to the functions and values of wetlands in a jurisdiction. Once all the possible disturbances have been identified (as discussed in the previous section), the next step in the characterization of risks is to identify which of the proposed land-use actions have the greatest risk of impacting wetlands (see third column in Table 10-1). This task is best done using maps, especially at the scale of the management area. The process described in Chapter 5 for performing a landscape analysis can be used to identify what parts of the landscape within the management area are sensitive to the different types of disturbance and risks that may be generated by proposed land use actions.

For example, if wetlands are located in an area zoned as urban or residential and the area serves to recharge an aquifer, then the risk to these wetlands is high as a result of the impervious surfaces created. Creating impervious surface in areas where water infiltrates rapidly into groundwater creates a risk to wetlands that rely on that groundwater.

Regulations that focus on the wetland sites themselves (site scale) can also be analyzed in terms of the risks they pose to wetlands. Using the example used previously, the exemption of single-family residences in the buffer of a wetland would pose a much

higher risk to wetlands that have a high habitat value than those that function poorly as habitat.

Corrective actions (regulatory and non-regulatory) should also be considered when assessing risks. Areas that are proposed for restoration or preservation, for example, should be considered in terms of how these actions might reduce the risks to wetlands. For example, the restoration (by non-regulatory means) of a diked field to a floodplain wetland identified in the landscape analysis as important for restoring hydrologic processes, reduce the overall risk to the jurisdiction from losses of hydrologic functions in other locations targeted for development.

10.3.3 Proposing Measures to Minimize the Risk or Replace the Resource at Risk

If the characterization of risks indicates that some of the policies, regulations, or plans pose a risk to the functions and values of wetlands in a jurisdiction, it is important to identify what actions can be taken to minimize this risk. Using a previous example, if a comprehensive plan calls for urban development in an area where groundwater is recharged, the risk to the aquatic resources can be reduced by requiring that all runoff be infiltrated on site or that paved areas use some of the more innovative approaches such as permeable surfaces.

A summary table such as that shown in Table 10-2 can be used to document the risks identified and the actions taken to minimize risks.

Table 10-2. An example of a table summarizing the risks of land-use actions and measures to minimize the risks.

Action	Disturbance Caused by Action	Risk of Disturbance to Wetland Functions and Values	Measures to Minimize Risk	Does This Reduce Risk to an Acceptable Level?
Urban zoning in a recharge area outside of wetland	Change in water regime, increased surface runoff, and less infiltration	High for wetlands fed by groundwater and for those that will receive the direct runoff from paved surfaces	Change development standards in recharge area to require all surface water to be infiltrated	Yes
Permit fill of wetlands	Change in structure of wetland and loss of wetland area	High for functions within wetland	1. Require compensation at ratios that will ensure no net loss 2. Ensure compliance 3. Do not permit fill in wetlands that cannot be replaced (e.g., bogs)	Maybe

The King County example of a characterization of risk

As part of revisions to its critical areas ordinance, King County has prepared an *Assessment of Proposed Ordinances* that describes the risks to resources from the county's proposed regulatory and non-regulatory actions. Section 2.9 from Chapter 2 of the King County report describes the risks to the wetland resource from actions such as specified buffers, allowed alterations, classification (rating), and mitigation requirements. This section of the King County report is reproduced in Appendix 10-A of this volume. The full report is available on the web at http://www.metrokc.gov/ddes/cao/.

By first identifying and categorizing the risks to wetland resources and then identifying the actions necessary to minimize those risks a local jurisdiction will be in a better position to make decisions that incorporate existing scientific information. The characterization of risk can also be used as the first step in a program of adaptive management (see Chapter 12). Actions deemed to be of different levels of risk can be monitored to determine if the initial conclusions were valid.

Chapter 11

Taking Actions: Regulatory and Non-Regulatory Activities

11.1 Introduction

This chapter discusses Step 3 of the four-step framework, taking actions to reduce risks to the wetland resource (Figure 11-1). In Step 3, the regulatory and non-regulatory solutions, developed for a wetland protection program during Step 2, are implemented. The solutions are described in Chapters 6, 7, 8 and 9, whereas characterizing the risks of implementing those solutions is discussed in Chapter 10.

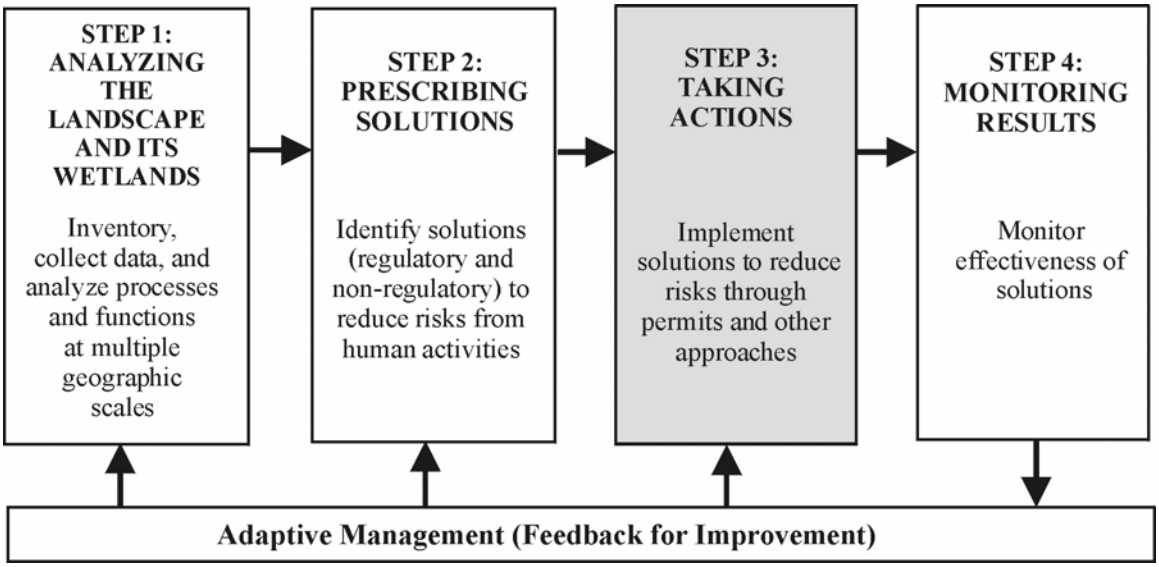


Figure 11-1. Implementing regulatory and non-regulatory components of a wetland protection program is Step 3 in the four-step framework presented in this volume (shaded box).

The chapter is divided into two major sections: implementing the regulatory and the non-regulatory components of a wetland protection program. As mentioned previously, both are needed to effectively protect and manage wetlands.

11.2 Implementing the Regulatory Component of a Protection Program

The single most important element in ensuring effective implementation of the regulatory component is having adequately trained staff or a qualified professional on contract. Other important elements include:

- A process to review permits that is clear and uses a team approach
- Inspecting the wetland site during construction of the development project
- Monitoring the wetland during and following construction
- Enforcing regulations
- Monitoring the effectiveness of regulations

The elements listed above require adequate funding for effective implementation. Local governments should include provisions, such as fees for permit review, for adequate funding of all the elements. It is also important to have an educational element such as materials for permit applicants and interested citizens.

11.2.1 Adequately Trained Staff or Qualified Wetland Professional

Local governments benefit greatly from having trained staff or access to qualified wetland professionals to implement their regulations, to make decisions where discretion is required, and to work with and review the materials submitted by the applicant's consultants. Most regulations pertaining to wetlands allow for some discretion in application to site-specific situations. They may pertain to site-specific buffer adjustments, stormwater considerations, or mitigation ratios. Even when regulations are written in a prescriptive fashion, many applicants and/or their consultants may make a case for why their projects should be granted some flexibility based on site-specific considerations over and above that allowed by the regulations.

In many instances, an applicant's consultant may be an individual with extensive experience and credentials in wetland science and it can be difficult for a local regulator to respond in a reasonable and appropriate manner to such requests. Additionally, while most applicants and their consultants provide accurate and complete information, occasionally a regulator will be confronted with information that is inaccurate or incomplete. It is critical that the local staff responsible for implementing wetland regulations have the knowledge or resources to effectively review submitted information and determine if it is accurate and complete.

Therefore, to effectively implement regulations, local government staff or wetland professionals on contract should have at least a basic familiarity with the following topics:

- Wetland identification and delineation
- Wetland rating
- Wetland function assessment
- Direct and indirect impacts to wetlands from different types of development projects
- Compensatory wetland mitigation, including site selection and design, construction oversight, monitoring, and maintenance
- Land-use regulations
- Writing permits and applying necessary conditions

The following resources can be used when becoming familiar with the basics of wetland regulation: Ecology's publications on wetland programs (www.ecy.wa.gov/programs/sea/ wetlan.html); periodic training offered by Ecology and other resource agencies; training classes provided by private vendors; and coursework such as the University of Washington's Certificate Program in Wetland Science and Management (www.extension.washington.edu/ext/certificates/wet/wet_gen.asp). Portland State University also offers various courses in wetland science and management through its Environmental Professional Development Program (www.esr.pdx.edu/epp/).

Some larger jurisdictions have one or more wetland professionals on staff. Most jurisdictions, however, rely on planning and general regulatory staff that have many responsibilities and who may not have the expertise in wetland ecology and management in order to effectively administer wetland regulations. To address this situation, many jurisdictions contract with a third-party wetland professional to provide the knowledge and experience needed to review proposals for changes in land uses such as development proposals. Considerations for choosing a qualified third-party wetland professional are discussed in Appendix 8-H, Hiring a Qualified Wetlands Professional.

11.2.2 The Process for Reviewing Permits

The process for review of permit applications for land development should be clear to both the applicant and the regulator. A local jurisdiction can require a separate permit for work in or near wetlands, or they can incorporate review for conformance with their wetland regulations into other permit review processes (see Appendix 8-B, the section on applicability). Regardless, the process for reviewing permit applications should include close coordination among appropriate regulatory staff, especially between those responsible for wetland protection, stormwater management, clearing and grading, and construction inspection.

Review of permit applications involving wetlands should at a minimum include a site investigation to verify delineation of the wetland boundary and confirmation of the rating of the wetland. Review for more complex projects that will alter wetlands should include assessment of wetland functions, analysis of project impacts, and review of proposed mitigation to compensate for adverse impacts. Some projects may require additional hydrologic analysis to ensure that wetland hydrology is not adversely affected. In such situations a hydrologist with understanding of wetland functions should become part of the review team to ensure that the project's stormwater management plan takes the wetland's hydrology into account.

Review of permit applications involving wetlands should result in written recommendations for approval, denial, or conditioning of the permit. Regulatory staff and/or qualified, third-party wetland professionals may be required to testify before the local Hearings Examiner to support decisions made during the review of the permit for certain types of applications.

11.2.3 Inspecting and Monitoring the Wetland During Construction

It is important that the conditions or wetland protection measures applied to permits upon their approval are in place and on the ground during and after construction of the project. For example, inspections during construction should ensure that clearing of vegetation is outside the wetland buffer or otherwise consistent with the approved plans and that measures for erosion and sediment control are protecting the wetland's water quality. Erosion and sediment controls should be in place and clearing limits well marked and easily visible on the ground.

When compensatory wetland mitigation is required for a permit, it is essential that the local jurisdiction inspect the mitigation project to see that it has been installed in accordance with the approved plans. Inspections at mitigation sites should take place annually or as specified on the approved mitigation plan to ensure that the project will be successful in compensating for the lost wetland functions.

11.2.4 Enforcing Regulations

Unfortunately, at times wetlands are altered without approval through a permit. A local jurisdiction should have specific authority in their critical areas ordinance to investigate the affected wetland, issue "stop work" orders (see Appendix 8-B), and require remediation of any violation. This includes the ability to require restoration of affected wetlands and/or compensatory mitigation for the reduction or loss of wetland functions. Effective enforcement often requires penalties for the unauthorized alteration of wetlands. These enforcement activities require adequate staff to investigate the initial violation, follow up on remediation, and coordinate with state and federal agencies as appropriate.

11.2.5 Monitoring the Effectiveness of Regulations

Local jurisdictions should create a tracking system to monitor the effectiveness of regulations in protecting wetlands. At a minimum, the jurisdiction should account for the acreage of wetlands altered as a result of permit activity and the success of compensatory mitigation projects. Evaluation of the results of the tracking system can be used by a local jurisdiction to revise regulations or procedures to provide better protection for wetlands. Please refer to Chapter 8 (Section 8.4) and Chapter 12 for additional discussion on monitoring the effectiveness of a wetland protection program. The tracking system can also be used to keep track of unauthorized activities in the jurisdiction.

11.2.6 Educational Materials

Many landowners and project applicants find it difficult to understand regulations and the requirements for permit application. Additionally, some landowners do not understand why wetlands are important and why regulations are needed. Brochures and other informational materials that discuss these topics and explain how applicants can get assistance can be very helpful and save regulatory staff a lot of time. Providing a clear explanation of the process for reviewing permits, such as a flow chart, can also be important to applicants. While general materials on some of these topics are available from federal and state agencies, materials developed locally are very useful.

11.3 Implementing the Non-Regulatory Component of a Protection Program

As with the regulatory component of a wetland protection program, implementing non-regulatory actions specified in plans and polices such as Green Infrastructure plans, Alternative Futures analysis, or comprehensive plans (discussed in Chapters 6, 7, and 9) requires dedicated staff to coordinate and support conservation, preservation, and restoration activities and manage sites. Other important elements include:

- Identifying, mapping, and prioritizing where non-regulatory tools should be applied
- Creating partnerships with organizations, government agencies, and others to help sponsor local projects
- Identifying a recipient to hold and manage land
- Obtaining funding for local actions
- Providing incentives to encourage participation by landowners

- Educating and involving the public and providing technical outreach to landowners
- Monitoring project sites
- Monitoring the overall success of the non-regulatory actions

An overview of each of these elements is provided below.

For more information about setting up a non-regulatory component of a wetland protection program, see *Designing Wetland Preservation Programs for Local Governments: A Guide to Non-Regulatory Protection* (Rubey 1992). This document is somewhat dated but still offers a general discussion of some of the topic.

11.3.1 Staffing the Non-Regulatory Component

It is optimal to have a dedicated coordinator overseeing the non-regulatory component of a wetland protection program. A coordinator would facilitate the numerous actions (e.g., restoration or preservation of high-priority areas that can be sponsored through the local government or through partnerships with other organizations. A coordinator would also work with private landowners to conserve the land through mechanisms such as conservation easements (see Chapter 9 for a description of non-regulatory tools). The following is a list of tasks a coordinator might oversee:

- Identifying appropriate sites for preservation and restoration
- Working with landowners to apply better conservation practices
- Establishing and updating incentive and funding mechanisms
- Engaging in education and outreach activities
- Providing technical assistance for non-regulatory actions
- Facilitating local projects sponsored by the local jurisdiction (obtaining grants, forming partnerships, developing the technical design, conducting site monitoring, etc.)
- Supervising support staff or volunteers working on non-regulatory actions
- Coordinating with other departments within the jurisdiction and with other organizations and agencies

The coordinator may perform all or some of these tasks depending on the number of staff available as support. The number of staff dedicated to implement the non-regulatory component of a protection program usually reflects the size of the local government and its emphasis on incorporating a non-regulatory approach.

11.3.2 Identifying, Mapping, and Prioritizing Sites

Identifying, mapping, and prioritizing sites for non-regulatory activities are best started during early planning stages such as landscape analysis, Green Infrastructure planning, or Alternative Futures analysis (see Chapters 5 and 6 for further discussion). If these plans have not been completed by the local jurisdiction, then non-regulatory actions such as acquisition and restoration could occur as opportunities arise. In addition, a jurisdiction could decide on potential projects based on technical reports and studies that point to desirable sites. In either case, projects will usually need to be prioritized and implemented sequentially.

Additional review and strategizing will probably be needed as implementation of the non-regulatory program begins. This might involve sorting through the various sub-basins or sensitive landscape areas within the entire management area to focus on sites with immediate threats or opportunities and deciding what projects can be funded over the immediate fiscal period. Prioritizing will likely be conducted on an ongoing basis as funding, staff, and opportunities fluctuate.

11.3.3 Creating Partnerships for Locally Sponsored Projects

Local governments benefit from partnerships with other agencies or organizations to successfully implement non-regulatory projects. Completing transactions associated with conservation, preservation, and restoration (e.g., purchasing, restoring, monitoring, managing sites, etc.) can be complex and take time. The following organizations are available to work with local governments on non-regulatory actions.

Land trusts offer the services of brokering land acquisitions, raising funds to purchase sites, and educating landowners about tax benefits and incentives. Land trusts protect land permanently. They work directly with landowners during transactions to acquire land. Land trusts are knowledgeable about the resources and the advantages of land preservation in regard to property taxes. They are perceived as non-adversarial by landowners (see Appendix 9-A). In addition, land trusts often attract the voluntary assistance of retired professionals who can provide technical assistance with site assessments and monitoring.

For example, a national land trust called the Trust for Public Land (TPL) will assist in securing properties for governments when funding is pending and the time available to preserve a parcel is short. TPL releases the property to the jurisdiction later when funding is available.

Partnerships with other **non-profit organizations** such as the local Audubon Society or Ducks Unlimited may be essential to completing site monitoring tasks (such as bird counts on restored wetlands) and for implementing actual site restoration plans.

State and federal agencies are also excellent partners to assist with non-regulatory efforts. These agencies can help with securing grant funds for projects. They can also

offer technical knowledge about wetland functions, restoration techniques, and long-term management. Agency assistance is provided at no charge to the local jurisdiction.

Either **internal coordination** or **internal partnerships** will also be needed between various department and staff within the local government (such as parks or public works departments). As discussed below, they may be the recipients of lands that have been purchased and/or restored.

Information on land trusts and other partners, as well as funding program opportunities, can be found in the publication *Exploring Wetlands Stewardship: A Reference Guide for Assisting Washington Landowners and Communities* (Rubey 2004).

11.3.4 Identifying a Recipient to Hold and Manage Land or Rights to Land

A local department such as parks or public works should be identified to receive and manage properties that are purchased or donated. For example, direct preservation of key critical areas is essential to maintaining landscape processes through time. Therefore, preservation resulting in permanent protection of land through *full-fee title* (ownership of all property rights) may be the best mechanism to use (see Chapter 9 for a description of full-fee). In such cases, as with restoration efforts, a recipient is needed for managing and monitoring the site.

Who the recipient should be will depend on whether or not the local jurisdiction buys land in full-fee and wishes to own and manage the land over time. If not, site ownership and management (or holding a conservation easement) may be handled by an external partner such as a land trust. However, a land trust usually requires an endowment to manage a site. Alternatively, property could be passed to a state agency. However, state agencies may not be willing to accept management of new properties. Therefore, as mentioned above, it is important to identify willing organizations and create partnerships for receiving and managing land as well as coordinating other aspects of conservation, restoration, and preservation projects.

11.3.5 Establishing Funding Mechanisms and Incentives for Landowners

Funding mechanisms and landowner incentives were reviewed in Chapter 9. These tools play an essential role in the non-regulatory component of a protection program. Obtaining funding is an absolute necessity to a local government that wishes to conduct voluntary preservation and restoration projects. Without a local funding source to provide a match, a local government cannot apply for state and federal grant programs. As mentioned elsewhere in this volume, lists of funding programs are provided in *Exploring Wetlands Stewardship: A Reference Guide for Assisting Washington Landowners and Communities* (Rubey 2004).

One very strong funding tool that can be established by a local government is the Conservation Futures Levy. This levy can be implemented by legislative ordinance and a portion of the funds dedicated to preservation and restoration projects (see Chapter 9 for further details). It may also be appropriate for a local government to use the funds generated to finance "engineered infrastructure," such as levies for *special purpose districts* and *in-lieu fees* as well as general funds, to implement non-regulatory actions (i.e., preservation and restoration) to maintain the services provided by "green infrastructure."

Landowner incentives are also essential for engaging citizens in voluntary conservation actions and are discussed in detail in Chapter 9. In particular, local jurisdictions may wish to consider the value of establishing a watershed-based Public Benefit Rating System (PBRS) to implement their Current Use Taxation Program for "Natural" Open Space. As discussed in Chapter 9, the results of a landscape analysis can be integrated into a PBRS program.

11.3.6 Educating and Involving the Public

Education and public involvement are vital parts of a non-regulatory effort, both initially and on an ongoing basis. The importance of education and public involvement is demonstrated by its inclusion and emphasis in Green Infrastructure planning, Alternative Futures analysis, and the development of comprehensive plans (as discussed in Chapters 6 and 7).

Education is essential because it provides the public with an accurate understanding of why non-regulatory efforts are valuable to the community, as well as to maintaining and restoring landscape processes. For example, decision-makers and the public should be informed that the expenditures needed for conservation, restoration, and preservation are justified when compared to long-term costs. When landscape processes are maintained or improved, the public saves; engineered infrastructure that would be built to replace lost services (functions) is not needed (see Chapter 6 for information on the fiscal savings of non-regulatory efforts).

Education and outreach efforts are also key factors in increasing enrollment in incentive programs that foster conservation of the land. Likewise, they encourage the public to get involved through voluntary actions either on their own property or by supporting local projects (e.g., volunteers monitoring sites). In so doing, education and public involvement can also improve support for regulatory protection.

11.3.7 Monitoring Preservation and Restoration

When preserving and/or restoring wetlands, it is important that the local jurisdiction implement monitoring at both the site level and the program level.

At the site level, it is recommended that local governments:

- Allocate Conservation Futures dollars, or other funds, to secure properties and fund restoration activities
- Engage in restoration actions such as breaching dikes, removing exotic plants, planting native vegetation, etc.
- Monitor site conditions and manage preserved and restored lands

At the program level, it is recommended that local governments monitor the effectiveness of the success of the following elements to provide feedback for adaptive management:

- Goals for preservation and restoration that are aligned with the objectives of plans such as Green Infrastructure or conservation plans
- Incentive programs for landowners, such as current use taxation
- Education programs for citizens about local stewardship activities
- Technical assistance for landowners

Monitoring and adaptive management is discussed in more detail in Chapter 12.

Chapter 12
Monitoring and Adaptive Management

12.1 Introduction

This chapter discusses two aspects of the framework of a program for protecting wetlands: 1) *monitoring results*, determining the effectiveness of the program (Step 4) and 2) *adaptive management*, a feedback mechanism for making improvements to the program if needed (Figure 12-1). Monitoring and adaptive management have often been low on the list of priorities for local jurisdictions. Funding, the availability of staff, and technical issues make establishing a monitoring program difficult for some jurisdictions. In addition, monitoring may also expose what are perceived as failures and may require changes that are difficult or unpopular (Washington State Joint Natural Resources Cabinet 1999).

However, the benefits of a successful monitoring program and the changes that may result from it can be substantial. Many actions taken to protect and manage wetlands have to be considered as experiments because we have not tracked their success in the past.

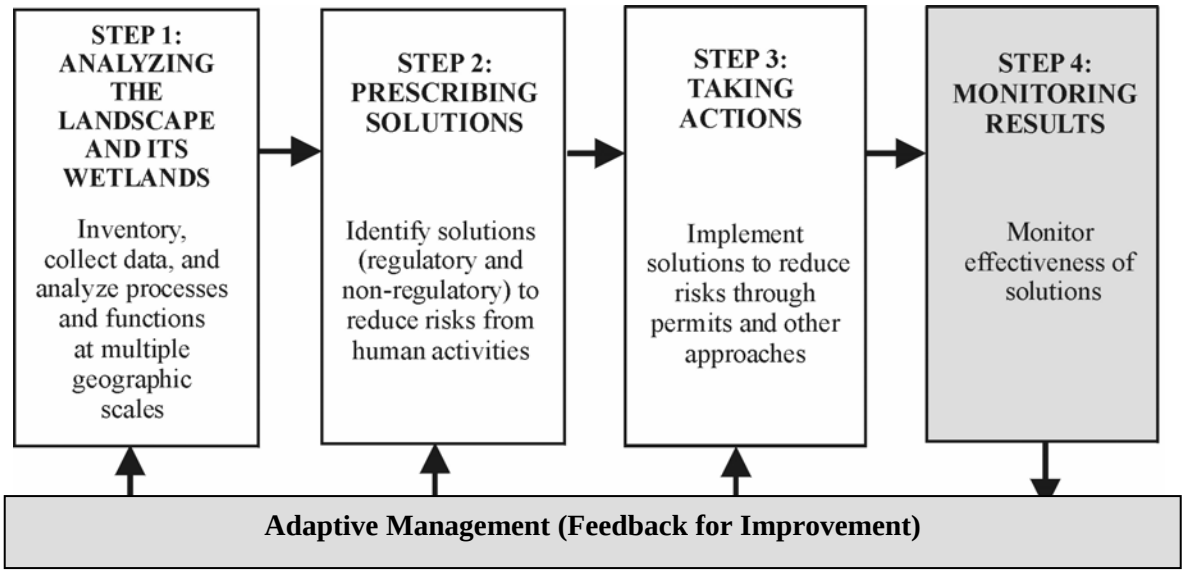


Figure 12-1. Monitoring is Step 4 of the four-step framework discussed in this volume, and Adaptive Management provides feedback for improving wetland protection programs (shaded box).

We do not know, or fully understand, all the cause and effect relationships between human actions on the land and the functions performed by wetlands (see Chapters 3 and 4 in Volume 1). Thus, we cannot fully predict the outcome of actions taken to protect and manage wetlands, other natural resources and critical areas, as well as landscape processes. Monitoring the effectiveness of protection measures in the context of adaptive management is the most efficient way to face this uncertainty. Adaptive management is a commitment by a local government to change approaches for protecting and managing wetlands and to redirect resources as warranted by new information. A willingness to make improvements to address insufficiencies identified through this monitoring step is important.

The focus is to monitor the effectiveness of solutions identified and actions taken in Steps 2 and 3 (described in previous chapters) and make changes as needed. The process is iterative as shown in Figure 12-2. The goal is to implement a system for modifying past decisions, if needed, that is based on information generated from monitoring the specific actions taken and on any scientific information that is newly available. Plans, regulations, and other actions should be reconsidered if the monitoring data show there are further losses of wetland functions and values. This will help to reduce cumulative impacts to wetlands and other resources.

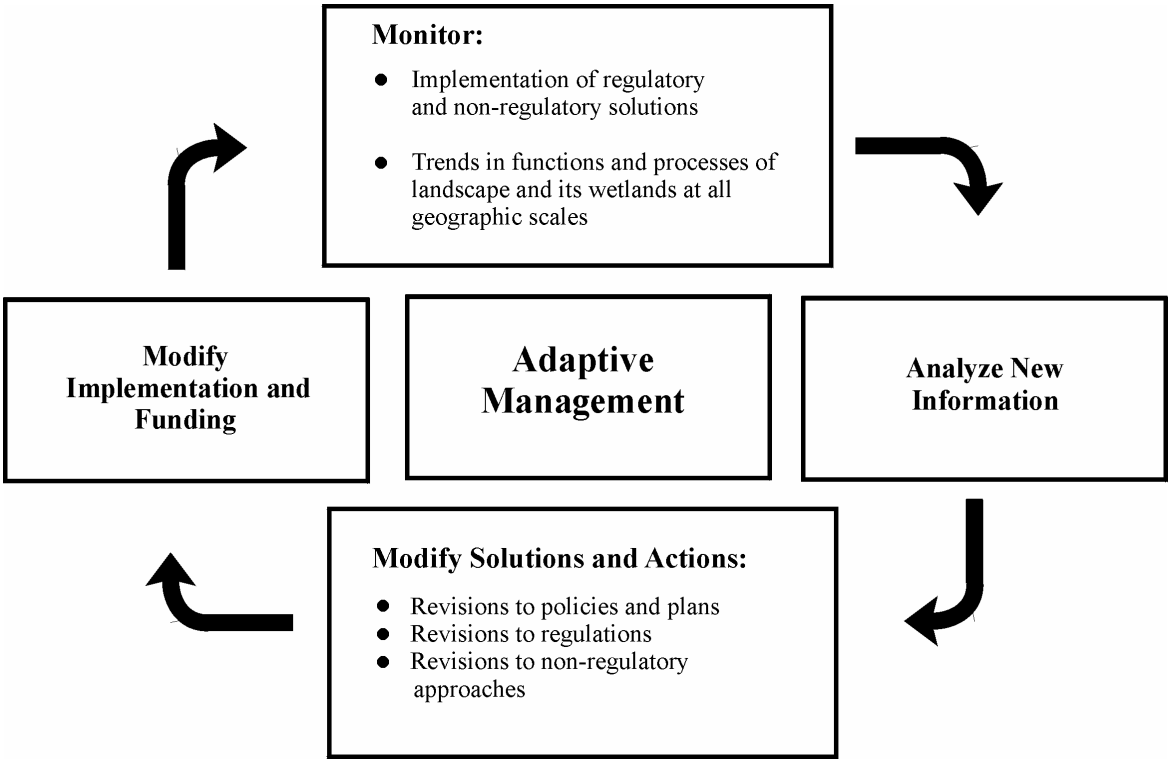


Figure 12-2. Conceptual representation of how wetlands can be protected and managed using adaptive management. Adaptive management implies that the process does not end with the completion of the four steps but keeps cycling.

12.2 What Should Be Monitored?

Monitoring associated with protecting and managing wetlands by local jurisdictions can be divided into three categories, as listed below. All aspects of monitoring are important in providing feedback to guide decisions for adaptive management. If the functions and values of wetlands are not adequately protected, managers need to know whether this results from inadequate implementation, inadequate standards, or inadequate strategies.

- **Monitoring trends** tracks landscape processes and wetlands over time at all geographic scales and records changes in functions and values at individual wetlands. The monitoring should determine if the goals and objectives established for the wetland resource by a local jurisdiction are being met. Monitoring trends is critical in interpreting the effectiveness of efforts to protect and manage wetlands. By monitoring trends, it is possible to document if cumulative impacts continue to occur.

- **Monitoring implementation** addresses the extent to which plans have been implemented and the extent to which regulatory and non-regulatory actions proposed in those plans and regulations have been taken. This type of monitoring provides a basis for tracking the actions taken and for quality assurance.

- **Monitoring the effectiveness of strategies** addresses how effectively the complete program, not just individual plans and actions, meets explicit objectives or conditions desired for the future.

Different approaches are needed to monitor at different geographic scales because the type of data collected is different. In addition, the objectives of a monitoring program may be met in many different ways, not all of which require extensive collection of data. It is not the intent of this chapter to describe the different monitoring approaches and methods that can be used. These will depend on the wetland resources present in a local jurisdiction, the goals and objectives set by that jurisdiction, the solutions they propose, and the actions they take.

The following sections outline some of the basic questions that need to be addressed when monitoring for an adaptive program for wetlands.

12.2.1 Monitoring Trends in the Resource

The goal of monitoring trends in wetlands is to understand if, and how, the landscape and site-specific processes that control structure and functions within a wetland(s) have been altered as a result of changes in land use. The resource needs to be monitored at all geographic scales used in the analysis of the resource (i.e., the contributing landscape, the management area, and the site scale).

The analysis can be undertaken using the guidance discussed in Chapter 5. Regardless of the methods used, however, there is one major question that needs to be addressed through monitoring: *Have changes in land use altered landscape processes to the extent that they impact the functions of wetlands in a jurisdiction?* Changes to processes and functions can be either negative (indicating further degradation), no change (indicating efforts at protecting existing levels of processes and functions are working), or positive (indicating that efforts at restoration are succeeding).

Monitoring trends at the landscape scale involves identifying:

- If the major sources of water to wetland(s) and flow paths have changed (either degraded or restored)
- If the major sources of sediment have changed
- If the major sources of nutrients have changed
- If the major sources of toxic compounds have changed
- If there has been an increase in the fragmentation of wildlife habitats

Monitoring trends at the wetlands themselves involves tracking how the functions and values of each individual wetland within a jurisdiction have changed. Continuously monitoring all wetlands, or even a random subset of them, in a jurisdiction is optimal but may not be feasible because of the cost. In the absence of such a program, it is suggested that a local jurisdiction track trends by analyzing the wetland assessments that applicants submit when they propose actions at individual sites. Qualitative trends can be tracked by noting the overall changes in the functions of wetlands being proposed for alteration within each hydrogeomorphic class (depressional, riverine, etc.) or wetlands of particular concern such as bogs and mature, forested wetlands.

The restoration of wetland functions at sites used for restoration should also be monitored to determine if the objectives of the projects are being met.

12.2.2 Monitoring the Implementation of Protection Measures

Monitoring implementation addresses the extent to which the solutions or actions proposed for protecting and managing wetlands, as developed in Step 2 (Prescribing Solutions), have actually been put into practice or carried out.

12.2.2.1 Monitoring Implementation at the Scale of the Contributing Landscape

Whether monitoring the implementation of solutions needs to take place at the scale of the contributing landscape depends on whether the contributing landscape falls entirely within the jurisdiction or if it includes several jurisdictions. In the former case, monitoring the contributing landscape is actually the same as monitoring the management area, described below. If the contributing landscape spans several jurisdictions, then monitoring at this scale is needed and should be based on the objectives of the plans and solutions developed among the jurisdictions.

It is not possible in this document to cover how to monitor all the possible watershed plans, regional plans, actions taken as a result of various partnerships, etc. However, it is important that each objective identified in such plans should have associated with it measures for monitoring its implementation. For example, a watershed plan may have an objective that all jurisdictions in the watershed adopt the same method for rating wetlands to ensure that wetland functions are characterized in the same way throughout the watershed. Monitoring this objective would involve examining the adoption and implementation of the chosen wetland rating system.

12.2.2.2 Monitoring Implementation at the Scale of the Management Area

Monitoring the implementation of solutions developed for the management area is a matter of keeping accurate records of the actions taken by the jurisdiction to protect and manage wetlands, and a commitment to compile and analyze the data at specified intervals. The analysis should include the actions actually taken compared to the solutions and actions proposed in the original comprehensive plan, critical areas ordinances, shoreline master programs, etc. For example, a critical areas ordinance may state that each permit that will result in a wetland impact requires that the wetland be rated on its functions and values. Monitoring the implementation of this would require an examination of how many permits were issued with a completed rating as well as how many were issued without a rating.

This type of monitoring should also be applied to non-regulatory programs. For example, if a jurisdiction has a program to acquire conservation easements on lands that it considers important to maintaining landscape processes, it should monitor how many easements have been acquired compared to the total number needed. Table 12-1 lists some of the common solutions used by jurisdictions in protecting and managing wetlands.

Table 12-1. Monitoring common solutions to protecting and managing wetlands at the scale of the management area. These are only a few examples, not an inclusive list of all that a jurisdiction should monitor.

Action	What to Monitor
Zoning	Number of zoning variances permitted
Development standards for areas sensitive to disturbance	Number of variances permitted
Setbacks, such as buffers or "no-spray" zones, to protect resources	Number of variances to setbacks permitted Number of violations
Preservation of important wetlands	Number of acres with conservation easements or fee title
Conservation of wetland resources	Number of acres enrolled in Current Use Taxation program or other applicable programs
Voluntary restoration of wetlands	Number of acres and types of functions successfully restored

12.2.2.3 Monitoring Implementation at the Site Scale

Monitoring the implementation at the site scale is a matter of keeping accurate records of the permits approved and other actions taken at individual sites. This includes, for example, monitoring the success of follow-up site visits, compliance with permit conditions, restoration efforts, and enforcement actions. The review of the scientific information presented in Volume 1, Chapter 6, highlighted the fact that many projects that compensate for impacts to wetlands are not successful because there has been no follow-up. Therefore, follow-up on projects is very important. As previously mentioned, this data can be used to ascertain general trends regarding the effectiveness of wetland protection and management in the jurisdiction.

12.3 Adaptive Management

Adaptive management has been defined in various ways since its development in the early 1970s. Different people and organizations continue to have somewhat differing views of the best definition for their purposes. In order to bring some consistency and clarity, the following working definition for this concept is used here:

> *Adaptive management is a systematic process for continually improving management policies and practices by learning from the outcomes of previous policies and practices.*

As mentioned earlier in the chapter, the goal of adaptive management, in the context of protecting and managing wetlands, is to implement a repetitive process for making decisions that is guided by scientific information that is newly available and data collected and analyzed through the monitoring program. The iterative nature of the process is shown in Figure 12-2. The results of the monitoring program provide the basis for revising past decisions, and these improved actions and solutions are subsequently monitored to determine their success in meeting the jurisdictions goals for protecting resources.

Adaptive management is based on the assumption that managed ecosystems are complex and inherently unpredictable. The approach incorporates the fact that, at present, humans do not know enough to adequately manage environmental resources. Adaptive management, from this perspective, treats management policies and practices as experiments, and it serves to assess the responses of natural resources as human behavior changes (Lee 1999). The goal is to learn and change objectives as needed. However, this has often not been considered the mark of a good manager, who is rewarded instead for steadfast pursuit of objectives (Lee 1999). The important point to stress is that adaptive management will only work if there is a willingness to actually change polices and practices as a result of monitoring.

Some of the characteristics of adaptive management are:

- Acknowledgement that there is still much uncertainty about what policy or practice is best for solving each particular issue related to protecting and managing wetlands
- Careful design and implementation of a monitoring plan designed to reveal the knowledge that is currently lacking
- Monitoring of both the resource itself and the implementation of plans and practices used to protect the resource
- Analysis of the outcomes of policies and practices in terms of the original objectives
- Incorporation of the results into future decisions

A brief history and additional resources for adaptive management

The text below is adapted from the University of Oregon (http://oregonstate.edu/instruction/anth481/ectop/ecadm.html).

C.S. Holling and several colleagues developed the concept of adaptive management at the University of British Columbia's Institute of Resource Ecology in the late 1960s. Adaptive management reached the scientific literature in Holling's book, *Resilience and Stability of Ecological Systems*, published in 1978. The emphasis of the Holling approach is to experiment to learn the boundaries of natural systems. Holling and his colleagues worked with resource managers in British Columbia on a number of management experiments and workshops designed for public participation, thereby testing the process.

Adaptive management became an important concept in resource management in the United States when K.N. Lee introduced it to the Northwest Power Planning Council in 1984. Lee studied adaptive management with Randall Peterman, who in February 1984 gave a talk about experimental management. Subsequently, different forms of adaptive management have become part of the Northwest Forest Plan, the Oregon Plan for Salmon and Watersheds, the Oregon Department of Forestry Plan to manage state forests, and many other processes for resource planning.

For additional information on adaptive management, see:

Holling C.S. 1978. Adaptive Environmental Assessment and Management. John Wiley & Sons. New York, New York.

Walters, C. 1986. Adaptive Management of Renewable Resources. The Free Press.

Lee, K.N. 1993. Compass and Gyroscope. Island Press. Washington D.C.

Lee, K.N. 1999. Appraising adaptive management. Conservation Ecology 3(2): 3: http://www.consecol.org/vol3/iss2/art3

The Collaborative Adaptive Management Network: http://www.iatp.org/AEAM/index.html

References

The following is a list of references for Chapters 1 and 3-12 of Volume 2. The legal citations in Chapter 2 are included as footnotes to the chapter and are not repeated here. Citations listed as personal communications in the text are not listed here since the citation contains the information. Most of the references cited in the appendices are contained within the text or are included at the end of the appendix in which they are cited. If the information cited was from a web site, the web address is provided in the text and may not be repeated in this reference list. Not all references listed have been cited in the text.

Alberti, M., D. Booth, K. Hill, B. Coburn, C. Avolio, S. Coe, and D. Spirandelli. 2003. The Impact of Urban Patterns on Aquatic Ecosystems: An Empirical Analysis in Puget Lowland Sub-basins. Department of Urban Design and Planning, University of Washington, Seattle, WA.

American Farmland Trust. 1999. Cost of Community Services: Skagit County, Washington. American Farmland Trust, Northampton, MA. Available: www.farmland.org

American Forests. 2001. Regional Ecosystem Analysis. Available: www.americanforests.org.

Azous, A.L. and R.R. Horner (eds). 2001. Wetlands and Urbanization: Implications for the Future. New York: Lewis Publishers.

Barclay, E. and D. Batker and A. Kaler. 2004. Untold Value: Nature's Services in Washington State. Asia Pacific Environmental Exchange, Seattle, WA. Available: www.a-p-e-x.org.

Bartoldus, C.C. 1999. A Comprehensive Review of Wetland Assessment Procedures: A Guide for Wetland Practitioners. Environmental Concern, Inc., St. Michaels, MD.

Bedford, B. 1996. The need to define hydrologic equivalence at the landscape scale for freshwater wetland mitigation. Ecological Applications 6:57-68.

Bedford, B.L. 1999. Cumulative effects on wetland landscapes: Links to wetland restoration in the United States and southern Canada. Wetlands 19(4): 775-788.

Beechie, T. and S. Bolton. 1999. An approach to restoring salmonid habitat-forming processes in Pacific Northwest watersheds. Fisheries 24:6-15.

Booth, D.E. 1991. Urbanization and the natural drainage system impacts, solutions, and prognoses. The Northwest Environmental Journal 7(1):93-118.

Brabec, E. and C. Smith. 2002. Agricultural land fragmentation: The spatial effects of three land protection strategies in the eastern United States. Landscape and Urban Planning 58: 255-268.

(Brinson 1993a) Brinson, M.M. 1993. Changes in the functioning of wetlands along environmental gradients. Wetlands 13(2): 65-74.

(Brinson 1993b) Brinson, M.M. 1993b. Hydrogeomorphic Classification for Wetlands. Technical Report WRP-DE-4. U.S. Army Corps of Engineers Waterways Experiment Station.

Brinson, M.M., F.R. Hauer, L.C. Lee, W.L. Nutter, R.D. Rheinhardt, R.D. Smith, and D. Whigham. 1995. Guidebook for application of hydrogeopmorphic assessments to riverine wetlands. Technical Report WRP-DE-11. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Cairns, J. Jr. 1997. Eco-societal restoration: creating a harmonious future between human society and natural systems. Pages 487-499 in: J.E. Williams, C.A. Wood, and M.P. Dombeck, eds., Watershed Restoration: Principles and Practices. American Fisheries Society, Bethesda, MD,

Castelle, A.J., C. Conolly, M. Emers, E.D. Metz, S. Meyer, M. Witter, S. Mauermann, M. Bentley, D. Sheldon, and D. Dole. 1992. Wetland Mitigation Replacement Ratios: Defining Equivalency. Washington Department of Ecology Publication #92-08. Olympia, WA.

City of Everett. 1997. Snohomish Estuary Wetland Integration Plan. City of Everett Department of Planning and Community Development. Everett. WA.

Council of Environmental Quality. 1997. Considering cumulative effects under the National Environmental Policy Act. Executive Office of the President. Washington D.C.

Conservation Foundation. 1988. Protecting America's Wetlands: An Action Agenda. The Final Report of the National Wetlands Policy Forum. Washington, D. C.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Washington, DC: U.S. Fish and Wildlife Service.

Cumminskey, J. 2001. The Cape Cod Land Bank: the use of a land acquisition strategy to preserve a Massachusetts coastal region. Ocean and Coastal Management 44: 61-85.

CTED. See Washington State Department of Community, Trade, and Economic Development.

Dale, V.H., S. Brown, R.A. Haeuber, N.T. Hobbs, N. Huntly, R.J. Naiman, W.E. Riebsame, M.G. Turner, and T.J. Valone. 2000. Ecological principles and guidelines for managing the use of land. Ecological Applications 10(3): 639-670.

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated Buffers in the Coastal Zone: A Summary Review and Bibliography. Coastal Resources Center Technical Report No. 2064. University of Rhode Island 72pp.

Ecology. See Washington State Department of Ecology.

Edwards, V.M. 1994. Developing America's Natural Areas Market. Natural Areas Journal 14(1): 17-21.

Everett, City of. See City of Everett.

Fausold, C. & Lilieholm, R. 1996. The economic value of open space. Landlines: Lincoln Institute Land Policy 8(5):1-4.

Florida, R. 2002. The Rise of the Creative Class. Basic Books, New York, N.Y.

Fodor, E. 1996. The Three Myths of Growth. Planning Commissioners Journal. Winter Issue 21. Available: www.plannersweb.com

Gersib, R. 2001. The need for process-driven, watershed-based wetland restoration in Washington State. Proceedings of the Puget Sound Research Conference 2001.

Gwin, S.E., M.E. Kentula, and P.W. Shaffer. 1999. Evaluating the effects of wetland regulation through hydrogeomorphic classification and landscape profiles. Wetlands 19(3):477-489.

Hollings, C.S. 1978 Adaptive Environmental Assessment and Management. John Wiley and Sons. New York, New York.

Horner, R.R. 1986. Water quality and carbon and nutrient cycling. Chapter 4 in R. Strickland (ed.), Wetland Functions, Rehabilitation and Creation in the Pacific Northwest: The State of Our Understanding. Washington State Department of Ecology Publication #86-14. Olympia WA.

Horner, R.R., D.B. Booth, A. Azous, and C.W. May. 1996. Watershed determinants of ecosystem functioning. In L.A. Roesner (ed.), Effects of Watershed Development and Management on Aquatic Ecosystems: Proceedings of an Engineering Foundation Conference, Snowbird, UT. American Society of Civil Engineers.

Hruby, T. 1999. Assessments of wetland functions: What they are and what they are not. Environmental Management 23:75-85.

(Hruby, T. 2004a) Hruby, T. 2004. Washington State Wetland Rating System for Eastern Washington – Revised. Washington State Department of Ecology Publication #04-06-015. Olympia, WA.

(Hruby, T. 2004b) Hruby, T. 2004. Washington State Wetland Rating System for Western Washington – Revised. Washington State Department of Ecology Publication #04-06-025. Olympia, WA.

Hruby, T, S. Stanley, T. Granger, T. Duebendorfer, R. Friesz, B. Lang, B. Leonard, K. March, and A. Wald. 2000. Methods for Assessing Wetland Functions, Volume II: Depressional Wetlands in the Columbia Basin of Eastern Washington. Parts I and II. Washington State Department of Ecology Publication #00-06-47 and#00-06-48. Olympia, WA.

Hruby, T., T. Granger, K. Brunner, S. Cooke, K. Dublanica, R. Gersib, L. Reinelt, K. Richter, D. Sheldon, E. Teachout, A. Wald, and F. Weinmann. 1999. Methods for Assessing Wetland Functions, Volume I: Riverine and Depressional Wetlands in the Lowlands of Western Washington. Parts I and II. Washington State Department of Ecology Publication #99-115 and #99-116. Olympia, WA.

Johnson, P., D.L. Mock, A. McMillan, L. Driscoll, and T. Hruby. 2002. Washington State Wetland Mitigation Evaluation Study Phase 2: Evaluating Success. Washington State Department of Ecology Publication #02-06-009. Olympia, WA.

Johnson, P., D.L. Mock, E.J. Teachout, and A. McMillan. 2000. Washington State Wetland Mitigation Evaluation Study Phase 1: Compliance. Washington State Department of Ecology Publication #00-06-016. Olympia, WA:.

Johnston, C.A., N.E. Detenbeck, and G.J. Niemi. 1990. The cumulative effect of wetlands on stream water quality and quantity: A landscape approach. Biogeochemistry 10:105-142.

Kitsap County Department of Community Development. 2003. Chico Watershed Alternatives Analysis: Process and Recommendations. Prepared by Parametrix Inc., Lacey, WA.

Kruczynski, W.L. 1990. Options to be considered in preparation and evaluation of mitigation plans. pp. 555-570 in: J.A. Kusler and M.E. Kentula (eds.), Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C. USA.

LaBaugh, J.W., T.C. Winter, V.A. Adomaitis, and G.A. Swanson. 1987. Geohydrology and Chemistry of Prairie Wetlands, Stutsman County, North Dakota. U.S. Geological Survey Professional Paper 1431.

Lee, K.N. 1993. Compass and Gyroscope. Island Press. Washington D.C.

Lee, K.N. 1999. Appraising adaptive management. Conservation Ecology 3(2): 3. Available: http://www.consecol.org/vol3/iss2/art3

Levin, S.A. 2001. Immune systems and ecosystems. Conservation Ecology 5:17. [online] URL: http://www.consecol.org/vol5/iss1/art17

Lofvenhaft, K. 2002. Spatial and temporal perspectives on biodiversity for physical planning. PhD Thesis. Stockholm University. Stockholm, Sweden.

Main, M.B., F.M. Roka, and R.F. Noss. 1999. Evaluating Costs of Conservation. Conservation Biology 13(6): 1262-1272.

Mazza, P. and E. Fodor. 2000. Taking Its Toll: The Hidden Costs of Sprawl in Washington State. Climate Solutions, Olympia, WA. Available: www.climatesolutions.org.

McGilvray, L. J., G.D. Anderson, and N. West. 1985. Managing coastal development: An evaluation of the transfer of development rights approach. Coastal Zone Management Journal 3(1): 25-47.

Muro, M. and R. Puentes. 2004. Investing in a Better Future: A Review of the Fiscal and Competitive Advantages of Smarter Growth Development Patterns. March 2004. The Brookings Institution Center on Urban and Metropolitan Policy. Washington D.C.

Naiman, R., and K.H. Rodgers. 1997. Large animals and system-level characteristics in river corridors. Bioscience 47:521-529.

Naiman, R.J., H. De'camps, and M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3(2): 209-212.

Naiman, R.J.T., L. Beechie, D. Benda, P. Berg, L. Bisson, M. McDonald, P. O'Connor, P. Olson, and E. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest coastal ecosystem. Pages 127-188 in: R.J.T. Naiman (ed.), Watershed Management. Springer-Verlag. New York, NY.

Nilsson C., J.E. Pizzuto, G.E. Moglen, M.A. Palmer, E.H. Stanley, N.E. Bockstael, and L.C. Thompson. 2003. Ecological forecasting and the urbanization of stream ecosystems: challenges for economists, hydrologists, geomorphologists, and ecologists. Ecosystems 6:659-674.

National Research Council. 2001. Compensating for Wetland Losses under the Clean Water Act. National Academy Press. Washington, DC.

Null, W.S., G. Skinner, and W. Leonard. 2000. Wetland Functions Characterization Tool for Linear Projects. Washington State Department of Transportation, Environmental Affairs Office, Olympia, WA.

Omernik, J. and A. Gallant. 1986. Ecoregions of the Pacific Northwest. US EPA Environmental Research Lab, Corvallis, OR. EPA600/3-86/033.

Preuss, I. and A. Vemuri. 2004. "Smart growth" and dynamic modeling: implications for quality of life in Montgomery County, Maryland. Ecological Modeling 17: 415-432.

Redford, K.H. and B.D. Richter. 1999. Conservation of Biodiversity in a World of Use. Conservation Biology 13(6): 1246-1256.

Rigg, G.G. 1958. Peat Resources of Washington. Bulletin No. 44, Division of Mines and Geology, Department of Conservation, State of Washington, Olympia, WA.

Robinson J. 2003. Future Subjunctive: Backcasting as Social Learning. Futures 35:839-856.

Rubey, J. 1992. Designing Wetland Preservation Programs for Local Governments: A Guide to Non-Regulatory Protection. Washington State Department of Ecology Publication #92-18. Olympia, WA.

Rubey, J. 1999. Open Space Taxation Act Current Use Assessment Program: Applying the Public Benefit Rating System as a Watershed Action Tool. July 1999. Washington State Department of Ecology Publication #99-108. Olympia, WA.

Rubey, J. 2004. Exploring Wetlands Stewardship: A Reference Guide for Assisting Washington Landowners and Communities. 1996, revised January 2004. Washington State Department of Ecology Publication #96-120. Olympia, WA.

Sheldon, D., T. Hruby, P. Johnson, K. Harper, A. McMillan, T. Granger, S. Stanley, and E. Stockdale. 2005. Wetlands in Washington State, Volume 1: A Synthesis of the Science. Washington State Department of Ecology Publication #05-06-006. Olympia, WA.

Sherer, P. 2003. Why America Needs More Parks and Open Space. The Trust for Public Land. San Francisco, CA.

Smart Growth Network. 2002. Getting to Smart Growth: 100 Policies for Implementation. Available: www.smartgrowth.org.

Stanley, S. and S. Grigsby. 2003. Assessing ecosystem function using a landscape scale approach. *In:* T.W. Droscher and D.A. Fraser (eds). Proceedings of the 2003 Georgia Basin/Puget Sound Research Conference. Available: http://www.psat.wa.gov/Publications/03_proceedings/start.htm [accessed February 2004]

Stanley, S., T. Hruby, B. Herbig, R. Behee, J. Polayes-Wein, R. Huey, G. Colburn, D. Karma, and L. Storm. 1997. Snohomish Estuary Wetland Integration Plan. City of Everett Department of Planning and Community Development. Everett, WA.

The Conservation Foundation. 1988. Protecting America's Wetlands: An Action Agenda. The Final Report of the National Wetlands Policy Forum. Washington, D.C.

Trust for Public Lands and National Association of County Officials. 2002. Local Greenprinting for Growth Vol. 1-4. Available: www.tpl.org.

U.S. Army Corps of Engineers. 1997. Mill Creek Special Area Management Plan (SAMP), King County, Washington. Seattle District, Us Army Corps of Engineers. Available: http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=REG&pagename=Mill_Creek_SAMP. accessed: February 15, 2004.

U.S. Environmental Protection Agency. 1999. Consideration of Cumulative Impacts in EPA Review of NEPA Documents. EPA 315-R-99-002.

United Nations. 1997. Guidelines and manual on land-use planning and practices in watershed management and disaster reduction. Economic and Social Commission for Asia and the Pacific. Available: http://unescap.org/publications

Walters, C. 1986. Adaptive Management of Renewable Resources. The Free Press.

Washington State Department of Community, Trade and Economic Development. November 2003. Critical Areas Assistance Handbook: Protecting Critical Areas within the Framework of the Washington Growth Management Act. Olympia, WA.

Washington State Department of Ecology. 1997. Washington State Wetlands Identification and Delineation Manual. Publication #96-94. Olympia, WA.

Washington State Department of Ecology. 2000. Alternative Mitigation Policy Guidance Interagency Implementation Agreement. State of Washington Alternative Mitigation Policy Guidance For Aquatic Permitting Requirements from the Departments of Ecology and Fish and Wildlife. Washington State Department of Ecology Publication #02-06-007. February 2000. Olympia, WA.

Washington State Department of Ecology. 2001. Stormwater management manual for western Washington. Washington State Department of Ecology Publications #s. 99-11 through 99-15. August 2001. Olympia, WA.

Washington State Department of Ecology. 2004. Stormwater management manual for eastern Washington. Washington State Department of Ecology Publication #04-10-076, September 2004. Olympia, WA.

Washington State Department of Ecology, U.S. Army Corps of Engineers, and U.S. Environmental Protection Agency. April 2004. Guidance on Wetland Mitigation in Washington State. Part 1 - Laws, Rules, Policies, and Guidance Related to Wetland Mitigation. Washington State Department of Ecology Publication #04-06-013a; Part 2 - Guidelines for Developing Wetland Mitigation Plans and Proposals. Washington State Department of Ecology Publication #04-06-013b. Olympia, WA.

Washington State Joint Natural Resources Cabinet. 1999. Statewide Strategy to Recover Salmon. September 21, 1999. Olympia, WA. Available: http://www.governor.wa.gov/gsro/strategy/longversion.htm

Wiedemann, A. M. 1984. The ecology of Pacific Northwest coastal sand dunes: a community profile. U. S. Fish & Wildlife Service. FWS/OBS-84/04.
Williamson, K.S. 2003. Growing with Green Infrastructure. Heritage Conservancy, Doylestown, PA. Available: www.heritageconservancy.org.

Winter, T.C. 1983. The interaction of lakes with variably saturated porous media. Water Resources 19: 1203-1218.

Winter, T.C. 1986. Effect of groundwater recharge on configuration of the water-table beneath sand dunes and on seepage in lakes in the Sandhills of Nebraska. Journal of Hydrology 86:221-237.

Winter, T.C. 1988. Conceptual framework for assessment of cumulative impacts on the hydrology of non-tidal wetlands. Environmental Management 12:605-620.

Winter, T.C. 1989. Hydrologic studies of wetlands in the northern prairie. Pages 16-54 in A. van der Valk (ed.), Northern Prairie Wetlands. Iowa State University Press. Ames, IA.

Winter, T.C. 1992. A physiographic and climatic framework for hydrologic studies of wetlands. Pages 127-148 in R.D. Robarts and M.L. Bothwell (eds.), Aquatic Ecosystems in Semi-Arid Regions: Implications for Resource Management. N.H.R.I Symposium Series 7: Environment Canada. Saskatoon, Saskatchewan, Canada.

Ziemer, R.R. and T.E. Lisle. 1998. Chapter 3. Hydrology. Pages 43-68, in: Naiman, R.J. and R.E. Bilby, eds. River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, N.Y.

Glossary

Adaptive management. A systematic process for continually improving management policies and practices by learning from the outcomes of previous policies and practices. Related to compensatory mitigation, it involves the applicant and the regulatory agencies discussing the problems occurring on a compensation site and coming to agreement on possible solutions or alternative approaches necessary to bring the site into compliance.

Alternative Futures. An approach to prescribing solutions for future development and the protection of wetlands by analyzing different alternative scenarios in terms of their impacts on wetlands and landscape processes. The scenarios include both general planning approaches, such as different patterns of zoning, and more specific approaches, such as different widths of buffers for wetlands with different ratings. The local government usually incorporates other factors into the scenarios based on the priorities of citizens for their communities.

Aquatic resources (systems). Refers to ecological systems where the regular or occasional presence of water is the dominant factor determining the characteristics of the site. Aquatic systems are made up of wetlands, rivers, streams, lakes and other deepwater habitats.

Aspen stands. A type of Washington Department of Fish and Wildlife Priority Habitat, which consists of pure or mixed stands of aspen greater than 0.8 ha (2 acres). See *Priority Habitat and Species list.*

Assessment methods. Methods that generate a number representing an estimate of the performance of a wetland function. The number generated is relative to a predetermined standard (e.g., level of function provided by reference wetlands). Numbers do not reflect an actual level of function performance (Hruby 1999). Examples include the Washington State Methods for Assessing Wetland Functions (also known as WFAM) (Hruby et al. 1999 and 2000) and a Hydrogeomorphic wetland function assessment method (Brinson et al. 1995).

Assessment metrics or metric measures. Represent environmental indicators of condition, stress, or response within an ecosystem that can be used in a predictive manner. Metrics are usually selected based on a significant statistical correlation with scientific data linking environmental stresses to a predictable environmental response (e.g., a correlation between impervious surface and the condition of aquatic habitat). Metrics are frequently used in Alternative Futures analysis to quantify the impacts of different land use scenarios on the landscape.

Atypical wetland. A wetland developed for compensatory mitigation (e.g., created, restored, or enhanced) that does not match the type of existing wetland that would be found in the geomorphic setting of the site (i.e., the water source(s) and hydroperiod proposed for the mitigation site are not typical for the geomorphic setting). For example, excavating a permanently inundated pond in an existing seasonally saturated or inundated wetland is one example of an enhancement project that could result in an atypical wetland.

Avoidance. The first step of mitigation sequencing. See *mitigation*.

Beneficial uses. The term used in the federal and state Clean Water Acts to represent the societal values of aquatic resources that need to be protected. These include, but are not limited to: water supply; surface and groundwater treatment; stormwater attenuation; fish and shellfish migration, rearing, spawning, and harvesting; wildlife habitat; recreation; support of biotic diversity; and aesthetics.

Best management practices (BMPs). Management measures which are reasonable and available and commonly used by professionals in the appropriate field that mitigate adverse impacts to surface and groundwater, and to the functions and values of critical areas.

Biodiversity. The sum total of all the plants, animals (including humans), fungi and microorganisms, along with their individual variations and the interactions between them.

Biological wetland. A biological wetland is a wetland that meets the three parameter criteria of either the 1987 Corps of Engineers Delineation Manual or the 1997 Washington State Wetlands Identification and Delineation Manual (WAC 173-22-035). Compare to *jurisdictional wetland*.

Bog. A unique type of wetland dominated by mosses at the surface and that form peat soils. Bogs form in areas where the climate allows the accumulation of peat to exceed its decomposition. The water regime in bogs is dominated by precipitation rather than surface inflow. The plant community is specialized to survive in the nutrient-poor and highly acidic conditions typical of bog systems.

Buffer averaging. Establishing a width for a buffer around a wetland based on averaging the widths at different points around the wetland rather setting the width as a minimum size everywhere around the wetland. For example, if the standard width for a buffer around a wetland is 100 feet, buffer averaging would allow the width to vary between a minimum and a maximum width but require that the buffer area average be 100 feet in width.

Buffers or buffer areas. Vegetated areas adjacent to wetlands, or other aquatic resources, that can reduce impacts from adjacent land uses through various physical, chemical, and/or biological processes.

Class. A grouping based on shared characteristics in a classification scheme. In the Cowardin et al. (1979) classification of wetlands a class is the third level in the 'taxonomy' of wetlands whereas in the *hydrogeomorphic classification* (Brinson 1993b) it is the highest taxonomic unit.

Clearing. The surface removal of vegetation by cutting, pruning, limbing, topping, relocating, application of herbicides or pesticides, or any application of hazardous or toxic substance that has the affect of destroying or removing the vegetation.

Compensatory mitigation. The compensation stage of the mitigation sequence where impacts to the functions and values of wetlands are replaced through creation, restoration, or enhancement of other wetlands. Because regulatory requirements and policies tend to focus on the compensation stage, the term "mitigation" is often used to refer to compensation, which is just one part of the overall mitigation sequence. See *mitigation*.

Comprehensive plan. A generalized coordinated land use policy statement of the governing body of a county or city.

Connectivity. The structures on the landscape that facilitate movement of living organisms between patches or their habitat that are found across the landscape. The movement can occur either within the lifetime of an organism or over a period of generations. The purpose of facilitating movement is to maintain viable populations that allow species and communities of species to persist in time. Connectivity can be achieved via a continuous and linear habitat feature (as in a corridor) or discrete habitat patches comprised of but not limited to individual forests, wetlands, shrub lands, and shorelines.

Conservation. The protection, preservation, restoration, or careful management of the environment and of natural resources.

Conservation easement. A restriction placed on a piece of property to protect the resources (natural or man-made) associated with the parcel. It restricts the type and amount of development that can take place on a parcel of land. For example, the landowner may sell or donate the development rights while retaining the ownership of the property. Easements are recorded on the property deed and are held in trust by a conservation easement "holder" such as a land trust or government agency. The holder polices the terms of the easement for the duration of its existence, which is usually into perpetuity.

Conservation Futures Levy. Optional provision under RCW 84.34.200 and RCW 84.34.230 authorizing any Washington county to establish a real property tax in the amount of $0.0625 per $1,000 of assessed valuation specifically for the purpose of acquiring land with ecosystem features deemed of high conservation value to the local community.

Contingency plan. A plan outlining actions that would be triggered if monitoring of a project revealed a problem that would prevent the site from attaining its stated goals, objectives, and performance standards. Contingency plans should identify anticipated problems and the specific maintenance activity that would be implemented to rectify each problem.

Contributing basin. The geographic area from which surface water drains to a particular wetland.

Contributing landscape/area. The geographic extent within which the landscape processes occur that influence the functions or structure of associated aquatic resources. A contributing landscape may span jurisdictional boundaries and even span several watersheds.

Conversion. Modification of the vegetation for the purpose of changing land use such a development or agriculture.

Corridor. Corridors are areas that contain relatively undisturbed habitat and/or vegetation that maintain connections for wildlife throughout the landscape. Corridors usually represent linear habitats with the range of environmental functions necessary to permit the movement of animals between larger and more fully functioning habitats. Corridors can include but are not limited to, annual or seasonal migration corridors that connect wintering and breeding habitat, or intra-seasonal corridors that connect foraging and nesting habitat or breeding and dispersal habitat.

Cowardin classification. The first commonly used classification system for wetlands developed in 1979 by the U.S. Fish and Wildlife Service. The Cowardin system classifies wetlands based on water flow, substrate types, vegetation types, and dominant plant species.

Creation. See *establishment*.

Critical areas. As defined by the Growth Management Act RCW 36.70A.030 "include the following areas and ecosystems: (a) Wetlands; (b) areas with a critical recharging effect on aquifers used for potable water; (c) fish and wildlife habitat conservation areas; (d) frequently flooded areas; and (e) geologically hazardous areas".

Cumulative impacts. The incremental effect of an impact added to other past, present, and reasonably foreseeable future impacts.

De minimus. A legal term meaning 'lacking significance or importance; so minor as to be disregarded.'

Deed restriction. Clauses in a deed limiting the future uses of the property. Deed restrictions may impose a vast variety of limitations and conditions, for example, they may limit the density of buildings, dictate the types of structures that can be erected or prevent buildings from being used for specific purposes or even from being used at all. (This definition is from a legal dictionary.)

Depressional wetland. A *class* of wetlands in the *hydrogeomorphic classification*. These are wetlands that occur in topographic depressions that exhibit closed contour interval(s) on three sides and elevations that are lower than the surrounding landscape.

Detention facility. A facility that collects water from developed areas and releases it at a slower rate than it enters the collection system. The excess of inflow over outflow is temporarily stored in a pond or a vault and is typically released over a few hours or a few days.

Disturbance. An event that disrupts the processes or structure of ecological systems. Disturbances may occur naturally (e.g., wildfires, storms, floods) or be caused by human actions (e.g., clearing land, building roads, altering stream channels). The effects of disturbances on ecological systems are controlled in large part by their intensity, duration, frequency, timing, and size and shape of area affected.

Ditch. Any channel that has been specifically dug to facilitate drainage.

Drainage systems. Often called basins, sub-basins, watersheds, or river basins depending on the size of the area. In this document, drainage systems are generally referred to using one of two terms: 1. *Watershed.* A watershed is a geographic area of land bounded by topographic high points in which water drains to a common destination; and 2. *Contributing basin*. An area from which surface water drains to a particular wetland.

Ecoregion. Geographic regions where climatic conditions are similar and the ecosystems (including wetlands) are relatively homogeneous. Omernik and Gallant (1986) mapped the following ecoregions in Washington: Coast Range, Puget Lowland, Cascades, Eastern Cascades Slopes and Foothills, North Cascades, Columbia Plateau, Blue Mountains, and Northern Rockies.

Ecosystem. A loosely defined assemblage of co-occurring organisms and the geographic location which they inhabit. The term is an operational convenience defined by the user of the term for the convenience of description (Levin 2001). There is no basic geographic scale associated with the term ecosystem, and that also has to be defined by a user. For example, the term can be used to describe the micro-organisms co-occurring in a spoonful of soil (soil ecosystem) at one end of the scale to the ecosystem of the world that encompasses all organisms on the planet.

Ecosystem management. The use of ecological principles in managing natural resources by blending social, physical, economic and biological needs and values to provide ecosystems that are properly functioning. Ecosystems, however, do not have well-defined attributes associated with proper functioning. "Hence, management of an ecosystem in accordance with some defined normative behavior rests on judgments as to what is important in those systems" (Levin 2001).

Edge. The boundary where different habitats meet or where successional stages of plant communities come together.

Effectively drained. Former wetlands that have been drained and converted to non-wetlands, primarily for the purposes of agricultural use. Compare to *partially drained.*

Emergent wetland. A wetland class under the Cowardin classification that is dominated by erect, rooted, herbaceous plants. Emergent wetlands include marshes and wet meadows.

Enhancement. The manipulation of the physical, chemical, or biological characteristics of a wetland site to heighten, intensify or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for specified purposes such as water quality improvement, flood water retention or wildlife habitat. Activities typically consist of planting vegetation, controlling non-native or invasive species, modifying site elevations or the proportion of open water to influence hydroperiods, or some combination of these. Enhancement results in a change in some wetland functions and can lead to a decline in other wetland functions, but does not result in a gain in wetland acres. Compare to *establishment, exchange*, and *restoration*.

Environmental processes. The same as *landscape processes*.

Establishment (creation). The manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland or deepwater site, where a wetland did not previously exist. Activities typically involve excavation of upland soils to elevations that will produce a wetland hydroperiod, create hydric soils, and support the growth of hydrophytic plant species. Establishment results in a gain in wetland acres. Compare to *enhancement*, and *restoration*. (Note: The U.S. Army Corps of Engineers' Regulatory Guidance Letter 02-2 uses the term "establishment" rather than the previously accepted term "creation." Federal agencies, as well as the Department of Ecology, have started using the term "establishment.")

Estuarine wetland. Wetlands where salt tolerant plant species are dominant and the water regime is influenced by tidal action. The wetlands are usually partially enclosed by land with open, or partially obstructed access to open saline water. In areas where freshwater wetlands grade into estuarine areas, the boundary of the latter extends to an area where the salinity is less than 5 ppt (parts per thousand) during the period of average annual low flow.

Estuary, estuary-like. A type of Washington Department of Fish and Wildlife Priority Habitat, which consists of deepwater tidal habitats and adjacent tidal wetlands, usually semi-enclosed by land but with open, partly obstructed or sporadic access to the open ocean and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The salinity may be periodically increased above that of the open ocean by evaporation. Along some low-energy coastlines there is appreciable dilution of sea water. Estuarine habitat extends upstream and landward to where ocean-derived salts measure less than 0.5% during the period of average annual low flow. This includes both estuaries and lagoons. See *Priority Habitat and Species list.*

Eutrophication. The undesirable overgrowth of vegetation caused by high concentrations of plant nutrients in bodies of water, especially nitrogen and phosphorous, often as a result of human activities.

Exchange. The conversion of one type of wetland for another. For example, resource managers may intend to enhance habitat value for waterfowl by excavating an area of open water within an existing emergent marsh. If the open water replaces the emergent wetland or a large proportion of it, wetland types have been exchanged. See *enhancement.*

Fen. A type of wetland similar to a bog, containing accumulated peat. Fens support marsh-like vegetation including sedges and wildflowers. Fens differ from bogs in their plant communities, hydrology, and water chemistry. They are fed mostly by groundwater and are not as acidic as bogs.

Filtration. The blockage of sediment by standing vegetation.

Flats. A *class* of wetlands in the *hydrogeomorphic classification*. These are wetlands that occur in topographically flat areas that are hydrologically isolated from surrounding ground or surface water. They are primarily maintained by precipitation.

Forested wetland. A wetland *class* in the Cowardin classification where woody plants taller than 20 feet form the dominant cover. Shrubs often form a second layer beneath the forest canopy, with a layer of herbaceous plants growing beneath the shrubs.

Fragmentation. The breaking up of ecosystems into patches of habitat that are separated by areas altered by human land uses. Fragmentation always consists of both the reduction in the area of the original habitat and a change in spatial configuration of what remains.

Functions. The physical, biological, chemical, and geologic interactions among different components of the environment. See *wetland functions*.

Function assessment. The process by which the capacity of a wetland to perform a function is measured or characterized. This approach analyzes the capacity to perform a function using a numeric model. See *assessment methods*.

Geographic Information System (GIS). A system of spatially referenced information, including computer programs that acquire, store, manipulate, analyze, and display spatial data.

Geomorphology. The geologic composition and structure of a landscape – its topography, landforms, soils, and geology.

Geospatial. Refers to the geographic location and characteristics of natural or constructed features and boundaries on the Earth.

Green infrastructure (GRIST). An interconnected network of relatively undisturbed land and water that is protected to support native species, maintains landscape processes, sustains air and water resources, and contributes to the physical and economic health and quality of life of communities. Green Infrastructure also refers to the "services" that this network of ecosystems provide to people and communities. Such services as water filtration and aquifer recharge, flood attenuation, and biodiversity.

Green infrastructure plan (greenprint or GRIST plan). A plan for conservation using the concepts of green infrastructure which is developed by a proactive planning approach that incorporates both an understanding of the landscape and visioning for the future by the community. The plan represents the preservation aspect of a Smart Growth action strategy. The plan identifies areas for preservation and conservation, ensures the economic vitality of working landscapes, and guides development in a manner that is compatible with sustaining landscape processes and the character, quality of life, and economic sustainability of the community.

Greenprint. See *green infrastructure plan*.

Hydrogeomorphic (HGM) classification. A system used to classify wetlands based on the position of the wetland in the landscape (geomorphic setting), the water source for the wetland, and the flow and fluctuation of the water once in the wetland.

Hydrogeomorphic wetland class. The highest level in the hydrogeomorphic classification of wetlands. There are six basic hydrogeomorphic wetland classes including depressional, tidal fringe, slope, riverine, lake fringe, and flat. See *class*.

Hydroperiod. The pattern of water level fluctuations in a wetland. Includes the depth, frequency, duration, and timing of inundation or flooding. Patterns can be daily, monthly, seasonal, annual or longer term.

Impervious surface. A hard surface area which either prevents or retards the entry of water into the soil relative to conditions prior to development; and/or a hard surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development.

In-kind mitigation. Defined in the 2000 State of Washington Alternative Mitigation Policy Guidance (Ecology 2000) as "replacing the same species, habitat type, and function as those affected. However, disturbed habitat shall not be replaced with additional disturbed habitat. In these cases the applicant must restore the site to its natural condition based on adjacent undisturbed sites, as approved by the permitting agencies."

In-lieu fee program. A program that allows applicants for permits that impact wetlands to compensate for wetland losses by paying a fee to a third party such as a government agency or conservation organization. The fees are intended to be used to restore, create, enhance, or preserve wetlands. Generally, in-lieu fee contributions are collected in advance of wetland losses. These funds are accumulated until they are sufficient to design and implement a wetland compensation project

Interdunal wetlands. Wetlands that form in the "deflation plains" and "swales" that are geomorphic features in areas of coastal dunes. These dune forms are the result of the interaction between sand, wind, water, and plants. The dune system immediately behind the ocean beach (i.e., the primary dune system) is very dynamic and can change from storm to storm. These wetlands provide critical habitat in this ecosystem.

Invasive species. Defined by the National Invasive Species Council (NISC) as "(1) a non-native (alien) to the ecosystem under consideration and (2) a species whose introduction is likely to cause economic or environmental harm, or harm to human health."

Isolated wetlands. Isolated wetlands are generally defined as those wetlands that have no surface water connections to other aquatic resources.

Jurisdictional wetland. A wetland that is regulated by the provisions of the law under the jurisdiction of one or more federal, state, or local agencies. Not all areas of the landscape that have the biological characteristics of wetlands are regulated or jurisdictional wetlands. Compare to *biological wetland*.

Keystone species. A keystone species is a species that plays an essential role in the structure, function, or productivity of a habitat or ecosystem at a defined level of organization (habitat, soil, seed dispersal, etc). They are species that have a greater effect on their ecosystems and associated environmentall processes than would otherwise be predicted from their relative abundance or biomass alone. The beaver is a good example of a keystone species because its activities can change the habitat (create open water) and many hydrologic processes (beaver dams reduce water velocities and create areas for water storage).

Lacustrine. Pertaining to lakes or lake shores.

Lacustrine (lake) fringe wetlands. A wetland *class* under the *hydrogeomorphic classification*. These are wetlands that occur at the margins of topographic depressions in which surface water is greater than 8 hectares (20 acres) and greater than 2 meters deep in western Washington and 3 meters in eastern Washington.

Land banking. Is a tool for funding the acquisition of land authorized under RCW 82.46.070. It allows for establishment of a real estate excise tax to generate revenue for land purchase under a "land banking program." Initiated either by resolution of the county legislators or by public petition, the excise tax is approved by citizen vote.

Landscape analysis. An analysis of environmental processes and human impacts that occur at the larger geographic scales. See *landscape processes.*

Landscape processes. Environmental factors that occur at larger geographic scales, such as basins, sub-basins, and watersheds. Processes are dynamic and usually represent the movement of a basic environmental characteristic, such as water, sediment, nutrients and chemicals, energy, or animals and plants. The interaction of landscape processes with the physical environment creates specific geographic locations where groundwater is recharged, flood waters are stored, stream water is oxygenated, pollutants are removed, and wetlands are created.

Landscape scale. The geographic scale that encompasses the broader landscape (i.e., large areas such as basins, sub-basins, watersheds, and habitat corridors). Also see *site scale* and *large scale*.

Land trust. A non-profit organization, with 501-c-3 status under federal tax law, whose purpose is to conserve natural lands through acquisition and ownership. Land Trusts are usually locally-based citizen run grass-roots organizations working to protect a range of different critical ecosystem features within their communities.

Large scale. Large in scope. This term is used specifically to indicate geographic areas that extend beyond the boundaries of an individual site, wetland, or resource. Please note that this term has the opposite meaning when it is used in cartography. Large-scale maps are ones that cover a smaller geographic area than a small-scale map.

Large woody debris (LWD). Large pieces of downed wood such as logs, rootwads, and limbs that are in or near a body of water. LWD provides habitat structure for fish and other aquatic organisms.

Lentic. Having slow moving or still water, such as a pond or lake. Compare to *lotic***.**

Lotic. Having running water, such as a river or stream. Compare to *lentic***.**

Low impact development. Low Impact Development (LID) is a stormwater management approach with a basic principle that is modeled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls. The goal of LID is to mimic a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source.

Management area. The geographic area for which plans and regulations are being developed by a local government. The management area is usually a subset of the contributing landscape because it can be based on political boundaries (e.g., a jurisdiction such as a city), or it may be defined geographically to include a specific basin, sub-basin, or WRIA (Water Resource Inventory Area) in a county. Compare to *site scale* and *contributing landscape*.

Marine/estuarine shorelines. A Washington Department of Fish and Wildlife Priority Habitat, which include the intertidal and subtidal zones of beaches, and may also include the backshore and adjacent components of the terrestrial landscape (e.g., cliffs, snags, mature trees, dunes, meadows). See *Priority Habitat and Species list.*

Metric measures. See *assessment metrics*.

Minimization. The second step of mitigation sequencing, in which an activity that cannot avoid some impact on wetlands is designed in a manner to have minimal impact. See *mitigation*.

Mitigation banking. As defined by the 1995 federal guidance on wetland mitigation banking, “wetland restoration, creation, enhancement, and in exceptional circumstances, preservation undertaken expressly for the purpose of compensating for unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be as environmentally beneficial."

Mitigation performance standards. See *performance standards*.

Mitigation (or mitigation sequencing). Mitigation is a series of actions that requires addressing each action, or step, in a particular order. This sequence of steps is used to reduce the severity of negative impacts from activities that potentially affect wetlands. Mitigation involves the following: 1) Avoiding the impact altogether by not taking a certain action or parts of an action; 2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps, such as project redesign, relocation, or timing, to avoid or reduce impacts; 3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment; 4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; 5) Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and 6) Monitoring the required compensation and taking remedial action when necessary (WAC 197.11.768). See *compensatory mitigation*.

Monitoring. The repetitive measurement of some aspect of a natural resource and/or human activity using ecological indicators as the basis for identifying changes to that resource.

Natural Heritage wetlands. As defined by the Natural Heritage Program of the Washington State Department of Natural Resources, wetlands that are either high quality undisturbed wetlands or wetlands that support threatened, endangered, or sensitive plant species.

Natural resources. The aspects of the non-human environment (often called natural ecosystems) that are valued by a society or culture. This includes wildlife and aquatic resources such as wetlands, estuaries, lakes, and rivers. Other natural resources include land, forests, mineral deposits, water, etc.

Off-site mitigation. Compensatory mitigation in which the replacement wetlands are **not** located at or near to the project that is affecting wetlands. Off-site mitigation is often only allowed if mitigation on the project site is not practicable or if it is environmentally preferable to on-site compensation.

Old-growth/mature forests. A type of Washington Department of Fish and Wildlife Priority Habitat. Old-growth west of Cascade crest: Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 20 trees/ha (8 trees/acre) > 81 cm (32 in) dbh or > 200 years of age; and > 10 snags/ha (4 snags/acre) over 51 cm (20 in) diameter and 4.6 m (15 ft) tall; with numerous downed logs, including 10 logs/ha (4 logs/acre) > 61 cm (24 in) diameter and > 15 m (50 ft) long. High elevation stands (> 762m [2500ft]) may have lesser dbh [> 76 cm (30 in)], fewer snags [> 0.6/ha (1.5/acre)], and fewer large downed logs [0.8 logs/ha (2 logs/acre) that are > 61 cm (24 in) diameter and > 15 m (50 ft) long]. Old-growth east of Cascade crest: Stands are highly variable in tree species composition and structural characteristics due to the influence of

fire, climate, and soils. In general, stands will be >150 years of age, with 25 trees/ha (10 trees/acre)> 53 cm (21 in) dbh, and 2.5-7.5 snags/ha (1 - 3 snags/acre) > 30-35 cm (12-14 in) diameter. Downed logs may vary from abundant to absent. Canopies may be single or multi-layered. Evidence of human-caused alterations to the stand will be absent or so slight as to not affect the ecosystem's essential structures and functions. Mature forests: Stands with average diameters exceeding 53 cm (21 in) dbh; crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80 - 200 years old west and 80 - 160 years old east of the Cascade crest. See *Priority Habitat and Species list.*

Ongoing agriculture. The continuation of any activity defined as agriculture, including crop rotations and changes in activity (for example, from pasturing to crop farming), as long as they do not include bringing new areas into agricultural use. Ongoing agriculture does not include the conversion of farmed wetlands into uplands.

On-site mitigation. Compensatory mitigation in which the replacement wetlands are located at or near to the project that is affecting wetlands.

Open Space Current Use Taxation (CUT) program. Property tax reduction program for landowners who retain natural landscape features in their undeveloped condition, authorized under RCW 84.34. See *Public Benefit Rating System.*

Open space. An area of land that is valued for natural processes and wildlife, for agricultural production, forestry, for active and passive recreation, and/or for providing other public benefits.

Oregon white oak woodlands. A type of Washington Department of Fish and Wildlife Priority Habitat, which includes stands of pure oak or oak/conifer associations where canopy coverage of the oak component of the stand is 25%; or where total canopy coverage of the stand is <25%, but oak accounts for at least 50% of the canopy coverage present. The latter is often referred to as oak savanna. In non-urbanized areas west of the Cascades, priority oak habitat consists of stands 0.4 ha (1.0 ac) in size. East of the Cascades, priority oak habitat consists of stands 2 ha (5 ac) in size. In urban or urbanizing areas, single oaks or stands < 0.4 ha (1 ac) may also be considered a priority when found to be particularly valuable to fish and wildlife.

Out-of-kind mitigation. Compensatory mitigation in which the wetland and its associated functions used to compensate for the impacts are of a different kind than those impacted. Out-of-kind mitigation is a fairly common practice, for example, when the affected wetlands are highly degraded (e.g., wet pastures dominated by exotic species), and they may be replaced by a native scrub-shrub wetland.

Partially drained. Refers to cases where the water regime of a wetland has been altered by such measures as ditching and/or tiling, but the area still retains sufficient water to meet the wetland criteria. See *effectively drained.*

Performance standards. Observable or measurable attributes used to determine whether a compensatory mitigation project meets its objectives. Standards are usually written as legally enforceable conditions on a permit.

Preservation. In a non-regulatory context, refers to permanently securing lands (using full-fee acquisition or *conservation easements*) to protect the important features of an ecosystem in an "un-impacted" condition. Preservation is essential when a feature of the ecosystem provides a high level of functions, is rare, or otherwise non-replaceable. See *protection/maintenance* for the definition of preservation used in a regulatory context.

Prior Converted Croplands (PCC). As defined in federal law, wetlands that were drained, dredged, filled, leveled, or otherwise manipulated, including the removal of woody vegetation, before December 23, 1985, to enable production of an agricultural commodity, and that: 1) Have had an agricultural commodity planted or produced at least once prior to December 23, 1985; 2) Do not have standing water (ponding) for more than 14 consecutive days during the growing season; and 3) Have not since been abandoned.

Priority Habitat and Species (PHS) list. The PHS List is a catalog of habitats and species considered to be priorities for conservation and management. "Priority species" require protective measures for their perpetuation due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance. Priority species include State Endangered, Threatened, Sensitive, and Candidate species; animal aggregations considered vulnerable; and those species of recreational, commercial, or tribal importance that are vulnerable. "Priority habitats" are those habitat types or elements with unique or significant value to a diverse assemblage of species. A priority habitat may consist of a unique vegetation type or dominant plant species, a described successional stage, or a specific structural element. There are 18 habitat types, 140 vertebrate species, 28 invertebrate species, and 14 species groups currently on the PHS List. These constitute about 16% of Washington's approximately 1000 vertebrate species and a fraction of the state's invertebrate fauna.

Programmatic mitigation area. A site (or series of sites) that have been identified by a local jurisdiction or a state or federal agency as the preferable area for wetland compensation.

Protection/maintenance (preservation). Removing a threat to, or preventing the decline of, wetland conditions by an action in or near a wetland. This includes the purchase of land or easements, repairing water control structures or fences, or structural protection such as repairing a barrier island. This term also includes activities commonly associated with the term preservation (in a regulatory context). Under regulatory actions preservation does not result in a gain of wetland acres, but may result in a gain in functions over the long term, and is used only in exceptional circumstances. Also see *preservation* for the definition used in a non-regulatory context.

Public Benefit Rating System (PBRS). An optional component of the *Open Space Current Use Taxation (CUT) program* allowing local jurisdictions to tailor their "open" category program to address protection of locally-important landscape features as defined and scored in their specific PBRS.

Reasonable use. That use of the land that is deemed appropriate by a reasonable person when balancing the public's interest against those of the private property owner. When balancing these interests, the reasonable person considers the seriousness of the public problem, the extent to which the owner's land contributes to that problem, the degree to which the proposed mitigating action or regulation solves the problem and the feasibility of less oppressive solutions. At the same time the reasonable person must consider the amount and percentage of value loss; the extent of remaining uses; the past, present, and future uses; the temporary or permanent nature of the regulation; and the extent to which the owner should have anticipated such mitigating actions or regulations and how feasible it is for the owner to alter present or currently planned uses.

Recruitment (of woody debris). The movement of large and small wood from surrounding areas into an aquatic system over time through the actions of wind, water, or other means. The potential for recruitment of woody debris influences the long-term habitat structure within an aquatic system.

Re-establishment. The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former wetland. Activities could include removing fill material, plugging ditches or breaking drain tiles. Re-establishment results in a gain in wetland acres and functions. Compare to *rehabilitation. S*ee also *restoration.*

Reference wetland. In the context of compensatory mitigation, means a wetland chosen to represent the functions and characteristics that are being created, restored, or enhanced at the "mitigation" site. A reference wetland, or wetlands, are used for monitoring the success of the mitigation project. Reference wetlands, in the context of methods for assessing wetland functions, mean the sites chosen to represent the full range of functioning in a region or hydrogeomorphic class. Data collected at these sites is used to calibrate the methods.

Rehabilitation. The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic functions and processes of a degraded wetland. Activities could involve breaching a dike to reconnect wetlands to a floodplain, restoring tidal influence to a wetland, or breaking drain tiles and plugging drainage ditches. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres. Compare to e*stablishment (creation), re-establishment* and *enhancement.* See also *restoration*.

Restoration. The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into *re-establishment* and *rehabilitation*.

Richness. The number of different species of organisms present in a community.

Riparian. A Washington Department of Fish and Wildlife Priority Habitat, which includes the area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other. In riparian systems, the vegetation, water tables, soils, microclimate, and wildlife inhabitants of terrestrial ecosystems are influenced by perennial or intermittent water. Simultaneously, the biological and physical properties of the aquatic ecosystems are influenced by adjacent vegetation, nutrient and sediment loading, terrestrial wildlife, as well as organic and inorganic debris. Riparian habitat encompasses the area beginning at the ordinary high water mark and extends to that portion of the terrestrial landscape that is influenced by, or that directly influences, the aquatic ecosystem. Riparian habitat includes the entire extent of the floodplain and riparian areas of wetlands that are directly connected to stream courses. See *Priority Habitat and Species list*. Also see *riparian* below.

Riparian. The strip of land adjacent to a body of water that is transitional between the aquatic system and the upland. Some riparian areas contain wetlands. Also see *riparian* above.

Riparian areas. Vegetated ecosystems along a water body through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body. These systems encompass wetlands, uplands, or some combination of these two landforms. They will not in all cases have all the characteristics necessary for them to be also classified as wetlands.

Risk assessment. The process of establishing information regarding acceptable levels of a risk and/or levels of risk for an individual, group, society, or the environment.

Riverine wetlands. A *class* of wetlands in the *hydrogeomorphic classification*. Wetlands that occur in floodplains and riparian corridors in association with stream or river channels where there is frequent overbank flooding.

Rural natural open space. A Washington Department of Fish and Wildlife Priority Habitat, which includes open spaces in which a priority species resides within it or adjacent to it and the priority species uses it for breeding or regular feeding; and/or the open space functions as a corridor connecting other priority habitats, especially areas that would otherwise be isolated; and/or the open space is an isolated remnant of natural habitat larger than 4 ha (10 acres) and surrounded by agricultural developments. Local consideration may be given to open space areas smaller than 4 ha (10 acres). Compare to *urban natural open space.* Also see *Priority Habitat and Species list.*

Sequencing (mitigation sequencing). A series of actions that requires addressing each action, or step, in a particular order. It is the process of working through a series of steps to determine what types of impacts may be permitted and what types of compensatory mitigation may be appropriate. See *mitigation.*

Site processes. Environmental factors that occur within the wetland itself or within its buffer. The interactions of site processes with landscape processes define how a wetland functions.

Site scale. The geographic scale that encompasses the area within the boundary of a single wetland and its immediate surroundings. Compare to *management area* and *contributing landscape*. Also see *landscape scale.*

Slope wetlands. A *class* of wetlands in the *hydrogeomorphic classification.* These are wetlands that occur on the slopes of hills or valleys. The principal water source is usually seepage from groundwater.

Smart Growth. A concept for improving land-use planning and the management of growth in communities by combining principles of ecosystem management with those of comprehensive planning. Its purpose is to minimize the negative effects of sprawl development on both the economic vitality of communities and the environment. Generally, Smart Growth principles and policies encourage limited outward expansion, higher density development, preservation of green space, walk-able communities, and revitalization of urban centers.

Species richness. See *richness***.**

Stormwater. Stormwater is the water coming from rain or snow that runs off surfaces such as rooftops, paved streets, highways, and parking lots. It can also come from hard grassy surfaces like lawns, play fields, and from graveled roads and parking lots.

Sub-basin. A smaller drainage basin that is part of a larger drainage basin or watershed. For example, the watershed of a large river may be composed of several sub-basins, one for each of the river's tributaries.

Temporal impacts. Impacts to wetland functions that will eventually be replaced as a project of compensatory mitigation matures, but cannot achieve similar levels of function in a short period of time. Compare to *temporal loss.*

Temporal loss (of functions). The concept that there is a time lag between the loss of existing wetland functions through human or natural disturbance and the re-establishment of functions over time in a site that is newly constructed or modified.

Tidal fringe wetlands. A *class* of wetlands in the *hydrogeomorphic classification*. Wetlands that occur on continental margins where marine waters are greater than 2 meters deep and more than 8 hectares (20 acres) in size.

Transfer of Development Rights (TDR). A process by which development rights are severed from parcels of land and transferred to other parcels. Areas are designated where such rights can be bought and used.

Urban natural open space. A Washington Department of Fish and Wildlife Priority Habitat, which includes open spaces in which a priority species resides within it or adjacent to it and the priority species uses it for breeding and/or regular feeding; and/or the open space functions as a corridor connecting other priority habitats, especially those that would otherwise be isolated; and/or the open space is an isolated remnant of natural habitat larger than 4 ha (10 acres) and is surrounded by urban development. Local considerations may be given to open space areas smaller than 4 ha (10 acres). Compare to *rural natural open space.* Also see *Priority Habitat and Species list.*

Values. See *wetland values*.

Vegetated marine/estuarine. A Washington Department of Fish and Wildlife Priority Habitat, which includes the following: Eelgrass meadows - habitats consisting of intertidal and shallow subtidal shores which are colonized by rooted vascular angiosperms of the genus *Zostera;* Kelp beds - patches of sedentary floating aquatic vegetation of the genus *Macrocystis* and/or *Nereocystis; and* Turf algae - habitats consisting of non-emergent green, red, and/or brown algae plants growing on solid substrates (rocks, shell, hardpan). See *Priority Habitat and Species list.*

Vernal pool. Small depressions in the scabrock or in shallow soils of eastern Washington that fill with snowmelt or spring rains. They retain water until the late spring when reduced precipitation and increased evapotranspiration lead to a complete drying out. The wetlands hold water long enough throughout the year to allow some strictly aquatic organisms to flourish, but not long enough for the development of a typical wetland environment.

Watershed. A geographic area of land bounded by topographic high points in which water drains to a common destination.

Wetland functions. The physical, biological, chemical, and geologic interactions among different components of the environment that occur within a wetland. Wetlands perform many valuable functions and these can be grouped into three categories: functions that improve water quality, functions that change the water regime in a watershed such as flood storage, and functions that provide habitat for plants and animals.

Wetland rating. Also called a wetland rating system. is a tool for dividing or grouping wetlands into groups that have similar needs for protection. One method used in Washington is the Washington State wetland rating systems (Hruby 2004a,b), which places wetlands in categories based on their rarity, sensitivity, our inability to replace them, and their functions.

Wetland values. Wetland processes, characteristics, or attributes that are considered to benefit society.

Wetlands. As defined by the *Washington State Wetlands Delineation Manual* (Ecology 1997), "The Corps of Engineers (CE) (Federal Register 1982), the Environmental Protection Agency (EPA) (Federal Register 1985), the Shoreline Management Act (SMA) and the Growth Management Act (GMA) all define wetlands as: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. In addition, the SMA and GMA definitions add: "Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands."

Appendix 1-A

Members of Core Team and Local Government Wetlands Advisory Team

Core Team Members Involved in the Production of Volume 2

Andy McMillan, Washington State Department of Ecology

Douglas Peters, Washington Department of Community, Trade, and Economic Development

Dyanne Sheldon, Sheldon & Associates

Erik Stockdale, Washington State Department of Ecology

Jane Rubey, Washington State Department of Ecology

Katherine March, Washington Department of Fish and Wildlife

Sara Noland, 2N Publications

Stephen Stanley, Washington State Department of Ecology

Teri Granger, Washington State Department of Ecology

Tom Hruby, Washington State Department of Ecology

Members of the Local Government Wetlands Advisory Team

Bill Blake, City of Arlington

Bob Landles, City of Everett

Brent Davis, Clark County

Chuck Jones, Douglas County

Dan Cox, Skagit County

Dean Patterson, Yakima County

Debbie Hyde, Pierce County

Douglas Peters, Washington Department of Community, Trade and Economic Development

Geoffrey Thomas, City of Redmond

John Marvin, Yakima County

Kim Spens, City of Bellingham

Klaus Richter, King County

Laura Casey, King County

Margaret Clancy, Parametrix

Mike Desimone, Pacific County

Phil Mees, Benton County

Randy Middaugh, Snohomish County

Rob Knable, City of Seattle

Steve Morrison, Thurston County

Teresa Vanderburg, Adolfson Associates

Todd Stamm, City of Olympia

Appendix 1-B
Reviewers of Volume 2

Representatives from the business and environmental community that provided input on concepts and early drafts of Volume 2:

Dee Arntz, WETNET (of Audubon)

Nina Carter, Audubon Washington

Andrew Cook, Business and Industry Association of Washington

Jerry Gorsline, Washington Environmental Council

Kristen Sawin, Association of Washington Business

Jody Slavik, Business and Industry Association of Washington

Tim Trohimovich, 1000 Friends of Washington (now called Futurewise)

Individuals and organizations that provided written comments during the public review period:

Harriet Beale, Outreach Manager, Puget Sound Action Team

Jerry Gorsline, Policy Associate, Washington Environmental Council

Maxine Keesling, Private Citizen

Mary J. Roberts, Watershed Steward, WSU Cooperative Extension/King County

Tim Trohimovich, AICP, Planning Director, 1000 Friends of Washington (now called Futurewise)

Sarah Cooke and Dee Arntz, Audubon WETNET Scientific Advisory Committee

Washington State Department of Fish and Wildlife (staff not on the Core Team)

Appendix 5-A

Some Sources of Existing Data for Use in Landscape Analysis

Type of Information	Database	Source
100-year flood hazard areas	FEMA	Federal Emergency Management Agency (Data distributed through the Department of Ecology) http://www.ecy.wa.gov/services/gis/data/flood/q3flood.htm or go to the Department of Ecology Floods home page http://www.ecy.wa.gov/programs/sea/floods/
Aerial photos	Digital Ortho Quads (DOQ)	University of Washington http://duff.geology.washington.edu/data/raster/index.html (See Images)
Boundaries of Water Resource Inventory Areas (WRIA) that can be used to define the contributing landscapes	WRIA/24	Washington State Department of Ecology http://www.ecy.wa.gov/services/gis/data/data.htm
Geologic formations under the soils	Surficial Geology	Washington State Department of Natural Resources http://www.dnr.wa.gov/geology/dig100k.htm
Land use/land cover data	National Land Cover Data (NLCD), 30-meter GIRAS Land Use / Land Cover (LUCL) data	The 30-meter NLCD http://landcover.usgs.gov Data for WA can be accessed directly at http://landcover.usgs.gov/nlcd/show_data.asp?code=WA&state=Washington GIRAS LUCL data collected by USGS and converted to ARC/INFO by the EPA http://www.epa.gov/ngispgm3/spdata/EPAGIRAS/
Location, size, and type of wetlands in a landscape	NWI (National Wetland Inventory)	U.S. Fish and Wildlife Service NWI is available either in paper maps or in digital format (http://wetlands.fws.gov/downloads.htm)
Mapping of streams and rivers	HYDRO (GIS layer of streams and rivers)	Washington State Department of Natural Resources http://www.dnr.wa.gov/dataandmaps/ (go to Available GIS data, Hydrography)
Priority Habitats and Species	PHS (Priority Habitats and Species -several data layers)	Washington State Department of Fish and Wildlife (WDFW) http://www.wdfw.wa.gov/hab/phspage.htm

Type of Information	Database	Source
Roads and rails	TRANS (GIS layer of roads and rails)	Washington State Department of Natural Resources http://www.dnr.wa.gov/dataandmaps/ (go to Available GIS data, Transportation) Also, the Washington State Department of Transportation http://www.wsdot.wa.gov/mapsdata/geodatacatalog/default.htm.
Salmon and fish use	WLRIS, SSHIAP	Washington Lakes and Rivers Information System - Fish Distribution can be ordered from WDFW http://www.wdfw.wa.gov/hab/release.htm (go to Fish and Wildlife maps and digital data products available from WDFW) Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) is also available through WDFW at http://wdfw.wa.gov/hab/sshiap/
Soil types	SOILS	USDA, Natural Resources Conservation Service http://soildatamart.nrcs.usda.gov/
USGS quadrangle data (7 ½')	QUADS	University of Washington , digital raster graphics http://duff.geology.washington.edu/data/raster/index.html Washington State Department of Natural Resources http://www.dnr.wa.gov/dataandmaps/ (go to Available GIS data) Data also distributed through Washington State Department of Ecology http://www.ecy.wa.gov/services/gis/data/data.htm
USGS topographic grid data	DIGITAL ELEVATION MODEL (DEM), 10 meter or 30 meter	University of Washington http://duff.geology.washington.edu/data/raster/index.html

Appendix 5-B

Methods and Information Resources for Use in Analyzing Landscapes and Wetlands

Chapter 5 of this volume presents a number of questions, regardless of the method used, that should be answered when conducting landscape analysis. This appendix presents various methods and general references that are available for use in analyzing the landscape and its wetlands, as well as assessing the characteristics and functions of individual wetlands. These analyses can assist local governments in developing plans, regulations, and non-regulatory approaches to protect landscape processes and wetlands.

Methods for analyzing the larger geographic scales (contributing landscape and management area) are under development and being tested in pilot projects here in Washington. Therefore, there is very little information about the effectiveness of these methods at providing the information necessary to protect and manage wetlands from this broader perspective. One of the methods described briefly in this appendix is the approach that the Department of Ecology is developing for analyzing the landscape (a link to a web site is provided in that section of the appendix).

On the other hand, methods for analyzing the functions and characteristics of individual wetlands have been extensively used in Washington State. Numerous methods are summarized in this appendix.

References on Landscape Processes in the Pacific Northwest

The following two books are recommended for developing an understanding of landscape processes in the coastal region of the Pacific Northwest. Though these books focus on river systems in one geographic area of Washington, the concepts, principles, and research presented are very useful in understanding the interaction of processes that occur at larger geographic scales with all wetland types.

Naiman, R. and R. Bilby (eds.). 1998. River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. 705 pp.

In particular, Chapters 2 through 4 in Part I (Physical Environment), Chapters 11 and 12 in Part III (Ecosystem Processes), and Chapters 19 and 20 in Part IV (Management) are very useful in understanding landscape processes and how to approach assessment of watersheds.

The following is text from the publisher's abstract:

> *Touching all parts of the natural environment and nearly all aspects of human culture, streams and rivers act as centers of organization within landscapes. They provide natural resources such as fish and clean water, transportation, energy, diffusion of wastes, and recreation. A basic ecological understanding of the structure and dynamics of running waters is needed to formulate sound management and policy decisions. The vast Pacific coastal ecoregion of the United States contains an extraordinary array of physical setting and examples of the range of dynamics associated with rivers and their management. The interface between the science and policy of natural resource management is illustrated by examples from this ecoregion, including the protection riparian forest, the marbled murrelet, salmon, and amphibians. This study includes sections on the physical environment, the biotic environments, ecosystem processes, management, and recommendations for the future. Specific topics include channel dynamics, hydrology, water quality, microbial process, primary production, fish and wildlife, riparian forest dynamics, organic matter and trophic dynamics, biogeochemical cycling, maintaining biodiversity, monitoring and assessment, economic perspectives, legal consideration, and the role of non-governmental organizations in river management.*

Montgomery, D., S. Bolton, D. Booth, and L. Wall (eds.). 2003. Restoration of Puget Sound Rivers. University of Washington Press. 512 pp.

The first five chapters of this book are very useful in gaining an understanding of landscape processes and the effect of alterations on these processes. The reference also addresses potential objectives for restoration based on landscape setting, geology, and land uses.

The following is text from the publisher's abstract:

> *In the Pacific Northwest, as in most regions of the United States, we are still learning about the processes that create habitat and river structure, how those processes influence aquatic ecosystems, and how to gauge the response of river systems to both land-use change and restoration efforts. River systems are still responding to historic changes, and degraded habitat may not be restored successfully if natural conditions are not well understood, particularly if massive change in watershed hydrology or other processes are the root cause…. The eighteen chapters of Restoration of Puget Sound Rivers – presented by the region's experts at a symposium of the Society for Ecological Restoration – examine geological and geomorphological controls on river and stream characteristics and dynamics, biological aspects of river systems in the region, and the application of fluvial river systems in the region, and the application of fluvial geomorphology, civil engineering, riparian ecology, and aquatic ecology in efforts to restore Puget Sound Rivers.*

General References for Analysis at a Landscape Scale

The following books provide some general information about tools for analyzing wetlands and aquatic resources at larger geographic scales. These may provide useful background information for anyone trying to develop an approach that will work in their jurisdiction.

Kroenert, R., U. Steinhardt, and M. Volk. 2001. Landscape Balance and Landscape Assessment. Springer-Verlag, New York. 304 pp.

The following is the abstract from the publisher:

> *During the last decades, landscape ecology has developed tremendously. It concerns both the theoretical basis and practical application. The authors follow a hierarchical approach that is inherent in landscape structures and processes as well as in planning practice. They show first approaches for the inclusion of factors of the landscape balance into planning procedures and new methods (GIS-coupled modeling, remote sensing) combined with more classical approaches from the basis of landscape assessment. Approaches for multi-criterial landscape assessments will be presented also. The overall target is to give recommendations for sustainable land-use and management. Each chapter concludes with a synthesis of the theme under discussion. Ideas concerning the state-of-the-art are integrated as well as future trends in research. All methodological approaches will be explained with examples from differing regions.*

Heathcote, I.W. 1998. Watershed Management: Principles and Practice. John Wiley & Sons, Inc. 414 pp.

The following is the abstract from the publisher:

> *This book presents a flexible, integrated framework for watershed management that addresses the biophysical, social, and economic issues affecting water resources and their use. Comprehensive in scope and multidisciplinary in approach, it equips you with the necessary tools and techniques to develop sound watershed management policy and practice - from problem definition and goal setting to electing management strategies and procedures for monitoring implementation. Topics include watershed components and processes; establishing management plan parameters and objectives; stakeholder identification and consultation; development of practical management options; both simple and detailed methods for the assessment of management alternatives; techniques for determining the legal implications and the environmental, economic, and social impact of a management plan; and choosing the best plan and putting it into action. Supplemented with case studies and examples, Integrated Watershed Management is an ideal resource for upper-level students and professionals in environmental science, natural resource management, and environmental engineering.*

Reimold, R.J. 1998. Watershed Management: Practice, Policies, and Coordination. McGraw-Hill Companies. 608 pp.

The following is the abstract from the publisher:

> *Ensuring a safe and adequate supply of water requires the combined efforts and expertise of resource managers, engineers, planners, technical experts, and policy analysts worldwide. This contributed volume is unique in recognizing this need and provides today's first truly comprehensive, international coverage of effective watershed management. Experts representing the full spectrum of environmental professions and viewpoints provide detailed case studies of how watershed management is being implemented around the world, focusing on the United States, France, the former Soviet Union, the Pacific Rim, the Nile River, and other areas. Successful approaches such as whole watershed and full stakeholder involvement; watershed sanitary surveys; urban watershed management; river basin planning; integrated management and water resource protection; watershed-based coastal management wetlands restoration; water quality monitoring and assessment; stormwater and other nonpoint pollution source management; water withdrawal; wastewater discharge permitting; and other tools for cost-effective watershed management are highlighted. Mathematical models demonstrate how various systems can be successfully managed for future sustainability.*

Methods for Analyzing the Contributing Landscape and Management Area

The following list identifies a few published methods that can provide information that can be used in protecting and managing wetlands at larger geographic scales.

Environmental Protection Agency's Synoptic Approach

Abbruzzese, B., and S.G. Leibowitz. 1997. A synoptic approach for assessing cumulative impacts to wetlands. Environmental Management 21(3): 457-475.

Leibowitz, S.G., B. Abbruzzese, P.R. Adamus, L.E. Hughes, and J.T. Irish. 1992. A synoptic approach to cumulative impact assessment: A proposed methodology. U.S. Environmental Protection Agency. EPA/600/R-92/167.

Washington State was one of the case studies used to demonstrate the concept of the synoptic approach.

The following is the abstract from the authors:

> *The U. S. Environmental Protection Agency's Wetlands Research Program has developed the synoptic approach as a proposed method for assessing cumulative impacts to wetlands by providing both a general and a comprehensive view of the environment. It can also be applied more broadly to regional prioritization of environmental issues. The synoptic approach is a framework for making comparisons between landscape subunits, such as watersheds, ecoregions, or counties, thereby allowing cumulative impacts to be considered in management decisions. Because there is a lack of tools that can be used to address cumulative impacts within regulatory constraints, the synoptic approach was designed as a method that could make use of available information and best professional judgment. Thus, the approach is a compromise between the need for rigorous results and the need for timely information. It is appropriate for decision-making when quantitative, accurate information is not available; the cost of improving existing information or obtaining better information is high; the cost of a wrong answer is low; there is a high demand for the information; and the situation calls for setting priorities between multiple decisions versus optimizing for a single decision. The synoptic approach should be useful for resource managers because an assessment is timely; it can be completed within one to two years at relatively low cost, tested, and improved over time. An assessment can also be customized to specific needs, and the results are presented in mapped format. However, the utility of a synoptic assessment depends on how well knowledge of the environment is incorporated into the assessment, relevant to particular management questions.*

The Washington State Department of Ecology's Guidance for Landscape Analysis

The Washington State Department of Ecology is developing guidance for conducting a landscape analysis. This guidance is designed to assist local governments in applying landscape principles to planning and regulatory activities (e.g., updating comprehensive plans, developing area-specific plans, creating land-use plans, etc.). A landscape analysis can be used to determine whether environmental processes have been altered, identify the mechanisms and geographic locations of the alterations, determine patterns of future land uses and development standards that are compatible with maintenance of landscape processes and natural resources, and identify viable restoration opportunities.

The purpose of Ecology's guidance is to

- Provide information that can be used to sustain and restore environmental processes and aquatic resources
- Establish a common environmental framework for developing, updating, and coordinating planning efforts

- Assist in the preparation of updates to comprehensive plans and Shoreline Master Plans:
  - Provide direction on appropriate designations for land use and zoning
  - Promote the integration of the Growth Management Act and Shoreline Management Act (SMA)
  - Establish a framework for characterizing environmental processes and developing a restoration plan as required under the new SMA guidelines
  - Promote "no net loss" of shoreline functions and the maintenance of landscape processes and wetland functions

By applying the guidance, a general model of the key environmental processes and their relationship to aquatic habitat is developed and areas important to maintaining those processes are identified. Next, specific indicators, such as land use, land cover, population density, channelization, and ditching are used to qualify the degree of alteration to these processes. By comparing the model of environmental conditions to the location and number of alterations, measures for protection and restoration can be identified. These can include determining appropriate land-use activities as well as identification and ranking of wetland restoration areas.

Ecology's guidance involves the following five steps. Information for completing these steps is available online at: www.ecy.wa.gov/programs/sea/landscape.

1. Identify and map the aquatic resources of interest
2. Identify and map the area that contributes surface and ground water to the resources of interest
3. Identify processes critical to the integrity and functions of the resources
4. Identify and map areas important for sustaining key processes
5. Identify and map the type of alterations that have affected key processes

The results of the analysis can then be used to develop:

- Land-use recommendations that protect key processes in important areas that are unaltered
- Land-use recommendations that restore key processes in important areas that have been altered

Ecology's approach to landscape analysis uses existing environmental data and land-use information including surficial geology and geologic hazards, soil types, topography, land cover and land use, water quality and quantity, and mapping of critical habitats.

Maryland Stream Corridor Assessment Survey

The following describes an assessment developed by Maryland's Department of Natural Resources. It was taken from the survey's web page in April 2004: http://www.dnr.state.md.us/streams/stream_corridor.html.

> *The Stream Corridor Assessment (SCA) survey was developed by DNR's Watershed Restoration Division as a tool to help environmental managers identify environmental problems and prioritize restoration opportunities on a watershed basis. As part of the survey, trained personnel walk the watershed's entire stream network and record information on a variety of environmental problems that can be easily observed within the stream corridor. Common environmental problems documented in the survey include: eroding stream banks, inadequate stream buffers, exposed pipes, altered stream channels, fish migration barriers, pipe outfalls, in-stream construction sites and trash dumping locations. In addition to identifying the location of common stream problems the survey also collects information on both in- and near-stream habitat conditions so that comparative assessments can be made of the condition of different stream segments.*
>
> *It is important to note that Stream Corridor Assessment Survey is not intended to be a detailed scientific evaluation of a stream system nor will it replace the more standard chemical and biological surveys. Instead the survey is intended to provide a rapid method of examining an entire drainage network so future monitoring and management efforts can be better targeted. Part of the need for this type of survey is that many existing scientific surveys are very time consuming, expensive and can only collect information for a relatively small section of stream at any one time. The Stream Corridor Assessment Survey, on the other hand, is designed so that teams of 2 or 3 volunteers are able to survey 2 or more stream miles per day. Individuals performing the survey receive training in both stream ecology and how to conduct the survey.*

North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS)

Sutter, L.A. and J.R. Wuenscher. 1996. NC-CREWS: A Wetland Functional Assessment Procedure for the North Carolina Coastal Area (Draft). Division of Coastal Management, North Carolina Department of Environment and Natural Resources, Raleigh, NC. 61 pp/appen.

The following description was taken from the NC-CREWS web page in April 2004: http://www.wes.army.mil/EL/emrrp/emris/emrishelp6/north_carolina_coastal_region_evaluation_of_wetland_significance_tools.htm. Note that this method was developed to rate wetlands in North Carolina. The indicators of function used would have to be modified to reflect conditions in the region of Washington where the method is being used.

Primary purpose: To predict the relative ecological significance of wetlands within their watershed and region using a GIS-based landscape-scale procedure. Developed for use in planning and overall management of wetlands rather than for regulatory decisions.

Eleven functions are addressed: surface runoff storage; floodwater storage; shoreline stabilization; terrestrial wildlife; aquatic life; nonpoint source; floodwater cleansing; landscape character; water characteristics; replacement difficulty; and restoration potential.

Procedure: Using GIS analysis, a High, Medium, or Low rating is assigned to each of 39 parameters that describe the landscape and internal wetland characteristics. The parameter ratings are successively combined to produce ratings (H, M, or L) for subfunctions and primary functions. The primary function ratings are combined to form an overall rating of the wetlands ecological significance (i.e., beneficial significance, substantial significance, or exceptional significance).

Output: Measure of overall ecological significance of a wetland within its watershed and the larger landscape.

Contact person: Jim Stanfill, Division of Coastal Management, North Carolina Department of Environment and Natural Resources, P.O. Box 27687, Raleigh, NC 27611 phone: (919) 733-2293; fax: (919) 733-1495; e-mail: jim_stanfill@mail.enr.state.nc.us

Limitations listed by authors: "The NC-CREWS models should not be used as a guide to design, however, individual variables (parameters) may provide useful information. It is not the intended purpose for the procedure, therefore, it contains properties that limit its application for this purpose. For example, NC-CREWS uses opportunity variables, but does not set upper limits on those opportunities that could potentially reduce functional capacity (e.g., a wetland located near a pollutant generating area is assigned a high rating). In some circumstances, a wetland may not have the capacity to remove all nutrient input. An upper limit on the opportunity must be defined to insure that the existing or planned wetland can predictably have the capacity to provide a function."

Spatial Wetland Assessment for Management and Planning (SWAMP)

Sutter, L.A., J.B. Stanfill, D.M. Haupt, C.J. Bruce, and J.E. Wuenscher. 1999. NC-CREWS: North Carolina Coastal Region Evaluation of Wetland Significance. North Carolina Division of Coastal Management, Department of Environment and Natural Resources. Raleigh, NC.

The following description was taken from the SWAMP web page in April 2004: http://www.csc.noaa.gov/lcr/swamp/text/p661.htm#intro. Note that this method was developed to rate wetlands in North Carolina. The indicators of function used would have to be modified to reflect conditions in the region of Washington where the method

is being used. Ecology is presently working on adapting this method to the coastal region of the Pacific Northwest.

> *The Spatial Wetland Assessment for Management and Planning (SWAMP) uses basic ecological principles to evaluate the significance of wetlands within a watershed while allowing the decision maker to establish the rules for overall rating. The model is based on the NC-CREWS model (Sutter et al. 1999) but has significantly faster processing time and offers greater flexibility in adjustment of parameters and rating rules. Three groups of functions are evaluated including water quality, hydrology and habitat.*
>
> *Procedure: Requires digital information in GIS format. including:(1) wetland boundaries and types; (2) land cover; (3) soils data; (4) hydrography; and (5) watershed boundaries.*
>
> *The functional significance of wetlands is rated (non quantitative) on the basis of three broad categories: exceptional functional significance, substantial functional significance, and beneficial functional significance.*
>
> *Output: To produce information about the relative ecological importance of wetlands that would be useful for wetland planning and management.*

The authors describe its limitations as follows:

> *The result of the procedure is not a substitute for a site visit in making regulatory decisions, but a predictor of what a site visit would determine. The parameters and thresholds developed for the ACE Basin would be more defensible if data had been collected to specifically support the assumptions behind each parameter.*

Methods for Analyzing Wetlands at the Site Scale

An assessment of the functions performed by a wetland is often required when impacts to that wetland will result from a change in land use. In many jurisdictions, the level of analysis depends upon the type, severity, and extent of the proposed impacts such that the detail necessary will be commensurate with the impacts.

As a minimum, many local governments require an analysis of functions be performed using a rating system. Rating systems also help determine if particular features or situations of concern exist at the site, such as the presence of a mature forest (see Chapter 8, Section 8.3.4, for more on rating). If Ecology is involved in a project, the applicant will generally be requested to apply the wetlands rating system for western Washington or eastern Washington (see below) to determine the category of the wetland and how well it performs three basic functions (improving water quality, reducing flooding and erosion, and potential to provide habitat for many species). However, a more thorough assessment of functions may be needed when wetland impacts will be significant. In such cases regulatory agencies may request that an applicant complete an assessment using the wetland function assessment method for Washington State, if the wetland is in one of the classes for which a method has been developed (see below).

The following is a list of methods that were specifically developed to analyze wetlands in Washington or are commonly used in the state.

Washington State Wetlands Rating Systems

Hruby, T. 2004. Washington State Wetland Rating System for Eastern Washington – Revised. Washington State Department of Ecology Publication #04-06-015. Olympia, WA.

Hruby, T. 2004. Washington State Wetland Rating System for Western Washington – Revised. Washington State Department of Ecology Publication #04-06-025. Olympia, WA.

The Washington State Wetlands rating systems for eastern and western Washington are technically characterizations that group wetlands based on sensitivity, rarity, functions, and other criteria including the performance of basic functions as described above. For more information and to download the rating systems go to the following web addresses:

For western Washington: http://www.ecy.wa.gov/biblio/0406025.html

For eastern Washington: http://www.ecy.wa.gov/biblio/0406015.html

Advantages

- Designed to categorize wetlands into one of four groups which allow agencies/local governments to determine how the wetlands should be protected and managed
- Rapid and relatively easy to perform; the vast majority of sites can be rated within 1 to 2 hours in the field

Limitations

- Not a numeric assessment of functions, but a characterization
- May oversimplify the performance of functions and understanding of the wetland functions needed to adequately protect it, especially in large wetlands having several types within one boundary

Recommended Uses

- Determine into which category a wetland is grouped, often for regulatory purposes to determine buffer widths and ratios for compensatory mitigation
- May provide sufficient characterization of potential functions for impacts to small (e.g., <1 acre), degraded wetlands when determining needs for compensation

Washington State Wetland Function Assessment Methods (WFAM)

Hruby, T, S. Stanley, T. Granger, T. Duebendorfer, R. Friesz, B. Lang, B. Leonard, K. March, and A. Wald. 2000. Methods for Assessing Wetland Functions, Volume II: Depressional Wetlands in the Columbia Basin of Eastern Washington. Parts I and II. Washington State Department of Ecology Publication #00-06-47 and#00-06-48. Olympia, WA.

Hruby, T., T. Granger, K. Brunner, S. Cooke, K. Dublanica, R. Gersib, L. Reinelt, K. Richter, D. Sheldon, E. Teachout, A. Wald, and F. Weinmann. 1999. Methods for Assessing Wetland Functions, Volume I: Riverine and Depressional Wetlands in the Lowlands of Western Washington. Parts I and II. Washington State Department of Ecology Publication #99-115 and #99-116. Olympia, WA.

Methods for Assessing Wetland Functions, commonly called Washington State Wetland Function Assessment Methods (WFAM), are a collection of assessment methods developed by interdisciplinary teams of experts and published by Ecology. Unlike rating systems which categorize wetlands using information about basic functions, the assessments provide a score for the degree to which several functions (up to 15) are performed by a wetland. The methods are based on the hydrogeomorphic (HGM) classification for wetlands. For more information and to download the methods go to the following web address: http://www.ecy.wa.gov/programs/sea/wfap/index.html.

Advantages

- Relatively rapid for the scientific rigor of the assessments that are needed
- Provide a numeric expression of the level of performance of wetlands in regard to their potential to perform and their opportunity to perform numerous functions
- Developed for specific areas in Washington and for specific wetland types
- Peer reviewed and field tested in the area for which they were developed
- Results are reproducible to ±10%, especially with training

Limitations

- Large, structurally complex sites may require a few days to complete an assessment
- Site visits at different times of the year may be necessary to accurately determine the water regime (e.g., the length and extent of inundation)
- Specific training in the application of WFAMs is required before one uses it for regulatory purposes
- WFAMs are lacking for specific wetland types. Methods do not exist for riverine wetlands in eastern Washington, any montane areas, or any slope, tidal, or interdunal wetlands
- Numeric results may be misused to assume scores are continuous functions rather than discrete integers

Recommended Uses

- Projects involving significant wetland impacts in terms of size (e.g. >2 acres) or estimated level of performance of the wetland
- Determine if functions lost to impacts have been adequately replaced in compensatory mitigation

Wetland Functions Characterization Tool for Linear Projects

Null, W., G. Skinner, and W. Leonard. 2000. Wetland Functions Characterization Tool for Linear Projects. Washington State Department of Transportation Environmental Affairs Office, Olympia, WA.

This method is also a characterization. It uses a list of criteria for each function to guide decision-making. It relies on professional judgment regarding the likelihood that the function is being performed. The tool is available online at: http://www.wsdot.wa.gov/environment/biology/docs/bpjtool.pdf.

Advantages

- Provides documentation of the criteria and rationale used when applying best professional judgment to analyze functions
- Can be very rapid when used by trained wetland ecologists
- Can also be used to characterize a portion of a larger wetland when a wetland exists on multiple properties and access to all parts of the wetland is restricted
- Based on WFAM, which corresponds to "best available science"

Limitations

- Cannot determine the level at which a function may be performed to plan compensatory mitigation
- This method should not be used to measure change over time or as the result of alterations (e.g., impacts or mitigation)
- Method is subjective and results may vary significantly based on the experience and expertise of the user

Recommended Uses

- Rapid screening of many wetlands to determine best areas for development or roads

Semi-Quantitative Assessment Methodology (SAM)

Cooke Scientific Services Inc. 2000. Wetland and Buffer Functions Semi-quantitative Assessment Methodology (SAM). Final Working Draft User's Manual. Cooke Scientific Services Inc. Seattle, WA.

This method has not been published but is available on the web at: http://www.cookescientific.com/sam.htm or http://www.cookescientific.com/SAM%20Stuff/SAM2000.pdf.

Although SAM is in wide use, better tools have been developed more recently. The WFAM method is much more accurate in its ability to characterize the functions and their performance in wetlands and should be used in its place, especially for larger (> 1 acre) wetlands.

SAM provides a rapid method for rating various wetland attributes, including functions, with high, medium, and low rating.

Advantages

- Easy to use and requires no specific training (some knowledge of wetland ecology would obviously be beneficial)
- Reproducible between users
- Developed for western Washington

Limitations

- Provides very general information
- "Low" ratings miss many site-specific details that are important for protection and management
- Allocates high ratings to large, rural, undisturbed wetlands, while smaller wetlands in urban areas rate lower
- Should not be used for wetlands east of the crest of the Cascade Mountains

Wetland Evaluation Technique (WET)

Adamus, P.R., E.J. Clairain, Jr., R.D. Smith, and R.E. Young. 1987. Wetland evaluation technique (WET), volume II: Methodology. Department of the Army, Waterways Experiment Station, Vicksburg, MS. NTIS No. ADA 189968.

WET is a rating method that was developed in the late 1980s by the U.S. Army Corps of Engineers in cooperation with Paul Adamus.

WET is no longer recommended for use in Washington's wetlands. Better tools have been developed more recently.

Wetland Values: Concepts and Methods for Wetlands Evaluation (often called the Reppert method after the author)

Reppert, R.T., W. Sigleo, E. Stakhiv, L. Messman and C. Beyers. 1979. Wetland Values: Concepts and Methods for Wetland Evaluation. U.S. Army Corps of Engineers, Institute for Water Resources. Fort Belvoir, Virginia.

Published in 1979, this was one of the first methods developed to help determine how wetlands function. It is a rating that groups wetlands into high, medium, or low based on "functional values."

This method is no longer recommended for use in Washington's wetlands. Better tools have been developed more recently.

Proper Functioning Condition for Lentic Areas (PFC)

Prichard, D., C. Bridges, R. Krapf, S. Leonard, and W. Hagenbuck. 1994. Riparian Area Management: Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas. TR 1737-11. Bureau of Land Management, BLM/SC/ST-94/008+1737, Service Center, CO. 37 pp.

PFC is a qualitative method to characterize streams, riparian areas, and riparian wetlands. It was developed by the Bureau of Land Management to assess how well the physical processes in a wetland are functioning.

Advantages

- Provides good information for designing restoration of riparian wetlands

Limitations

- Correct application of this method requires an interdisciplinary team of experts
- Does not separate wetlands from the rest of the riparian resources
- Primarily for riparian wetlands
- Not an assessment that can be used independently to rate, characterize, or assess wetlands and their functions

Recommended Uses

- Could be useful in combination with other assessment methods
- For wetlands that are "functional - at risk" or "nonfunctional" the methods can help to identify what is lacking (vegetation, soil, water) and may provide guidance on the likelihood of improving the condition and what actions could be taken to improve the condition

Best Professional Judgment (BPJ)

Application of BPJ is the most common method used to determine the functions that a wetland provides. Application of this method requires that a wetland biologist/consultant decide how well a wetland performs functions based on his/her own experience or knowledge.

Most methods are based to some degree on the best professional judgment of the individuals or the teams of individuals who developed them.

Advantages

- Can be very rapid
- If the expert has local knowledge, the information on functions may be very specific to the region and wetland type

Limitations

- Not reproducible. Reliability of results varies greatly with expertise
- Can't track the criteria used to base the judgment unless they are carefully recorded
- Easier to be biased in regard to functions for which the expert has more knowledge

Recommended Uses

BPJ may be used in analyzing functions for small impacts where more intensive analysis is not warranted. BPJ should also be used in concert with other methods to help define and clarify the functional performance of wetlands, based on specific site conditions of the wetland and adjacent watersheds.

Hydrogeomorphic Approach (HGM)

Smith, D. R., Ammann, A., Bartoldus, C., and Brinson, M. M. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Technical Report WRP-DE-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. NTIS No. AD A307 121.

The HGM approach is not a method to assess, characterize, or rate wetlands. This approach has been developed by the U.S. Army Corps of Engineers to provide guidance on how to develop regional methods for analyzing functions. It was put forth by the Corps for use in Section 404 permitting. WFAM is based on many concepts in this approach. Other documents associated with this approach are available at: http://www.wes.army.mil/el/wetlands/hgmhp.html.

Appendix 6-A

References on Smart Growth and Related Topics

This appendix provides references for additional information on Smart Growth and related topics, as discussed in Chapter 6 of this volume. Web pages and phone numbers are provided where available.

Documents

Baker J.P., D.W. Hulse, S.V. Gregory, D. White, J. Van Sickle, P.A. Berger, D. Dole and N.H. Schumaker. 2004. Alternative Futures for the Willamette River Basin, Oregon. Ecological Applications 14: 313-324.

Benedict, M.A. and E.T. McMahan. 2002. Green Infrastructure: Smart Conservation for the 21st Century. Renewable Resources Journal 20: 12-17. The Conservation Fund. Available: www.sprawlwatch.org/green

Bolte, J.P., D.W. Hulse, S.V. Gregory, and C. Smith. 2004. Modeling Biocomplexity - Actors, Landscapes and Alternative Futures. International conference proceedings, Complexity and Integrated Resources Management, Transactions of the 2nd Biennial Meeting of the International Environmental Modelling and Software Society, iEMSs: Manno, Switzerland, 2004. Available: www.iemss.org

Hammond, A. 1998. Which World? Scenarios for the 21st Century: Global Destinies, Regional Choices. Island Press/Shearwater Books, Washington, D.C.

Harms, B., J. P. Knaapen and J. G. Rademakers. 1993. Landscape Planning for Nature Restoration: Comparing Regional Scenarios. In: C. Vos & P. Opdam, (eds.), Landscape ecology of a stressed environment. Chapman & Hall, London.

Hirschhorn, J.S. and P. Souze. 2001. New Community Design to the Rescue: Fulfilling Another American Dream. July 24, 2001. 101pp. National Governor's Association. Available: www.nga.org/center

Hulse, D., S.V. Gregory, and J.P. Baker (eds). 2002. Willamette River Basin Planning Atlas: Trajectories of Environmental and Ecological Change. Oregon State University Press, Corvallis, OR.

Morris, H. 2002. Trails and Greenways: Advancing the Smart Growth Agenda. Rails to Trails Conservancy. 43 pp. Available: www.trailsandgreenways.org

Nelson, P. and S. Graham. 2004. Assembling and Presenting Watershed Process Models for Evaluating Future Land Use. In: T.W. Droscher and D.A. Fraser (eds.), Proceedings of the 2003 Georgia Basin/Puget Sound Research Conference. CD-ROM or Online. Available: www.psat.wa.gov/03_proceedings/start.htm [February 2004]

Northwest Environment Watch. 2002. This Place on Earth 2002. Measuring What Matters. Seattle, WA. Available: www.northwestwatch.org/publications

Northwest Environment Watch. 2004. Cascadia Scorecard: Seven Key Trends Shaping the Northwest. Seattle, WA. Available: www.northwestwatch.org/publications

Ogilvy, J. A. 2002. Creating Better Futures: Scenario Planning as a Tool for a Better Tomorrow. Oxford University Press, Inc., New York, N.Y. 238 pp.

Parsell, D.L. 2002. "Green-Based" Urban Growth: Next Wave of Environmentalism. National Geographic News, April 22, 2002. Available: http://news.nationalgeographic.com/news/2002/04/0422_020422_landplan.html

Smart Growth Network. Getting to Smart Growth – 100 Policies for Implementation. Available: www.smartgrowth.org

Trust for Public Land. 1999. Building Green Infrastructure: Land Conservation as a Watershed Protection Strategy, Available: www.tpl.org

Trust for Public Land. 2002. Local Greenprinting for Growth, Volumes I– IV. Available: www.tpl.org

Williamson, K.S. 2003. Growing with Green Infrastructure. Heritage Conservancy. Available: www.greeninfrastructure.net OR www.heritageconservancy.org

Fiscal Models

Behan Planning Associates. Fiscal analysis model for assessing the financial impact of Greenprint plans. Call (518) 583-4335. Web site: www.behanplanning.com

Frank, M. 2003. Opportunity Knocks – Open Space is a Community Investment. [Helps calculate the fiscal savings from purchasing open space]. Web site: www.heritageconservancy.org

Mittelstaedt, G. Sustainable Community Solutions, Issaquah, WA. Fiscal analysis on Compact Building Design. Call (425) 427-6443.

Penn State Cooperative Extension, 2000. Costs and Revenue of Residential Development: A Workbook for Local Officials and Citizens. Call (814) 865-6713. Web site: http://cax.aers.psu.edu/residentialimpact/

Funding Assistance

Green Communities Program, Center for Green Space Design. [Fifty percent matching grants to design Greenprint Plans]. Call (801) 483-2100. Web site: www.greenspacedesign.org

Washington State Department of Ecology – Coastal Zone Management 306 Planning Grants. Contact Bev Huether at (360) 407-7254. Web site: www.ecy.wa.gov/programs/sea/grants/czm/index.html

The Environmental Protection Agency's (EPAs) Smart Growth Implementation Assistance. Web site: www.epa.gov/smartgrowth/sg_implementation.htm

Federal Funding Grants. Web site: www.grants.gov

Washington State Department of Community, Trade, and Economic Development (CTED) offers several grant programs as follows:

- Competitive Grants Funds (CGF) for furthering planning. Note: this grant has been used for Green Infrastructure planning. Contact Ike Nwanko at (360)825-3056 or visit the website below.
- Emerging Issues Grant (EIG) – limited to $10K per project. Contact Ike Nwanko at (360)825-3056 or visit the website below.
- Community Development Block Grants (CDBG) – for infrastructure planning. Contact Dan Riebli at (360) 725-3017 or visit the website below.

For information on all of CTED's grants go to www.cted.wa.gov (Divisions>Local Government>Programs & Services>Growth Management Services>Grants)

Other Web Sites

Organization/Topics Associated with Smart Growth or Green Infrastructure	Web Address
The Conservation Fund	www.conservationfund.org
Green Infrastructure	www.greeninfrastructure.net
Lincoln Institute on Smart Growth	www.lincolninst.edu
Maryland Dept. of Natural Resources	www.dnr.state.md.us
National Governors Association – Center for Best Practices	www.nga.org/center
Pennsylvania State Education Center	www.pennscapes.psu.ecu/
Planning Commissioners Journal	www.plannersweb.com
Puget Sound Action Team	www.psat.wa.gov/Programs/Growth.htm
Smart Growth	www.smartgrowth.org
Smart Growth in Washington	www.smartgrowth.wa.gov

Organization/Topics Associated with Smart Growth or Green Infrastructure	Web Address
Sprawl Watch	www.sprawlwatch.org/green/
The Trust for Public Lands	www.tpl.org
U.S. EPA, Green Kit	www.epa.gov/greenkit/index.html
Western Governors Association – Economic Benefits of Open Space	www.westgov.org/wga/initiatives/tpl/ecoben.htm

Appendix 7-A

Examples of Cross-Jurisdictional Planning for Aquatic Resources

Managing natural resources across jurisdictions at larger geographic scales has become recognized internationally as an important approach to protecting aquatic resources, including wetlands (United Nations 1997). While planning at this scale may be difficult for some local jurisdictions, it is possible for them to join existing programs that are developing plans and actions at larger, geographic scales. Examples of planning efforts at a larger scale that are being conducted by state and federal agencies in relation to aquatic resources are provided below.

Watershed Planning

In 1998, the Washington State Legislature passed the Watershed Planning Act (RCW 90.82) providing a framework for developing local solutions to water supply issues on a watershed-wide basis. The planning is based on Water Resource Inventory Areas (WRIAs) which are framed around watersheds or subwatersheds. This voluntary planning process is designed to encourage local citizens, governments, and tribes to form planning units for the development of watershed management plans. Through the Act, state agencies manage grants, provide technical assistance and, if requested, serve on the planning units. Planning units may choose to develop strategies for improving water quality, protecting or enhancing fish habitat and, in collaboration with Ecology, setting minimum instream flows. At present, 45 of Washington's 62 WRIAs are represented by 36 planning units engaged in watershed planning.

See the Ecology watershed homepage for the status and listings of watershed planning efforts by WRIA throughout the state: www.ecy.wa.gov/watershed/. Many WRIA plans were due by December 2004, with completion being required for all by December 2006 and 2007.

Total Maximum Daily Load or Water Cleanup Plan

The Water Cleanup Plan, also known as Total Maximum Daily Load (TMDL), is a process for planning to facilitate the improvement of the quality of surface water. It was established by Section 303(d) of the Clean Water Act. This federal law requires states to identify sources of pollution in waters that fail to meet state water quality standards and to develop Water Cleanup Plans to address those pollutants. The Water Cleanup Plan establishes limits on pollutants that can be discharged to a waterbody and still allow state standards to be met. Setting such standards requires planning and monitoring at large geographic scales, and this is currently being done by Ecology's Water Quality Program.

The protection, management and restoration of wetlands are an important part of planning for water cleanup. Wetlands play an important role in reducing the amount of pollutants in a watershed because they function to remove nutrients, sediments, and toxic compounds (see Chapter 2 in Volume 1).

TMDL Water Cleanup Plans, however, do not presently consider wetland protection, restoration, and enhancement as elements in meeting the cleanup standards. Ecology has not yet adopted water quality standards for wetlands.

Interior Columbia Basin Ecosystem Management Project

The Interior Columbia Basin Ecosystem Management Project (ICBEMP) was charged by several federal agencies with developing a management strategy for the region that is scientifically and ecologically based. It may potentially alter the direction of management on over 60 million acres of lands administered by the Forest Service and Bureau of Land Management (BLM).

This effort combines science and management. Scientists developed a framework for ecosystem management and an assessment of the ecological, bio-physical, social, and economic conditions of the Columbia Basin including lands outside of federal control. Land managers are using the scientific information to develop management strategies and provide context for Forest Service and BLM plans for land management.

A large focus of this effort is on protecting and managing the aquatic resources that are related to salmon, including wetlands. Local governments in the region can use the information and analyses done by the ICBEMP to manage resources at larger geographic scales.

Columbia River Initiative

The Columbia River Initiative was developed as a way to manage the increasing conflict related to the river's water resources. The public has been divided on the issue of whether additional water can be diverted from the river to off-stream uses without negatively affecting endangered salmon runs. The purpose of the Columbia River Initiative, therefore, is to develop an integrated state program for managing the water resources of the Columbia River to allow new water withdrawals while providing support for salmon recovery.

To address this issue, scientific studies are being performed to serve as the cornerstone of a new management program that defines the conditions under which Ecology may issue water rights from the river. Since wetlands play an important role in the hydrologic cycle on which salmon depend, there is both an opportunity and a need to integrate the protection and management of wetlands into this process.

Appendix 8-A

An Overview of Ways to Protect and Manage Wetlands

Introduction

An important component of wetland protection and management is to identify what wetland functions need to be protected, and which wetlands need additional protection because they have other important characteristics. The first section of this appendix discusses ways to protect and manage wetland functions, whereas the second describes what is needed to protect wetlands with other characteristics such as "Natural Heritage" wetlands.

Wetland functions can be grouped into three broad categories: water quality improvement, hydrologic functions, and habitat functions. Each of these can be further divided into more specific functions. For example, habitat functions can be divided into habitat for amphibians, habitat for mammals, etc. At the finest scale, we can consider the function of habitat for an individual species. (Chapter 2 in Volume 1 discusses the functions of wetlands in Washington State in detail.)

In addition to identifying what functions need to be protected, managing wetlands requires an understanding of how the functions are performed. Wetlands in each hydrogeomorphic class (see Chapter 2 of Volume 1) perform a particular set of functions; some are the same and some are different from wetlands in other classes. For example, the functions performed by wetlands in the depressional class are not the same as those performed in the riverine class. In addition, individual wetlands perform each function to a different degree based on a variety of factors. Some functions of wetlands are greatly affected by processes or influences that operate at large scales, while other functions are affected more by site-specific characteristics (see Chapter 2 of Volume 1).

Understanding how each function operates and how human activities can affect that function is critical to determining the appropriate type and level of protection and management that will be achieved through comprehensive plans, critical areas ordinances, and other regulations, as well as non-regulatory tools. Chapter 4 in Volume 1 provides more information on how functions can be changed by human activities.

In spite of the many differences in how wetlands function, one can generalize several approaches that will be effective in protecting each of the three groups of wetland functions (e.g., water quality improvement, hydrologic functions, and habitat functions). This appendix synthesizes the information available on what is needed to protect a wetland and its immediate vicinity to maintain performance of functions or to replace functions if impacts are unavoidable. The discussion is organized by the three major

groups of functions and by the different types of wetlands with other characteristics used to categorize wetlands using the Washington State wetland rating systems (Hruby 2004a,b).

The two most common methods for protecting wetland functions have been the use of buffers and compensatory mitigation. Buffers are used to maintain existing functions by reducing the impacts of adjacent land uses. When impacts to wetlands are unavoidable, replacement of lost functions has typically been through compensatory mitigation in which other wetlands are created, restored, or enhanced using specific ratios based on area.

Scientific information regarding buffers and ratios are discussed in detail in Chapters 5 and 6 of Volume 1. The authors have also recommended specific widths for buffers and specific ratios for compensatory mitigation to be used in conjunction with the Washington State wetland rating systems (Hruby 2004a,b) in Appendices 8-C and 8-D of this document. Although the rating systems are referenced frequently in this appendix, the citations are not repeated again.

Wetland protection should encompass more than buffers and compensatory mitigation

The review of recent scientific information (Volume 1) has shown that protecting the functions of wetlands by using only buffers and establishing "mitigation ratios" is not adequate. These measures by themselves will not completely protect many wetland functions from disturbances or replace the functions lost if impacts are unavoidable. Providing protection in the immediate vicinity of a wetland (e.g., buffers, use restrictions, etc.) will not always adequately protect wetland functions from disturbances that may occur elsewhere in the landscape. Other measures that take a larger landscape approach and that use tools outside of the traditional regulatory realm may also be needed to fully protect wetland functions. See Chapters 6, 7, and 9 in this document for more details on additional approaches.

Protecting and Managing Habitat Functions for Animals

Wetlands provide habitat for a large number of animal species and play an integral part in maintaining the richness of species in the environment. Many different environmental factors affect the suitability of wetlands as habitat, the most important being the physical structure of the vegetation in the wetland, the water regime, and the condition of the vegetated and hydrologic connections between the wetland, uplands, and other aquatic resources. More detailed descriptions of how wetlands provide habitat are given in Volume 1.

The main question that arises when protecting and managing wetlands to maintain their capacity to provide habitat is: *What species of vertebrates and invertebrates use the*

wetland and need protection? The recommendations made here are based on the assumption that wetlands with good structure and good connections to other habitats will provide habitat for a large range of species. In the absence of information on use, or lack of use, of an individual wetland by certain species, adequate protection should be based on the probability that the species are there. Wetlands that score highly for the habitat function in the rating system have a higher probability of providing habitat for a variety of species than those with a low score. High-scoring wetlands have the connections and structure to provide relatively diverse habitat.

Widths of Buffers for Habitat Functions

The review of the literature indicates that there are several aspects of buffers that are important for wildlife. First, the width of vegetated buffers needed to protect habitat functions depends on the individual species needing protection. Some species using wetlands need buffers in excess of 600 feet. Others, however, need only 100 feet. In general, the information available indicates that buffers between 100 and 300 feet are adequate to protect most species closely associated with wetlands in Washington.

Second, most studies on the effectiveness of buffers have been done using buffers that were relatively undisturbed. It is difficult to extrapolate this information to judge the effectiveness of buffers that consist of lawns or tilled fields or that have otherwise been disturbed.

Third, the width of the buffer needed to protect species depends on the type of disturbance the buffer is intended to reduce. Noise, light, or the movement of humans and pets may be reduced by providing a buffer of 100 feet. However, protecting the nesting and breeding of waterfowl from pets or human disturbance generally requires a buffer of at least 200 to 300 feet depending on the type of disturbance and species of waterfowl.

The scientific information summarized in Volume 1 also points out that fragmentation and the disruption of the vegetated corridors between undeveloped areas that provide habitat are major causes of the loss of species richness (biodiversity). Existing connections and corridors between wetlands and other habitats, as well as the structure within the wetland and its buffer, need to be protected to maintain the wetland's habitat functions.

Replacing Habitat Functions Through Compensatory Mitigation

Historically, the loss of habitat functions has been mitigated by creating, restoring, or enhancing wetlands with the physical structure (e.g., vegetation, large woody debris) that provides ecological niches for different species. Studies of mitigation projects have shown, however, that less attention is given to other environmental factors that play an important role in the provision of habitat (i.e., time of ponding, depth of ponding, temperature of water, connectivity with other habitats that provide access for wildlife etc.). The studies of compensatory mitigation also indicate that high mitigation ratios alone will not guarantee that habitat functions will be adequately replaced. Chapter 6 of

Volume 1 summarizes the many factors involved in determining whether a mitigation site is successful or not, and concludes that adequate ratios are only one factor.

At a minimum, a mitigation ratio should compensate for the loss of habitat during the time it takes the habitat structure to develop and the species to colonize the mitigation site (i.e., temporal loss of function). In the case of forested wetlands, this temporal loss can be as long as 100 years or more, and as reported in Volume 1, no studies have found that all functions in a forested wetland have been reproduced through compensatory mitigation. Thus, some functions cannot be replaced within a regulatory time frame.

The authors recommend several strategies to address this difficulty. First, avoidance of the wetland altogether can be emphasized for the wetland types that are most difficult to compensate or take the longest to replace. Another strategy can be to require higher ratios for unavoidable impacts to these types of wetlands. A third strategy can be to require longer monitoring ($\geq$ 10 years) of the compensation site to ensure that the site is on a trajectory to actually replace the habitat functions that were lost.

Protecting and Managing Functions That Improve Water Quality

Wetlands generally improve water quality by trapping pollutants (e.g., sediment) or by chemically transforming some pollutants into compounds that are no longer polluting (e.g., changing nitrates into nitrogen gas). The performance of the water quality functions by wetlands (i.e., removing sediment, removing nutrients, and removing toxic compounds) depends mostly on the structure of the vegetation that reduces water velocities and causes sediments and pollutants to settle and on the chemical and biological properties of the soil in the wetland. It is the geomorphic characteristics of the wetland and the physical structures found therein that control how a wetland improves water quality. Thus, a dense stand of invasive reed canarygrass can be just as effective at trapping pollutants as a dense stand of native sedges. More detailed descriptions of how these functions are performed are available in Volume 1.

The primary question when protecting and managing wetlands to maintain their capacity to improve water quality is: *How much pollution is too much?* Wetlands in watersheds where human activities generate pollutants provide important functions by removing some of these pollutants. Large quantities of pollutants, however, can overwhelm the capacity of a wetland to improve water quality. For example, too much sediment entering a wetland can cover the organic soils that are important in trapping phosphorus and removing nitrogen.

To protect the water quality functions of a wetland, the authors of Volume 1 recommend minimizing the local input of any additional pollutants generated by changes in land use. For example, when a forest adjacent to a wetland is changed to a residential development care should be taken to control the new input of sediment from construction and the pollutants coming from lawns, landscaping, septic systems, and pets.

Widths of Buffer for Functions that Improve Water Quality

Buffers trap pollutants before they reach the wetland. This helps to maintain the existing capability of a wetland for improving water quality. Protecting the water quality functions currently performed by a wetland would therefore require that any existing, vegetated buffers be protected from further degradation in the portion of the buffer that is most effective at trapping pollutants.

The review of existing literature in Volume 1 indicates that the effectiveness of buffers at trapping pollutants depends on many different factors, including the type of soils present, the type of vegetation present, and the slope. Furthermore, the effectiveness is not linear. For example, a buffer of approximately 33 feet will remove approximately 60% of the sediment and other pollutants, while it takes a buffer of approximately 150 feet to remove 75% or more of the sediment and other pollutants, and a buffer of 660 feet to remove 90% of the sediment and other pollutants.

Buffers will not adequately protect functions in a wetland if polluted waters bypass the buffer and enter the wetland directly via pipes, ditches, or other channels. To maintain the current levels at which a wetland improves water quality, it may be necessary to limit the introduction of any additional pollutants that might come in through untreated runoff that bypasses the buffer. In most cases, runoff from lawns and landscaped areas adjacent to wetlands will contain pollutants (particularly nutrients and pesticides). This runoff is rarely collected and treated in stormwater treatment facilities and thus, larger well-vegetated buffers are particularly important to protecting wetlands in these situations.

Replacing Functions That Improve Water Quality Through Compensatory Mitigation

The review of the information on mitigation in Volume 1 found very few projects in which the replacement of the water quality functions was an objective. These functions have not been the focus of compensatory mitigation in the past. A study by Johnson et al. (2002), however, found that creation or restoration of wetlands generally resulted in the creation and restoration of the water quality functions to some degree. Enhancement, on the other hand, did not often improve the water quality functions of the wetlands enhanced and may even have reduced them. Over half of the enhanced sites that were evaluated in Washington State had minimal or no increase in the levels of the water quality functions.

If a wetland is created or restored, some of the water quality functions will tend to be established fairly quickly while others may take much longer. The temporal loss of functions incurred during compensatory mitigation is very dependent on site-specific conditions. The structural characteristics and water regime needed to perform the water quality functions can be established early, while the organic soils needed to more effectively trap phosphorus and remove nitrogen can take over 50 years to develop.

At a minimum, a mitigation ratio should compensate for the loss of the water quality functions during the time it takes to build the mitigation site. The study by Johnson et al.

(2002) found that the risks of replacing the water quality functions through restoration and creation are less than those for wildlife habitat. Therefore, replacing lost water quality functions may be possible through mitigation ratios that are lower than those for wildlife habitat functions.

Ratios for enhancement, however, may have to be high because most enhancement projects that require revegetation of disturbed wetlands result in little, if any, increase in water quality functions. Many of the wetlands used for enhancement are degraded in terms of their habitat but actually perform water quality functions at a high level. It is not likely that enhancement will increase the sites effectiveness at improving water quality to mitigate for the loss of those functions. For example, if enhancement increases the water quality functions by only 5%, a ratio of 20:1 (by area) is needed to compensate for the impacts.

Protecting and Maintaining Hydrologic Functions

The group of hydrologic functions characterized in the rating systems include reducing flooding, reducing erosive flows, and recharging groundwater. The performance of these functions depends mostly on the water storage available in the wetland, the density of vegetation that can reduce the velocity of flood waters, the permeability of the soils, and the distance from the wetland surface to groundwater. More detailed descriptions of how these functions are performed are available in Chapter 2 of Volume 1.

Widths of Buffers for Hydrologic Functions

Generally speaking, the factors that control the hydrologic functions in a wetland are not significantly altered by changes in the buffer. The amount of water coming into a wetland, its velocity, and its timing are controlled by processes that occur at the larger scale of the watershed or the contributing basin of that wetland.

There is one case, however, in which buffers may help protect hydrologic functions. Buffers may protect the storage capacity of depressional wetlands by trapping sediments that might otherwise fill the wetland. In the absence of buffers that trap sediment, a wetland can slowly fill with sediment, reducing the amount of water it can store. In this case, the requirements for a buffer would be similar to those for the water quality functions described above.

Replacing Hydrologic Functions Through Compensatory Mitigation

The review of the information on compensatory mitigation in Volume 1 found very few projects in which the replacement of hydrologic functions was an objective. The study by Johnson et al. (2002), however, found that creation or restoration of wetlands generally resulted in the creation and restoration of hydrologic functions to some degree. Enhancement, on the other hand, did not often improve the hydrologic functions of the

wetlands enhanced. Approximately two-thirds of the enhanced sites that were evaluated had no increase in the performance of hydrologic functions.

If a wetland is created or restored, the hydrologic functions will tend to be established fairly quickly because they depend mostly on the physical structure of the wetland (e.g., storage capacity, permeability of soils). Compensation for impacts to these functions is more dependent on the structure and water regime of the mitigation site rather than the mitigation ratio.

Protecting and Managing Wetlands with Other Characteristics

The Washington State wetland rating systems (described in Appendix 5-B) also differentiate between wetlands based on their sensitivity to disturbance, their significance in the landscape, their rarity, and our ability to replace them through compensatory mitigation. These other characteristics were chosen because they can be used to provide additional guidance on the ways in which these wetlands need to be protected and managed. The following discussion provides a general summary of what is needed to protect these types of wetlands.

Natural Heritage Wetlands (Freshwater)

"Natural Heritage" wetlands, as defined by the Natural Heritage Program of the Washington State Department of Natural Resources, contain rare plants or those that are particularly sensitive to disturbance. These types of plant species are very sensitive to nutrient enrichment (*eutrophication*) that results from the input of nutrient-laden waters. The greatest richness of plant species, especially rare species, is found in nutrient-poor wetlands. Rare plant species are outcompeted by large, regionally common species when excess nutrients are introduced to a wetland. Protection of Natural Heritage wetlands should focus on keeping nutrients out of these wetlands, maintaining the natural water regime, and reducing physical disturbance by humans (trampling, cutting vegetation, draining, etc.) within the wetlands.

Widths of Buffers for Natural Heritage Wetlands

The buffer around a Natural Heritage wetland is needed to remove excess nutrients before they reach the wetland. The most efficient vegetated buffer, based on width-to-removal ratios, is about 197 feet for removal of nitrogen and 253 feet for phosphorus. However, a 250-foot buffer alone may not protect the rare or sensitive plants in the wetland if the watershed has high nutrient loadings or a water regime that is unstable.

Buffers will not adequately protect rare plants in a wetland if polluted waters bypass the buffer and enter the wetland directly via pipes, ditches, or other channels. Furthermore, discharges of stormwater and changes in the water regime resulting from development

will also change the plant communities in a wetland (see review in Chapter 4 of Volume 1). Such changes might also impact the populations of the rare species in the wetland. Designs for treating stormwater do not reduce the nutrient loads significantly because they do not effectively remove nitrogen. To protect rare plants, it is necessary to limit the introduction of any additional nutrients that might come into the wetland through untreated runoff that bypasses the buffer.

Replacing Natural Heritage Wetlands Through Compensatory Mitigation

To our knowledge, there have been no successful mitigation projects that replaced the rare, threatened or endangered plant species found in a Natural Heritage wetland. The Departments of Ecology and Fish and Wildlife assume that it is impossible to replace a Natural Heritage wetland through compensatory mitigation because the habitat required by rare and sensitive plant species cannot be reconstructed. The reconstruction of the habitat would require an extremely detailed understanding of the geological, biological, chemical, and physical requirements of each rare species found in the wetland. Such an understanding is not currently available in the existing scientific literature and would have to be developed through basic research.

Bogs

Bogs are also particularly sensitive to nutrient enrichment (eutrophication) because they have naturally low levels of nutrients (see discussion in Chapter 2 of Volume 1). Also, bogs often contain a high richness of plant species, especially rare ones, and ones that are found only in nutrient-poor wetlands. The rare plants in bogs, as in Natural Heritage wetlands, can be outcompeted by large, regionally common species when excess nutrients are introduced to a wetland.

Width of Buffers for Bogs

The buffer needs to remove excess nutrients before they reach the bog. The most efficient vegetated buffer, based on width-to-removal ratios, is about 197 feet for removal of nitrogen and 253 feet for phosphorus.

Buffers will not adequately protect the functions of a bog if polluted waters bypass the buffer and enter the wetland via pipes, ditches, or other channels. To protect the bog it is necessary to limit the introduction of any additional nutrients and excess water that might come in through untreated runoff that bypasses the buffer.

Replacing Bogs Through Compensatory Mitigation

Bogs are characterized by their highly organic soil conditions, unique water regimes, and water chemistries. Studies of bog and fen restoration in Northern Europe and Canada (reviewed in Volume 1) concluded that restoration may not be possible due to irreversible

changes of the characteristics of a bog. No information was available on the success of bogs or fens that were restored or created as wetland compensation. However, the literature suggests that even if it is possible to recreate the appropriate environmental conditions, bogs and fens cannot be reproduced within a regulatory time frame. In Washington, Rigg (1958) reports that peat accumulates naturally in the Puget Sound lowlands at an average rate of 1 inch per 41 years. For 55 bogs studied in eastern and northeastern Washington, Idaho, and British Columbia, Rigg reported an average rate of accumulation of 1 inch per 48.5 years. The Departments of Ecology and Fish and Wildlife therefore assume that it is not feasible to replace bogs through compensatory mitigation.

Mature or Old-Growth Forested Wetlands

Mature or "old-growth" forested wetlands are given extra consideration because they are difficult to replace through compensatory mitigation. The protection they need is based on the functions they provide. Buffers and other measures to protect the functions, therefore, should be determined based on how well the wetland performs these functions rather than on the presence of a forested community.

Replacing Forested Wetlands Through Compensatory Mitigation

Though the studies reviewed in Volume 1 have found that trees can be planted in Washington State wetlands and they will grow, mature forested wetlands have not been successfully reproduced simply because of the time necessary for the trees and the structural characteristics of the forest to mature. Enhanced and created sites that have been planted often have a high density of stems to rapidly provide woody cover and shade out invasive species in the understory. Unless these sites are thinned, they will not reproduce the attributes of mature forested wetlands.

Alkali Wetlands

Alkali wetlands are characterized by the occurrence of shallow saline water. These wetlands provide the primary habitat for several species of migrant shorebirds and are also heavily used by migrant waterfowl. They also have unique plants and animals that are not found anywhere else in eastern Washington. The salt concentrations in these wetlands have resulted from a relatively long-term process of groundwater surfacing and evaporating.

Width of Buffers for Alkali Wetlands

The ecological process that maintains an alkali wetland is the dynamic between the inflow of groundwater and evaporation. Buffers have little impact on maintaining this process. The width of buffer needed for an alkali wetland should therefore be based on the wetland's habitat functions. Alkali wetlands in eastern Washington are a major

resource for migratory shorebirds and other water-dependent birds, and the buffers are needed to protect the shorebirds and waterfowl from disturbance.

The routing of additional surface water to alkali wetlands will change the balance between inflow of groundwater and evaporation. No information was found, however, on the impacts this may have on the ecosystem in the alkali wetland. There is a significant risk, therefore, that the ecosystem may be impacted if discharges into alkali wetlands are allowed.

Replacing Alkali Wetlands Through Compensatory Mitigation

The salt concentrations in alkali wetlands have resulted from a relatively, long-term process of groundwater surfacing and evaporating. These conditions cannot be easily reproduced through compensatory mitigation because the balance of salts, evaporation, and water inflows is hard to reproduce. No references were found suggesting that alkali wetlands have ever been created or restored. Until alkali wetlands have been successfully created, the departments of Ecology and Fish and Wildlife view any proposed creation project as highly experimental.

Vernal Pools

Vernal pools in the scablands of eastern Washington are the first areas of open water to melt in the early spring even though they dry out by late spring. This open water provides areas where migrating waterfowl can find food while other, larger bodies of water are still frozen. Furthermore, the open water provides areas for pair bonding of waterfowl. Thus, vernal pools are very important for migratory waterfowl during a short period in the early spring. The rest of the time the vernal pools provide little habitat for larger animals that need larger buffers.

Width of Buffers for Vernal Pools

The review of the literature indicates that waterfowl need at least 200-foot buffers to protect them from disturbance. In a vernal pool that is currently undisturbed, such a buffer would protect the birds from disturbance while they feed and use the pool for courtship activities.

Replacing Vernal Pools Through Compensatory Mitigation

Vernal pools are characterized by the short duration of their inundation. Thus, in order to reproduce a vernal pool, a site with a suitable substrate must be found and the correct depth and water regime must be created or restored. The literature as reviewed for Volume 1, Chapter 6, suggests that, in California, vernal pools may be reproduced under the right conditions. No information was found on the reproducibility of vernal pools in Washington.

Wetlands in Estuaries and Coastal Lagoons

Wetlands in areas where the water has salinity higher than 0.5 parts per thousand are classified as *estuarine* or *coastal lagoons* for the purposes of rating and management. The ecological process that maintains estuarine wetlands and those in coastal lagoons is the mixing of marine waters coming from the ocean and fresh waters coming from land. Both types of wetlands are found along the coast and in the mouths of rivers.

Width of Buffers for Estuaries and Lagoons

Although wetlands in estuaries and coastal lagoons are not the focus of this synthesis as described in Chapter 1 of Volume 1, we are including some information about these wetlands because they are included in the Washington State wetland rating systems. Please note, therefore, that the information presented here is not as detailed as for freshwater wetlands.

Estuarine wetlands and coastal lagoons are a major resource for migratory shorebirds and other water-dependent birds, and buffers are definitely needed to protect the shorebirds and waterfowl from disturbance. In estuarine systems, buffers also provide a source of wood and sediment that nourish the beaches. In addition, estuaries and coastal lagoons have a high density of fish and wildlife and high species diversity, provide important breeding habitat, and serve as movement corridors (see Washington Department of Fish and Wildlife web page, http://wdfw.wa.gov/hab/phshabs.htm). Both types of wetlands are also a habitat that has been significantly impacted by human activities and are highly vulnerable to alteration. Therefore, the width of buffers needed to protect these wetlands will have to be based on protecting a wide range of functions.

Replacing Wetlands in Estuaries and Coastal Lagoons Through Compensatory Mitigation

The main focus of Volume 1 was freshwater wetlands. Information on mitigating impacts to estuaries and coastal lagoons was not compiled, so no recommendations can be made. Decisions about compensating for impacts to these types of wetlands will have to be made on a case-by-case basis.

Also, it is not possible to specify in advance what other tools or non-regulatory approaches are needed to protect these types of wetlands because of the many different habitat functions they provide. Protecting the functions of these wetlands will require considering each wetland on a case-by-case basis.

Interdunal Wetlands

Interdunal wetlands form in the *deflation plains* and *swales* that are geomorphic features in areas of coastal dunes. These dune forms are the result of the interaction between sand, wind, water, and plants. Interdunal wetlands provide critical habitat in this

ecosystem (Wiedemann 1984), but no methods have been developed to characterize how well these wetlands function.

Width of Buffers for Interdunal Wetlands

Although we have little detailed information on how interdunal wetlands function as habitat, the information does show that these wetlands provide an important resource for many species. In the absence of more detailed information about the needs of species using interdunal wetlands, the width of buffers should be based on the assumption that these wetlands provide a moderately high level of habitat. It is assumed that species using interdunal wetlands will need some protection from disturbance, but not the 300 feet needed by the more sensitive species. Interdunal wetlands are physically highly dynamic and exposed, and it is assumed that species using these wetlands do have some adaptations to disturbance.

Replacing Interdunal Wetlands Through Compensatory Mitigation

One of the mitigation sites assessed by Johnson et al. (2002) was an interdunal wetland that was found to be moderately successful. Other undocumented observations would also suggest that creating wetlands in the interdunal ecosystem is usually fairly successful (P. Lund, Department of Ecology, personal communications 2003). As a result, the recommended ratios for creating these types of wetlands are lower than for other types. The one stipulation, however, is that losses of interdunal wetlands should be compensated only by creating other interdunal wetlands. The interdunal ecosystem in Washington and elsewhere along the Pacific Coast covers a very limited area. Any further losses of this resource should be minimized.

References

Johnson, P., D.L. Mock, A. McMillan, L. Driscoll, and T. Hruby. 2002. Washington State Wetland Mitigation Evaluation Study Phase 2: Evaluating Success. Publication # 02-06-009. Washington State Department of Ecology. Olympia, WA.

Rigg, G. B. 1958. Peat Resources of Washington. Bulletin No. 44 Division of Mines and Geology, State of Washington.

Wiedemann, A.M. 1984. The Ecology of Pacific Northwest Coastal Sand Dunes: A Community Profile. U.S. Fish and Wildlife Service FWS/OBS-84/04.

Appendix 8-B

Recommendations for Wetland Language in a Critical Areas Ordinance

Appendix 8-B is a complement to Chapter 8 and its other appendices. Local governments should not use suggested language contained in Appendix 8-B in their critical areas ordinances without also carefully reviewing all of Chapter 8 and its supporting appendices.

This appendix contains specific recommendations for language that can be used in critical area regulations to protect wetlands. The recommendations are based on the relevant best available science from Volume 1. While other language may also adequately include the best available science, the language recommended in this appendix represents the State of Washington's best attempt to provide a reasonable, science-based approach to wetlands regulation.

The language below is provided in a format similar to that found in many local critical areas ordinances and therefore is different from other appendices. This appendix does not include the more general provisions typically found in critical areas regulations that relate to all critical areas. These can be found in Appendix A of the *Critical Areas Assistance Handbook* published by the Washington State Department of Community, Trade and Economic Development in November 2003 (http://www.cted.wa.gov/uploads/CA_Handbook.pdf). This appendix revises the wetland specific provisions in Appendix A of the *Critical Areas Assistance Handbook.*

Appendix 8-B should be used in conjunction with Appendices 8-C through 8-F, which contain guidance on wetland mitigation ratios and buffer widths with supporting rationale as well as with Chapter 8, which includes additional discussion on developing the necessary elements of a wetland regulatory ordinance. This appendix includes:

Wetland Provisions

- Designating, Defining, Identifying, and Mapping Wetlands
- Applicability
- Regulated Activities
- Activities Allowed in Wetlands
- Wetland Ratings
- Standards
    - General Requirements
    - Criteria for a Critical Area Report for Wetlands
    - Requirements for Compensatory Mitigation
    - Subdivisions
    - Signs and Fencing of Wetlands
    - Wetland Buffers

- Stormwater Management Impacts to Wetlands
- Agricultural Impacts to Wetlands
- Removal of Hazard Trees
- Unauthorized Alterations and Enforcement

Wetland Provisions

Designating, Defining, Identifying, and Mapping Wetlands

A. **Designating, Defining, and Identifying Wetlands.** Wetlands are those areas, identified in accordance with the *Washington State Wetlands Identification and Delineation Manual* (Ecology 1997), that meet the following definition: "Wetland" or "wetlands" means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from non-wetland areas created to mitigate conversion of wetlands.

All areas within the [city/county] meeting the criteria in the wetland definition in the *Wetlands Identification and Delineation Manual* (Ecology 1997), regardless of whether these areas have previously been identified or mapped, are hereby designated critical areas and are subject to the provisions of this Title.

B. **Mapping.** The approximate location and extent of wetlands are shown on the adopted critical area(s) maps. The following critical area(s) maps, including [*locally adopted maps or the National Wetlands Inventory*] are hereby adopted. Additionally, soil maps produced by U.S. Department of Agriculture Natural Resources Conservation Service may be useful in helping to identify potential wetland areas. These maps are to be used as a guide for the [city/county], project applicants, and/or property owners to identify potential wetland areas that may be subject to the provisions of this Title.

It is the actual presence of wetlands on a parcel, as delineated by the requirements of the *Washington State Wetlands Identification and Delineation Manual* (Ecology 1997), that triggers the requirements of this Title, whether or not the wetland is identified on the adopted maps. The exact location of a wetland's boundary shall be determined through the performance of a field delineation by a qualified wetlands professional, applying the *Washington State Wetlands Identification and Delineation Manual* (Ecology 1997) as required by RCW 36.70A.175.

Applicability

No sample language is provided for the applicability section of a critical areas ordinance. Please see Chapter 8.3.2 for the discussion on applicability. Code language needs to be crafted to align with the manner in which the local government chooses to trigger its regulations. The two options discussed in Chapter 8 are: 1) integrating provisions for wetland protection throughout various elements of the development code as appropriate (e.g., grading and filling ordinance, stormwater management, etc.); or 2) developing a specific critical areas (or wetland) ordinance and permit that encompasses all activities that may influence a wetland. Section 8.3.2 in Chapter 8 includes a discussion of applicability for both options.

Regulated Activities

The following activities are regulated if they occur in a regulated wetland or its buffer:

A. The removal, excavation, grading, or dredging of soil, sand, gravel, minerals, organic matter, or material of any kind;

B. The dumping of, discharging of, or filling with any material;

C. The draining, flooding, or disturbing of the water level or water table;

D. The driving of pilings;

E. The placing of obstructions;

F. The construction, reconstruction, demolition, or expansion of any structure;

G. The destruction or alteration of wetland vegetation through clearing, harvesting, shading, intentional burning, or planting of vegetation that would alter the character of a regulated wetland, provided that these activities are not part of a forest practice governed under Chapter 76.09 RCW and its rules; or

H. Activities that result in:

1. a significant change of water temperature;

2. a significant change of physical or chemical characteristics of the sources of water to the wetland;

3. a significant change in the quantity, timing or duration of the water entering the wetland, or

4. the introduction of pollutants.

Activities Allowed in Wetlands

The activities listed below are allowed in wetlands in addition to those activities listed in the provisions established in *Allowed Activities* (Section [#]) in this Title. These activities do not require submission of a critical area report, except where such activities result in a loss to the functions and values of a wetland or wetland buffer. These activities include:

A. Conservation or preservation of soil, water, vegetation, fish, shellfish, and other wildlife that does not entail changing the structure or functions of the existing wetland;

B. The harvesting of wild crops in a manner that is not injurious to natural reproduction of such crops and provided the harvesting does not require tilling of soil, planting of crops, chemical applications, or alteration of the wetland by changing existing topography, water conditions, or water sources;

C. Drilling for utilities/utility corridors under a wetland, with entrance/exit portals located completely outside of the wetland boundary, provided that the drilling does not interrupt the ground water connection to the wetland or percolation of surface water down through the soil column. Specific studies by a hydrologist are necessary to determine whether the ground water connection to the wetland or percolation of surface water down through the soil column is disturbed; or

D. Enhancement of a wetland through the removal of non-native invasive plant species. Removal of invasive plant species shall be restricted to hand removal. All removed plant material shall be taken away from the site and appropriately disposed of. Revegetation with appropriate native species at natural densities is allowed in conjunction with removal of invasive plant species.

Wetland Ratings

A. Wetlands shall be rated according to the Washington State wetland rating system for [*eastern or western Washington*] (*Washington State Wetland Rating System for Eastern Washington - Revised*, Ecology Publication #04-06-015; *Washington State Wetland Rating System for Western Washington - Revised*, Ecology Publication #04-06-025) or as revised by Ecology. Wetland rating categories shall be applied as the wetland exists at the time of the adoption of this Title or as it exists at the time of an associated permit application. Wetland rating categories shall not change due to illegal modifications.

Note: Choose either the rating system for eastern or western Washington as appropriate.

Wetland Rating Categories – Eastern Washington

1. **Category I.** Category I wetlands are: 1) those identified by the Washington Natural Heritage Program/DNR as high quality, relatively undisturbed wetlands, or wetlands that support state Threatened or Endangered plant species; 2) alkali wetlands; 3) bogs; 4) mature and old-growth forested wetlands over ¼ acre in size dominated by slow-growing native trees; 5) forested wetlands with stands of Aspen; or 6) wetlands that perform many functions very well.

   Category I wetlands represent a unique or rare wetland type, are more sensitive to disturbance than most wetlands, are relatively undisturbed and contain some ecological attributes that are impossible to replace within a human lifetime, or provide a very high level of functions.

2. **Category II.** Category II wetlands are: 1) forested wetlands in the channel migration zone of rivers; 2) mature forested wetlands containing fast growing trees; 3) vernal pools present within a mosaic of other wetlands; or 4) wetlands with a moderately high level of functions. These wetlands are difficult, though not impossible, to replace, and provide high levels of some functions. These wetlands occur more commonly than Category I wetlands, but still need a high level of protection.

3. **Category III.** Category III wetlands are: 1) vernal pools that are isolated; or 2) wetlands with a moderate level of functions. Generally, wetlands in this category have been disturbed in some way, and are often smaller, less diverse and/or more isolated in the landscape than Category II wetlands. They may not need as much protection as Category I and II wetlands.

4. **Category IV.** Category IV wetlands have the lowest levels of functions and are often heavily disturbed. These are wetlands that should be replaceable, and in some cases may be improved. However, experience has shown that replacement cannot be guaranteed in any specific case. These wetlands do provide some important functions and should be protected to some degree.

Wetland Rating Categories – Western Washington

1. **Category I.** Category I wetlands are: 1) relatively undisturbed estuarine wetlands larger than 1 acre; 2) wetlands that are identified by scientists of the Washington Natural Heritage Program/DNR as high quality wetlands; 3) bogs larger than ½ acre; 4) mature and old-growth forested wetlands larger than 1 acre; 5) wetlands in coastal lagoons; or 6) wetlands that perform many functions well.

   Category I wetlands represent a unique or rare wetland type, are more sensitive to disturbance than most wetlands, are relatively undisturbed and

contain some ecological attributes that are impossible to replace within a human lifetime, or provide a very high level of functions.

2. **Category II.** Category II wetlands are: 1) estuarine wetlands smaller than 1 acre, or disturbed estuarine wetlands larger than 1 acre; 2) a wetland identified by the Washington State Department of Natural Resources as containing "sensitive" plant species; 3) a bog between ¼ and ½ acre in size; 4) an interdunal wetland larger than 1 acre; or 5) wetlands with a moderately high level of functions.

   Category II wetlands are difficult, though not impossible, to replace, and provide high levels of some functions. These wetlands occur more commonly than Category I wetlands, but they still need a relatively high level of protection.

3. **Category III.** Category III wetlands are: 1) wetlands with a moderate level of functions; or 2) interdunal wetlands between 0.1 and 1 acre in size. Generally, wetlands in this category may have been disturbed in some way and are often less diverse or more isolated from other natural resources in the landscape than Category II wetlands.

4. **Category IV.** Category IV wetlands have the lowest levels of functions and are often heavily disturbed. These are wetlands that should be replaceable, and in some cases may be improved. However, experience has shown that replacement cannot be guaranteed in any specific case. These wetlands may provide some important functions, and should be protected to some degree.

Standards

General Requirements

A. Activities and uses shall be prohibited in wetlands and wetland buffers, except as provided for in this Title.

B. **Category I Wetlands.** Activities and uses shall be prohibited from Category I wetlands, except as provided for in the *Public Agency and Utility Exception* (Section [#]), *Reasonable Use Exception* (Section [#]), and *Variance* (Section [#]) elements of this Title.

C. **Category II and III Wetlands.** For Category II and III wetlands, the following standard shall apply:

1. Where wetland fill is proposed, it is presumed that an alternative development location exists; activities and uses shall be prohibited unless the applicant can demonstrate that:

a. The basic project purpose cannot reasonably be accomplished on another site or sites in the general region while still successfully avoiding or resulting in less adverse impact on a wetland; and

b. All on-site alternative designs that would avoid or result in less adverse impact on a wetland or its buffer, such as a reduction in the size, scope, configuration or density of the project, are not feasible.

Full compensation for the loss of acreage and functions of wetland and buffers shall be provided under the terms established under *Mitigation* (Section [#]) in this Title.

D. **Category IV Wetlands.** Activities and uses that result in unavoidable impacts may be permitted in Category IV wetlands and associated buffers in accordance with an approved critical area(s) report and compensatory mitigation plan, and only if the proposed activity is the only reasonable alternative that will accomplish the applicant's objectives. Full compensation for the loss of acreage and functions of wetland and buffers shall be provided under the terms established under *Mitigation* (Section [#]) in this Title.

Criteria for a Critical Area Report for Wetlands

A. **Preparation by a Qualified Professional.** A critical area report for wetlands shall be prepared by a qualified professional who is a certified Professional Wetland Scientist or a non-certified professional wetland scientist with a minimum of five (5) years of experience in the field of wetland science, including experience preparing wetland reports.

See Appendix 8-H for further information on what constitutes a qualified wetland professional.

B. **Minimum Standards for Wetland Reports.** The written report and the accompanying plan sheets shall contain the following information, at a minimum:

1. The written report shall include at a minimum:

a. The name and contact information of the applicant; the name, qualifications, and contact information for the primary author(s) of the wetland critical area report; a description of the proposal; identification of all the local, state, and/or federal wetland-related permit(s) required for the project; and a vicinity map for the project;

b. A statement specifying the accuracy of the report and all assumptions made and relied upon;

c. Documentation of any fieldwork performed on the site, including field data sheets for delineations, function assessments, baseline hydrologic data, etc.;

d. A description of the methodologies used to conduct the wetland delineations, function assessments, or impact analyses including references;

e. Identification and characterization of all critical areas, wetlands, water bodies, shorelines, floodplains, and buffers on or adjacent to the proposed project area. For areas off-site of the project site, estimate conditions within 300 feet of the project boundaries using the best available information;

f. For each wetland identified on-site and within 300 feet of the project site provide: the wetland rating per *Wetland Ratings* (Section [#]) of this Title; required buffers; hydrogeomorphic classification; wetland acreage based on a professional survey from the field delineation (acreages for on-site portion and entire wetland area including off-site portions); Cowardin classification of vegetation communities; habitat elements; soil conditions based on site assessment and/or soil survey information; and to the extent possible, hydrologic information such as location and condition of inlet/outlets (if they can be legally accessed), estimated water depths within the wetland, and estimated hydroperiod patterns based on visual cues (e.g., algal mats, drift lines, flood debris, etc.). Provide acreage estimates, classifications, and ratings based on entire wetland complexes, not only the portion present on the proposed project site;

g. A description of the proposed actions including an estimation of acreages of impacts to wetlands and buffers based on the field delineation and survey and an analysis of site development alternatives including a no-development alternative;

h. An assessment of the probable cumulative impacts to the wetlands and buffers resulting from the proposed development;

i. A description of reasonable efforts made to apply mitigation sequencing pursuant to *Mitigation Sequencing* (Section [#]) to avoid, minimize, and mitigate impacts to critical areas;

j. A discussion of measures, including avoidance, minimization, and compensation, proposed to preserve existing wetlands and restore any wetlands that were degraded prior to the current proposed land use activity;

k. A conservation strategy for habitat and native vegetation that addresses methods to protect and enhance on-site habitat and wetland functions, and;

l. Evaluation of functions of the wetland and adjacent buffer using a functions assessment method recognized by local or state agency

staff and including the reference for the method used and all data sheets.

2. A copy of the site plan sheet(s) for the project must be included with the written report and must include, at a minimum:

   a. Maps (to scale) depicting delineated and surveyed wetland and required buffers on-site, including buffers for off-site critical areas that extend onto the project site; the development proposal; other critical areas; grading and clearing limits; areas of proposed impacts to wetlands and/or buffers (include square footage estimates);

   b. A depiction of the proposed stormwater management facilities and outlets (to scale) for the development, including estimated areas of intrusion into the buffers of any critical areas. The written report shall contain a discussion of the potential impacts to the wetland(s) associated with anticipated hydroperiod alterations from the project.

C. **Compensatory Mitigation Reports.** When a project involves wetland and/or buffer impacts, a compensatory mitigation report shall be required, meeting the following minimum standards:

1. **Preparation by a Qualified Professional.** A compensatory mitigation report for wetland or buffer impacts shall be prepared by one or more qualified professional(s) including someone who is a certified Professional Wetland Scientist or a non-certified professional wetland scientist with a minimum of five (5) years experience designing compensatory mitigation projects. The compensatory mitigation projects must have been installed and monitored for a minimum of two (2) years, in order to verify success. In addition, the design team may include civil engineers, landscape architects, or landscape designers depending upon the complexity of the project.

2. **Wetland Critical Area Report.** A critical area report for wetlands must accompany or be included in the compensatory mitigation report and include the minimum parameters described in *Minimum Standards for Wetland Reports* (Section [#]) of this Title.

3. **Compensatory Mitigation Report**. The report must include a written report and plan sheets that must contain, at a minimum, the following elements. Full guidance can be found in the *Guidance on Wetland Mitigation in Washington State - Part 2: Guidelines for Developing Wetland Mitigation Plans and Proposals*, April 2004 (Washington State Department of Ecology, U.S. Army Corps of Engineers Seattle District, and U.S. Environmental Protection Agency Region 10; Ecology Publication #04-06-013b) or as revised.

   a. The written report must contain, at a minimum:

i. The name and contact information of the applicant; the name, qualifications, and contact information for the primary author(s) of the Compensatory Mitigation Report; a description of the proposal; a summary of the impacts and proposed compensation concept; identification of all the local, state, and/or federal wetland related permit(s) required for the project; and a vicinity map for the project;

ii. Description of the existing wetland and buffer areas proposed to be impacted including: acreages (or square footage) based on professional surveys of the delineations; Cowardin classifications including dominant vegetation community types (for upland and wetland habitats); hydrogeomorphic classification of wetland(s) on and adjacent to the site; the results of a functional assessment for the entire wetland and the portions proposed to be impacted; wetland rating based on *Wetland Ratings* (Section [#]) of this Title;

iii. An assessment of the potential changes in wetland hydroperiod from the proposed project and how the design has been modified to avoid, minimize, or reduce adverse impacts to the wetland hydroperiod;

iv. An assessment of existing conditions in the zone of the proposed compensation, including: vegetation community structure and composition, existing hydroperiod, existing soil conditions, existing habitat functions. Estimate future conditions in this location if the compensation actions are NOT undertaken (i.e., how would this site progress through natural succession?);

v. A description of the proposed conceptual actions for compensation of wetland and upland areas affected by the project. Describe future vegetation community types for years 1, 3, 5, 10, and 25 post-installation including the succession of vegetation community types and dominants expected. Describe the successional sequence of expected changes in hydroperiod for the compensation site(s) for the same time periods as vegetation success. Describe the change in habitat characteristics expected over the same 25-year time period;

vi. The field data collected to document existing conditions and on which future condition assumptions are based for hydroperiod (e.g., existing hydroperiod based on piezometer data, staff/crest gage data, hydrologic modeling, visual observations, etc.) and soils (e.g., soil pit data - hand dug or mechanically trenched,

and soil boring data. Do not rely upon soil survey data for establishing existing conditions.);

vii. A discussion of ongoing management practices that will protect wetlands after the project site has been developed, including proposed monitoring and maintenance programs (for remaining wetlands and compensatory mitigation wetlands);

viii. A bond estimate for the entire compensatory mitigation including the following elements: site preparation, plant materials, construction materials, installation oversight, maintenance twice/year for up to five (5) years, annual monitoring field work and reporting, and contingency actions for a maximum of the total required number of years for monitoring;

ix. Proof of establishment of Notice on Title for the wetlands and buffers on the project site, including the compensatory mitigation areas.

b. The scaled plan sheets for the compensatory mitigation must contain, at a minimum:

i. Surveyed edges of the existing wetland and buffers, proposed areas of wetland and/or buffer impacts, location of proposed wetland and/or buffer compensation actions;

ii. Existing topography, ground-proofed, at two-foot contour intervals in the zone of the proposed compensation actions if any grading activity is proposed to create the compensation area(s). Also existing cross-sections of on-site wetland areas that are proposed to be impacted, and cross-section(s) (estimated one-foot intervals) for the proposed areas of wetland or buffer compensation;

iii. Surface and subsurface hydrologic conditions including an analysis of existing and proposed hydrologic regimes for enhanced, created, or restored compensatory mitigation areas. Also, illustrations of how data for existing hydrologic conditions were used to determine the estimates of future hydrologic conditions;

iv. Proposed conditions expected from the proposed actions on site including future hydrogeomorphic types, vegetation community types by dominant species (wetland and upland), and future hydrologic regimes;

v. Required wetland buffers for existing wetlands and proposed compensation areas. Also, identify any zones where buffers are proposed to be reduced or enlarged outside of the standards identified in this Title;

vi. A plant schedule for the compensatory area including all species by proposed community type and hydrologic regime, size and type of plant material to be installed, spacing of plants, "typical" clustering patterns, total number of each species by community type, timing of installation;

vii. Performance standards (measurable standards reflective of years post-installation) for upland and wetland communities, monitoring schedule, and maintenance schedule and actions by each biennium.

D. **Additional Information.** When appropriate, the [director] may also require the wetland report to include an evaluation by the State Department of Ecology or an independent qualified expert regarding the applicant's analysis and the effectiveness of any proposed mitigating measures or programs and to include any recommendations as appropriate.

1. If the development proposal site contains or is within a wetland area, the applicant shall submit an affidavit, which declares whether the applicant has knowledge of any illegal alteration to any or all wetlands on the proposed site and whether the applicant previously had been found in violation of this ordinance. If the applicant has been found previously in violation, the applicant shall declare whether such violation has been corrected to the satisfaction of the jurisdiction.

2. The [director] shall determine if the mitigation and monitoring plans and bonding measures proposed by the applicant are sufficient to protect the public health, safety, and welfare, consistent with the goals, purposes, objectives, and requirements of this Title.

Requirements for Compensatory Mitigation

A. Compensatory mitigation for alterations to wetlands shall achieve equivalent or greater biologic functions. Compensatory mitigation plans shall be consistent with the *Guidance on Wetland Mitigation in Washington State - Part 2: Guidelines for Developing Wetland Mitigation Plans and Proposals,* April 2004 (Washington State Department of Ecology, U.S. Army Corps of Engineers Seattle District, and U.S. Environmental Protection Agency Region 10; Ecology Publication #04-06-013b), or as revised.

B. **Mitigation Shall Be Required in the Following Order of Preference:**

1. Avoiding the impact altogether by not taking a certain action or parts of an action.

2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts.

3. Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

4. Reducing or eliminating the impact over time by preservation and maintenance operations.

5. Compensating for the impact by replacing, enhancing, or providing substitute resources or environments.

6. Monitoring the required compensation and taking remedial or corrective measures when necessary.

C. **Compensating for Lost or Affected Functions.** Compensatory mitigation shall address the functions affected by the proposed project, with an intention to achieve functional equivalency or improvement of functions. The goal shall be for the compensatory mitigation to provide similar wetland functions as those lost, except when either:

1. The lost wetland provides minimal functions as determined by a site-specific function assessment, and the proposed compensatory mitigation action(s) will provide equal or greater functions or will provide functions shown to be limiting within a watershed through a formal Washington State watershed assessment plan or protocol; or

2. Out-of-kind replacement of wetland type or functions will best meet watershed goals formally identified by the [city/county], such as replacement of historically diminished wetland types.

D. **Preference of Mitigation Actions.** Methods to achieve compensation for wetland functions shall be approached in the following order of preference:

1. Restoration (re-establishment and rehabilitation) of wetlands.

2. Creation (establishment) of wetlands on disturbed upland sites such as those with vegetative cover consisting primarily of non-native introduced species. This should only be attempted when there is an adequate source of water and it can be shown that the surface and subsurface hydrologic regime is conducive for the wetland community that is anticipated in the design.

3. Enhancement of significantly degraded wetlands in combination with restoration or creation. Such enhancement should be part of a mitigation package that includes replacing the impacted area and meeting appropriate ratio requirements.

See Appendices 8-C and 8-D for definitions of the types of compensatory mitigation actions (restoration, creation, enhancement).

E. **Type and Location of Compensatory Mitigation.** Unless it is demonstrated that a higher level of ecological functioning would result from an alternate approach, compensatory mitigation for ecological functions shall be either in-kind and on-site, or in-kind and within the same stream reach, sub-basin, or drift cell (if estuarine wetlands are impacted). Compensatory mitigation actions shall be conducted within the same sub-drainage basin and on the site of the alteration except when all of the following apply:

1. There are no reasonable on-site or in sub-drainage basin opportunities (e.g., on-site options would require elimination of high-functioning upland habitat), or on-site and in sub-drainage basin opportunities do not have a high likelihood of success based on a determination of the capacity of the site to compensate for the impacts. Considerations should include: anticipated replacement ratios for wetland mitigation, buffer conditions and proposed widths, available water to maintain anticipated hydrogeomorphic classes of wetlands when restored, proposed flood storage capacity, and potential to mitigate riparian fish and wildlife impacts (such as connectivity);

2. Off-site mitigation has a greater likelihood of providing equal or improved wetland functions than the impacted wetland; and

3. Off-site locations shall be in the same sub-drainage basin unless:

    a. Established watershed goals for water quality, flood storage or conveyance, habitat, or other wetland functions have been established by the [city/county] and strongly justify location of mitigation at another site; or

    b. Credits from a state-certified wetland mitigation bank are used as compensation and the use of credits is consistent with the terms of the bank's certification.

4. The design for the compensatory mitigation project needs to be appropriate for its location (i.e., position in the landscape). Therefore, compensatory mitigation should not result in the creation, restoration, or enhancement of an atypical wetland. An atypical wetland refers to a compensation wetland (e.g., created or enhanced)

that does not match the type of existing wetland that would be found in the geomorphic setting of the site (i.e., the water source(s) and hydroperiod proposed for the mitigation site are not typical for the geomorphic setting). Likewise, it should not provide exaggerated morphology or require a berm or other engineered structures to hold back water. For example, excavating a permanently inundated pond in an existing seasonally saturated or inundated wetland is one example of an enhancement project that could result in an atypical wetland. Another example would be excavating depressions in an existing wetland on a slope, which required the construction of berms to hold the water.

F. **Timing of Compensatory Mitigation.** It is preferred that compensatory mitigation projects be completed prior to activities that will disturb the on-site wetlands. At the least, compensatory mitigation shall be completed immediately following disturbance and prior to use or occupancy of the action or development. Construction of mitigation projects shall be timed to reduce impacts to existing fisheries, wildlife, and flora.

The [director] may authorize a one-time temporary delay in completing construction or installation of the compensatory mitigation when the applicant provides a written explanation from a qualified wetland professional as to the rationale for the delay. An appropriate rationale would include identification of the environmental conditions that could produce a high probability of failure or significant construction difficulties (e.g., project delay lapses past a fisheries window; or installing plants should be delayed until the dormant season to ensure greater survival of installed materials). The delay shall not create or perpetuate hazardous conditions or environmental damage or degradation, and the delay shall not be injurious to the health, safety, and general welfare of the public. The request for the temporary delay must include a written justification that documents the environmental constraints that preclude implementation of the compensatory mitigation plan. The justification must be verified and approved by the [city/county].

G. **Mitigation Ratios.** [insert appropriate acreage ratios]

See Appendices 8-C and 8-D for recommended mitigation ratios and criteria for increasing or reducing ratios to be used with the Washington State wetland rating systems. Appendix 8-F provides the rationale for the recommended ratios.

1. The mitigation ratio is the acreage required for compensatory mitigation divided by the acreage of impact.

2. The ratios are for a concurrent compensatory mitigation project. If the impacts to a wetland are to be mitigated by using an approved and established mitigation bank, the rules and ratios applicable to the bank should be used.

3. The ratios are based on the assumption that the category, based on *Wetland Rating*s (Section [#]) of this Title, and hydrogeomorphic (HGM) class/subclass of the wetland proposed as compensation are the same as the category and HGM class/subclass of the wetland impacts.

4. Ratios for projects in which the category and HGM class/subclass of wetlands proposed as compensation is not the same as that of the wetland impacts will be determined on a case-by-case basis using the recommended ratios as a starting point. The ratios could be higher in such cases.

5. The ratio for using rehabilitation as compensation is 2 times that for using re-establishment or creation (R/C) (1 acre of R/C = 2 acres of rehabilitation). The ratio for using enhancement as compensation is 4 times that for using R/C (1 acre of R/C = 4 acres of enhancement).

6. Re-establishment or creation (R/C) can be used in combination with rehabilitation or enhancement. For example, 1 acre of impact to a Category III wetland would require two acres of R/C. If an applicant provides 1 acre of R/C (i.e. replacing the lost acreage at a 1:1 ratio), the remaining 1 acre of R/C necessary to compensate for the impact could be substituted with 2 acres of rehabilitation or 4 acres of enhancement.

7. Generally the use of enhancement alone as compensation is discouraged. Using enhancement in combination with the replacement of wetland area at a minimum of 1:1 through re-establishment or creation is preferred.

H. **Preservation.** Impacts to wetlands may be mitigated by preservation of wetland areas when used in combination with other forms of mitigation such as creation, restoration, or enhancement. Preservation may also be used by itself, but more restrictions apply as outlined below.

1. **Acceptable Uses of Preservation.** The preservation of at-risk, high-quality wetlands and habitat may be considered as part of an acceptable mitigation plan when the following criteria are met:

   a. Preservation is used as a form of compensation only after the standard sequencing of mitigation (avoid, minimize, and then compensate). Refer to *Mitigation Sequencing* (Section [#]) of this Title;

   b. Restoration (re-establishment and rehabilitation), creation, and enhancement opportunities have also been considered, and preservation is proposed by the applicant and approved by the permitting agencies as the best compensation option;

c. The preservation site is determined to be under imminent threat; that is, the site has the potential to experience a high rate of undesirable ecological change due to on-site or off-site activities that are not regulated (e.g., logging of forested wetlands). This potential includes permitted, planned, or likely actions;

d. The area proposed for preservation is of high quality or critical for the health of the watershed or basin due to its location. Some of the following features may be indicative of high-quality sites:

i. Category I or II wetland rating (using the Washington State wetland rating system for eastern or western WA);

ii. Rare or irreplaceable wetland type (e.g., bogs, mature forested wetlands, estuaries) or aquatic habitat that is rare or a limited resource in the area;

iii. Habitat for threatened or endangered species;

iv. Provides biological and/or hydrological connectivity;

vi. High regional or watershed importance (e.g., listed as priority site in a watershed or basin plan);

vii. Large size with high species diversity (plants and/or animals) and/or high abundance of native species;

viii. A site that is continuous with the head of a watershed, or with a lake or pond in an upper watershed that significantly improves outflow hydrology and water quality.

2. **Preservation in combination with other forms of compensation.** Using preservation as compensation is acceptable when done in combination with restoration, creation, or enhancement, provided that a minimum of 1:1 acreage replacement is provided by re-establishment or creation and the criteria below are met:

a. All criteria listed in [H.1] are met.

b. The impact area is small and/or impacts are occurring to a low-functioning system (Category III or IV wetland);

c. Preservation of a high-quality system occurs in the same watershed or basin as the wetland impact;

d. Preservation sites include buffer areas adequate to protect the habitat and its functions from encroachment and degradation; and

e. Mitigation ratios for preservation in combination with other forms of mitigation shall range from 10:1 to 20:1, as determined on a case-by-case basis, depending on the quality of the wetlands being impacted and the quality of the wetlands being preserved.

3. **Preservation as the sole means of compensation for wetland impacts.** Preservation alone shall only be used as compensatory mitigation in exceptional circumstances. Preservation alone shall not apply if impacts are occurring to functions that must be replaced on site, such as flood storage or water quality treatment that need to be replicated by water quality measures implemented within the project limits. Preservation of at-risk, high-quality wetlands and habitat (as defined above) may be considered as the sole means of compensation for wetland impacts when the following criteria are met:

a. All criteria listed in [H.1] and [H.2] are met;

b. There are no adverse impacts to habitat for fish and species listed as endangered and threatened;

c. There is no net loss of habitat functions within the watershed or basin;

d. Higher mitigation ratios are applied. Mitigation ratios for preservation as the sole means of mitigation shall generally start at 20:1. Specific ratios should depend upon the significance of the preservation project and the quality of the wetland resources lost.

I. **Wetland Mitigation Banks.**

1. Credits from a wetland mitigation bank may be approved for use as compensation for unavoidable impacts to wetlands when:

a. The bank is certified under Chapter 173-700 WAC;

b. The [director] determines that the wetland mitigation bank provides appropriate compensation for the authorized impacts; and

c. The proposed use of credits is consistent with the terms and conditions of the bank's certification.

2. Replacement ratios for projects using bank credits shall be consistent with replacement ratios specified in the bank's certification.

3. Credits from a certified wetland mitigation bank may be used to compensate for impacts located within the service area specified in the bank's certification. In some cases, the service area of the bank may include portions of more than one adjacent drainage basin for specific wetland functions.

Subdivisions

The subdivision and short subdivision of land in wetlands and associated buffers is subject to the following:

A. Land that is located wholly within a wetland or its buffer may not be subdivided.

B. Land that is located partially within a wetland or its buffer may be subdivided provided that an accessible and contiguous portion of each new lot is:

1. Located outside of the wetland and its buffer; and

2. Meets the minimum lot size requirements of [locally adopted zoning dimensions].

C. Access roads and utilities serving the proposed subdivision may be permitted within the wetland and associated buffers only if the [city/county] determines that no other feasible alternative exists, consistent with this Title.

Signs and Fencing of Wetlands

A. **Temporary Markers.** The outer perimeter of the wetland buffer and the clearing limits identified by an approved permit or authorization shall be marked in the field with temporary "clearing limits" fencing in such a way as to ensure that no unauthorized intrusion will occur. The marking is subject to inspection by the [director] prior to the commencement of permitted activities. This temporary marking shall be maintained throughout construction and shall not be removed until permanent signs, if required, are in place.

B. **Permanent Signs.** As a condition of any permit or authorization issued pursuant to this Title, the [director] may require the applicant to install permanent signs along the boundary of a wetland or buffer.

1. Permanent signs shall be made of an enamel-coated metal face and attached to a metal post or another non-treated material of equal durability. Signs must be posted at an interval of one (1) per lot or every fifty (50) feet, whichever is less, and must be maintained by

the property owner in perpetuity. The sign shall be worded as follows or with alternative language approved by the director:

Protected Wetland Area
Do Not Disturb
Contact [Local Jurisdiction]
Regarding Uses, Restrictions, and Opportunities for Stewardship

2. The provisions of Subsection (1) may be modified as necessary to assure protection of sensitive features or wildlife.

C. **Fencing**

1. The [director] shall determine if fencing is necessary to protect the functions and values of the critical area. If found to be necessary, the [director] shall condition any permit or authorization issued pursuant to this Title to require the applicant to install a permanent fence at the edge of the wetland buffer, when fencing will prevent future impacts to the wetland.

2. The applicant shall be required to install a permanent fence around the wetland or buffer when domestic grazing animals are present or may be introduced on site.

3. Fencing installed as part of a proposed activity or as required in this Subsection shall be designed so as to not interfere with species migration, including fish runs, and shall be constructed in a manner that minimizes impacts to the wetland and associated habitat.

Wetland Buffers

A. **Buffer Requirements.** [insert buffer requirements]

> See Appendices 8-C and 8-D for recommended buffer widths and criteria for increasing, reducing and averaging buffers to be used with the Washington State wetland rating systems. Appendix 8-E provides the rationale for the recommended buffers.

B. **Measurement of Wetland Buffers.** All buffers shall be measured from the wetland boundary as surveyed in the field. The width of the wetland buffer shall be determined according to the wetland category and the proposed land use as identified in this Title. The buffer for a wetland created, restored, or enhanced as compensation for approved wetland alterations shall be the same as the buffer required for the category of the created, restored, or enhanced wetland. Only fully vegetated buffers will be considered. Lawns, walkways, driveways, and other mowed or paved areas will not be considered buffers.

C. **Buffers on Mitigation Sites.** All mitigation sites shall have buffers consistent with the buffer requirements of this Title and based on the expected category of the wetland once the mitigation actions are completed.

D. **Buffer Maintenance.** Except as otherwise specified or allowed in accordance with this Title, wetland buffers shall be retained in an undisturbed or enhanced condition. In the case of compensatory mitigation sites, removal of invasive non-native weeds is required for the duration of the mitigation bond.

E. **Impacts to Buffers.** Requirements for the compensation for impacts to buffers are outlined in *Compensatory Mitigation Requirements* (Section [#]) of this title.

F. **Overlapping Critical Area Buffers.** If buffers for two contiguous critical areas overlap (such as buffers for a stream and a wetland), the wider buffer applies.

G. **Buffer Uses.** The following uses may be permitted within a wetland buffer in accordance with the review procedures of this Title, provided they are not prohibited by any other applicable law and they are conducted in a manner so as to minimize impacts to the buffer and adjacent wetland:

1. **Conservation and Restoration Activities.** Conservation or restoration activities aimed at protecting the soil, water, vegetation, or wildlife.

2. **Passive Recreation.** Passive recreation facilities designed and in accordance with an approved critical area report, including:

    a. Walkways and trails, provided that those pathways are limited to minor crossings having no adverse impact on water quality. They should be generally parallel to the perimeter of the wetland, located only in the outer twenty-five percent (25%) of the wetland buffer area, and located to avoid removal of significant trees. They should be limited to pervious surfaces no more than five (5) feet in width for pedestrian use only. Raised boardwalks utilizing non-treated pilings may be acceptable; and

    b. Wildlife viewing structures.

3. **Stormwater Management Facilities.** Stormwater management facilities, limited to stormwater dispersion outfalls and bioswales, may be allowed within the outer twenty-five percent (25%) of the buffer of Category III or IV wetlands only, provided that:

    a. No other location is feasible; and

    b. The location of such facilities will not degrade the functions or values of the wetland; and

c. Stormwater management facilities are not allowed in buffers of Category I or II wetlands.

Stormwater Management Impacts to Wetlands

A. **Protection of Wetland Hydrology.** Wetland hydrology shall be protected through the development process. Post-development wetland hydrology shall match pre-development wetland hydrology to the maximum extent feasible.

B. **Construction of New Surface Water Conveyance Systems.** Construction of new surface water conveyance systems in wetland buffers is allowed only if discharging at the wetland edge has less adverse impact upon the wetland or wetland buffer than if the surface water is discharged at the buffer edge and allowed to naturally drain through the buffer.

C. **Stormwater Facilities on Roads Adjacent to Wetlands and their Buffers.** Construction of new surface water flow control or surface water quality treatment facilities are only allowed in wetlands and buffers when such facilities are located in the right-of-way of an existing road and conducted consistent with established guidelines for road maintenance and best management practices. This does NOT include an outlet structure for a detention facility that is designed to impound water in a wetland up-gradient of a road, unless the provisions in *Limits on Use of Wetlands for Stormwater Detention* (Subsection [#]) are satisfied.

D. **Limits on Use of Wetlands for Stormwater Detention.** Wetlands cannot be used for stormwater detention and treatment unless the project satisfies the guidance and criteria developed by the Puget Sound Wetlands and Stormwater Management Research Program (Azous and Horner, eds, 2001, *Wetlands and Urbanization: Implications for the Future*) and contained in Appendix I-D of the *Stormwater Management Manual for Western Washington,* titled "Wetlands and Stormwater Management Guidelines." Compensatory mitigation should be provided for unavoidable loss of functions through hydrologic or structural modification of wetlands.

At this point we are not aware of wetland management guidelines that have been developed to address stormwater issues specific to eastern Washington. However, many of the wetland management principles embodied in Appendix I-D of the stormwater manual are applicable to wetlands regardless of the region in which they are located.

Agricultural Impacts to Wetlands

Chapter 8 of this volume recommends that a local government regulate on-going agricultural activities in wetlands through best management practices and farm plans. The scope and details of such practices and plans are too site-specific and detailed for the purposes of this appendix.

The following language addresses the conversion of wetlands to new agricultural uses, and conversion of wetlands currently in agricultural use to non-agricultural uses. Both of these activities are legitimately regulated by a local government through its critical areas ordinance.

A. The conversion of wetlands not currently in agricultural use to a new agricultural use is subject to the compensatory mitigation provisions of this Title, including avoidance, minimization, and compensatory mitigation. Conversion includes the clearing of wetland vegetation for pasture or preparation for planting of crops.

B. The conversion of wetlands currently in agricultural uses to non-agricultural uses is subject to the compensatory mitigation provisions of this Title, including avoidance, minimization, and mitigation.

Removal of Hazard Trees

Refer to Section 8.3.3.12 in Chapter 8 of this volume for the discussion on the removal hazard trees in wetlands and their buffers. A local critical areas ordinance may defer to its clearing, landscaping, or other applicable code to address the removal of hazard trees. Local governments should require that hazard trees be replaced either in kind or with species that are underrepresented in the community and under the direction of an arborist. A recommended goal for the replacement of hazard trees is 2:1 for younger trees and 4:1 for mature and old-growth trees.

Unauthorized Alterations and Enforcement

A. When a wetland or its buffer has been altered in violation of this Title, all ongoing development work shall stop and the critical area shall be restored. The [city/county] shall have the authority to issue a "stop-work" order to cease all ongoing development work and order restoration, rehabilitation, or replacement measures at the owner's or other responsible party's expense to compensate for violation of provisions of this Title.

B. **Requirement for Restoration Plan.** All development work shall remain stopped until a restoration plan is prepared and approved by [city/county]. Such a plan shall be prepared by a qualified professional using the currently accepted scientific principles and shall describe how the actions proposed meet the minimum requirements described in Subsection (C). The [director] shall, at the violator's expense, seek expert advice in determining the adequacy of the plan. Inadequate plans shall be returned to the applicant or violator for revision and resubmittal.

C. **Minimum Performance Standards for Restoration.** The following minimum performance standards shall be met for the restoration of a wetland, provided that if the violator can demonstrate that greater functions and habitat values can be obtained, these standards may be modified:

1. The historic structure, functions, and values of the affected wetland shall be restored, including water quality and habitat functions;

2. The historic soil types and configuration shall be replicated;

3. The wetland and buffers shall be replanted with native vegetation that replicates the vegetation historically found on the site in species types, sizes, and densities. The historic functions and values should be replicated at the location of the alteration; and

4. Information demonstrating compliance with other applicable provisions of this Title shall be submitted to the [director].

D. **Site Investigations.** The [director] is authorized to make site inspections and take such actions as are necessary to enforce this Title. The [director] shall present proper credentials and make a reasonable effort to contact any property owner before entering onto private property.

E. **Penalties.** Any person, party, firm, corporation, or other legal entity convicted of violating any of the provisions of this Title shall be guilty of a misdemeanor. Each day or portion of a day during which a violation of this Title is committed or continued shall constitute a separate offense. Any development carried out contrary to the provisions of this Title shall constitute a public nuisance and may be enjoined as provided by the statutes of the State of Washington. The [city/county] may levy civil penalties against any person, party, firm, corporation, or other legal entity for violation of any of the provisions of this Title. The civil penalty shall be assessed at a maximum rate of [amount] dollars per day per violation.

If the wetland affected cannot be restored, monies collected as penalties shall be deposited in a dedicated account for the preservation or restoration of landscape processes and functions in the watershed in which the affected wetland is located. The [city/county] may coordinate its preservation or restoration activities with other [city/county] in the watershed to optimize the effectiveness of the restoration action.

Appendix 8-C

Guidance on Widths of Buffers and Ratios for Compensatory Mitigation for Use with the Western Washington Wetland Rating System

8C.1 Introduction

This appendix provides guidance on widths of buffers, ratios for compensatory mitigation, and other measures for protecting wetlands that are linked to the *Washington State Wetland Rating System for Western Washington-Revised* (Hruby 2004b). Refer to Appendix 8-D for guidance for eastern Washington. Appendices 8-C through 8-F have been formatted similar to the main text of this volume (i.e., with a numbering system) to help with organization.

The tables below list the recommended widths of buffers for various alternatives, examples of measures to minimize impacts, and ratios for compensatory mitigation.

- **Table 8C-1.** Width of buffers needed to protect wetlands in western Washington if impacts from land use and wetland functions are NOT incorporated (Buffer Alternative 1). [Page 4]
- **Table 8C-2.** Width of buffers based on wetland category and modified by the intensity of the impacts from changes in proposed land use (Buffer Alternative 2). [Page 5]
- **Table 8C-3.** Types of land uses that can result in high, moderate, and low levels of impacts to adjacent wetlands (used in Buffer Alternatives 2 and 3). [Page 5]
- **Table 8C-4.** Width of buffers needed to protect Category IV wetlands in western Washington (Buffer Alternative 3). [Page 6]
- **Table 8C-5.** Width of buffers needed to protect Category III wetlands in western Washington (Buffer Alternative 3). [Page 6]
- **Table 8C-6**. Width of buffers needed to protect Category II wetlands in western Washington (Buffer Alternative 3). [Page 7]
- **Table 8C-7.** Width of buffers needed to protect Category I wetlands in western Washington (Buffer Alternative 3). [Page 8]
- **Table 8C-8.** Examples of measures to minimize impacts to wetlands from different types of activities. [Page 10]

- **Table 8C-9.** Comparison of recommended buffer widths for high intensity land uses between Alternative 3 (step-wise scale) and Alternative 3A (graduated scale) based on score for habitat functions [Page 14].
- **Table 8C-10.** Comparison of recommended widths for buffers between Alternative 3 and Alternative 3A for proposed land uses with high impacts with mitigation for impacts. [Page 15]
- **Table 8C-11.** Mitigation ratios for projects in western Washington. [Page 21]

The guidance in this appendix can be used in developing regulations such as critical areas ordinances for protecting and managing the functions and values of wetlands. The recommendations are based on the analysis of the current scientific literature found in Volume 1. The detailed rationale for the recommendations is provided in Appendices 8-E and 8-F.

The recommendations on buffer widths and mitigation ratios are general, and there may be some wetlands for which these recommendations are either too restrictive or not protective enough. The recommendations are based on the assumption that a wetland will be protected only at the scale of the site itself. They do not reflect buffers and ratios that might result from regulations that are developed based on a larger landscape-scale approach.

8C.2 Widths of Buffers

Requiring buffers of a specific width has been one of the primary methods by which local jurisdictions in Washington have protected the functions and values of wetlands. Generally, buffers are the uplands adjacent to an aquatic resource that can, through various physical, chemical, and biological processes, reduce impacts to wetlands from adjacent land uses. The physical characteristics of buffers (e.g., slope, soils, vegetation, and width) determine how well buffers reduce the adverse impacts of human development. These characteristics are discussed in detail in Chapter 5, Volume 1.

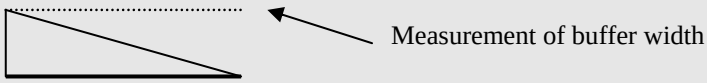
In addition to reducing the impacts of adjacent land uses, buffers also protect and maintain a wide variety of functions and values provided by wetlands. For example, buffers can provide the terrestrial habitats needed by many species of wildlife that use wetlands to meet some of their needs.

The review of the scientific literature has shown, however, that buffers alone cannot adequately protect all functions that a wetland performs. Additional guidance is, therefore, provided on other ways in which wetlands can be managed and regulated to provide some of the necessary protection that buffers alone do not provide. The following guidance for protecting the functions and values of wetlands is based on their category as determined through the rating system for western Washington.

Basic assumptions for using the guidance on widths for buffers

Recommendations for widths of buffers assume that:

- The wetland has been categorized using the *Washington State Wetland Rating System for Western Washington-Revised* (Hruby 2004b).
- The buffer is vegetated with native plant communities that are appropriate for the *ecoregion* or with a plant community that provides similar functions. Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. The U.S. Environmental Protection Agency maintains updated maps of ecoregions that are available at http://www.epa.gov/naaujydh/pages/models/ecoregions.htm . Ecoregions currently mapped for Washington are: Coast Range, Puget Lowland, Cascades, Eastern Cascades Slopes and Foothills, North Cascades, Columbia Plateau, Blue Mountains, and Northern Rockies.
- If the vegetation in the buffer is disturbed (grazed, mowed, etc.), proponents planning changes to land use that will increase impacts to wetlands need to rehabilitate the buffer with native plant communities that are appropriate for the ecoregion, or with a plant community that provides similar functions.
- The width of the buffer is measured along the horizontal plane (see drawing below):



- The buffer will remain relatively undisturbed in the future within the width specified.

Three alternatives for protecting the functions of wetlands using buffers are described in the following sections:

- **Buffer Alternative 1.** Width based only on wetland category.
- **Buffer Alternative 2.** Width based on wetland category and the intensity of impacts from proposed changes in land use.
- **Buffer Alternative 3.** Width based on wetland category, intensity of impacts, and wetland functions or special characteristics. This alternative has two options for determining the widths of buffers when they are based on the score for habitat. Alternative 3 provides three buffer widths based on habitat scores, while Alternative 3A provides a graduated scale of widths for buffers based on habitat scores.

The buffer widths recommended for each alternative were based on the review of scientific information in Volume 1. The guidance in this appendix synthesizes the information about the types and sizes of buffers needed to protect the functions and special characteristics of wetlands.

Appendices 8-C and 8-D do not provide the metric equivalents for buffer widths even though most of the research on buffers uses the metric scale. This decision was made because most local governments use the English Customary measures. For example, a buffer width is set at 50 feet rather than 15 meters.

8C.2.1 Buffer Alternative 1: Width Based Only on Wetland Category

This alternative, in which the width of buffers is based only on the category of the wetland, is the simplest (Table 8C-1). The width recommended for each category of wetland in Alternative 1 is the widest recommended for that category in both Alternatives 2 and 3 (discussed below). Alternative 1 provides the least flexibility because many different types of wetlands and types of human impacts are combined. For example, not all wetlands that fall into Category I or II need a 300-foot buffer. If no distinctions are made between the wetlands that fall into Category I or II, all wetlands that fall into these categories have to be protected with a 300-foot buffer so adequate protection is provided for those wetlands that do need a buffer this wide. Also, the widths recommended for this alternative are those needed to protect the wetland from proposed land uses that have the greatest impacts since no distinctions between impacts are made.

Table 8C-1. Width of buffers needed to protect wetlands in western Washington if impacts from land use and wetland functions are NOT incorporated (Buffer Alternative 1).

Category of Wetland	Widths of Buffers
IV	50 ft
III	150 ft
II	300 ft
I	300 ft

8C.2.2 Buffer Alternative 2: Width Based on Wetland Category and Modified by the Intensity of the Impacts from Proposed Land Use

The second alternative increases the regulatory flexibility by including the concept that not all proposed changes in land uses have the same level of impact (Table 8C-2). For example, one new residence being built on 5 acres of land near a wetland is expected to have a smaller impact than 20 houses built on the same 5 acres. Three categories of impacts from proposed land uses are outlined: land uses that can create high impacts, moderate impacts, and low impacts to wetlands. Different land uses that can cause these levels of impacts are listed in Table 8C-3.

Table 8C-2. Width of buffers needed to protect wetlands in western Washington considering impacts of proposed land uses (Buffer Alternative 2)**.**

Category of Wetland	Land Use with Low Impact *	Land Use with Moderate Impact *	Land Use with High Impact*
IV	25 ft	40 ft	50 ft
III	75 ft	110 ft	150 ft
II	150 ft	225 ft	300 ft
I	150 ft	225 ft	300 ft
* See Table 8C-3 below for types of land uses that can result in low, moderate, and high impacts to wetlands.			

Table 8C-3. Types of proposed land use that can result in high, moderate, and low levels of impacts to adjacent wetlands.

Level of Impact from Proposed Change in Land Use	Types of Land Use Based on Common Zoning Designations *
High	• Commercial • Urban • Industrial • Institutional • Retail sales • Residential (more than 1 unit/acre) • Conversion to high-intensity agriculture (dairies, nurseries, greenhouses, growing and harvesting crops requiring annual tilling and raising and maintaining animals, etc.) • High-intensity recreation (golf courses, ball fields, etc.) • Hobby farms
Moderate	• Residential (1 unit/acre or less) • Moderate-intensity open space (parks with biking, jogging, etc.) • Conversion to moderate-intensity agriculture (orchards, hay fields, etc.) • Paved trails • Building of logging roads • Utility corridor or right-of-way shared by several utilities and including access/maintenance road
Low	• Forestry (cutting of trees only) • Low-intensity open space (hiking, bird-watching, preservation of natural resources, etc.) • Unpaved trails • Utility corridor without a maintenance road and little or no vegetation management.
* Local governments are encouraged to create land-use designations for zoning that are consistent with these examples.	

8C.2.3 Buffer Alternative 3: Width Based on Wetland Category, Intensity of Impacts, Wetland Functions, or Special Characteristics

The third alternative provides the most flexibility by basing the widths of buffers on three factors: the wetland category, the intensity of the impacts (as used in Alternative 2), and the functions or special characteristics of the wetland that need to be protected as determined through the rating system. The recommended widths for buffers are shown in Tables 8C-4 to 8C-7. Using this alternative, a wetland may fall into more than one category in the table. For example, an interdunal wetland may be rated a Category III wetland because it is an isolated interdunal wetland, but it may be rated a Category II wetland based on its score for functions.

If a wetland meets more than one of the characteristics listed in Tables 8C-4 to 8C-7, the buffer recommended to protect the wetland is the widest one. For example, if a Category I wetland (Table 8C-7) scores 32 points for habitat and 27 points for water quality functions, a 300-foot buffer is needed for land uses with high impacts because the widths needed to protect habitat are wider than those needed for the other functions.

Table 8C-4. Width of buffers needed to protect Category IV wetlands in western Washington (Buffer Alternative 3 for wetlands scoring less than 30 points for all functions).

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use	Other Measures Recommended for Protection
Score for all 3 basic functions is less than 30 points	Low - 25 ft Moderate – 40 ft High – 50 ft	No recommendations at this time[1]

Table 8C-5. Width of buffers needed to protect Category III wetlands in western Washington (Buffer Alternative 3 for wetlands scoring 30 – 50 points for all functions).

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use	Other Measures Recommended for Protection
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[1]
Not meeting above characteristic	Low - 40 ft Moderate – 60 ft High – 80 ft	No recommendations at this time[1]

[1] No information on other measures for protection was available at the time this document was written. The Washington State Department of Ecology will continue to collect new information for future updates to this document.

Table 8C-6. Width of buffers needed to protect Category II wetlands in western Washington (Buffer Alternative 3 for wetlands scoring 51-69 points for all functions or having the "Special Characteristics" identified in the rating system).

Wetland Characteristics	**Buffer Widths by Impact of Proposed Land Use** (Apply most protective if more than one criterion is met.)	**Other Measures Recommended for Protection**
High level of function for habitat (score for habitat 29 - 36 points)	Low - 150 ft Moderate – 225 ft High – 300 ft*	Maintain connections to other habitat areas
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[2]
High level of function for water quality improvement and low for habitat (score for water quality 24 - 32 points; habitat less than 20 points)	Low - 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Estuarine	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[2]
Interdunal	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[2]
Not meeting above characteristics	Low - 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time[2]
* Fifty of the 122 wetlands used to calibrate the rating system for western Washington were Category II. Of these 50, only five (10%) would require 300-foot buffers to protect them from high-impact land uses. The maximum buffer width for the remaining 45 wetlands would be 150 feet.		

[2] See footnote on the previous page.

Table 8C-7. Width of buffers needed to protect Category I wetlands in western Washington (Buffer Alternative 3 for wetlands scoring 70 points or more for all functions or having the "Special Characteristics" identified in the rating system).

Wetland Characteristics	**Buffer Widths by Impact of Proposed Land Use** (Apply most protective if more than one criterion is met)	**Other Measures Recommended for Protection**
Natural Heritage Wetlands	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries No septic systems within 300 ft of wetland Restore degraded parts of buffer
Bogs	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries Restore degraded parts of buffer
Forested	Buffer width to be based on score for habitat functions or water quality functions	If forested wetland scores high for habitat, need to maintain connections to other habitat areas Restore degraded parts of buffer
Estuarine	Low - 100 ft Moderate – 150 ft High – 200 ft	No recommendations at this time[3]
Wetlands in Coastal Lagoons	Low - 100 ft Moderate – 150 ft High – 200 ft	No recommendations at this time[3]
High level of function for habitat (score for habitat 29 - 36 points)	Low – 150 ft Moderate – 225 ft High – 300 ft	Maintain connections to other habitat areas Restore degraded parts of buffer
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low – 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[3]
High level of function for water quality improvement (24 – 32 points) and low for habitat (less than 20 points)	Low – 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Not meeting any of the above characteristics	Low – 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time[3]

[3] See footnote on page 6.

8C.2.4 Special Conditions for a Possible Reduction in Buffer Widths

8C.2.4.1 Condition 1: Reduction in Buffer Width Based on Reducing the Intensity of Impacts from Proposed Land Uses

The buffer widths recommended for proposed land uses with high-intensity impacts to wetlands can be reduced to those recommended for moderate-intensity impacts under the following conditions:

- For wetlands that score moderate or high for habitat (20 points or more for the habitat functions), the width of the buffer can be reduced if both of the following criteria are met:

    1) A relatively undisturbed, vegetated corridor at least 100-feet wide is protected between the wetland and any other Priority Habitats as defined by the Washington State Department of Fish and Wildlife ("relatively undisturbed" and "vegetated corridor" are defined in questions H 2.1 and H 2.2.1 of the *Washington State Wetland Rating System for Western Washington – Revised,* (Hruby 2004b)). Priority Habitats in western Washington include:

        - Wetlands
        - Riparian zones
        - Aspen stands
        - Cliffs
        - Prairies
        - Caves
        - Stands of Oregon White Oak
        - Old-growth forests
        - Estuary/estuary-like
        - Marine/estuarine shorelines
        - Eelgrass meadows
        - Talus slopes
        - Urban natural open space (for current definitions of Priority Habitats, see http://wdfw.wa.gov/hab/phshabs.htm)

        The corridor must be protected for the entire distance between the wetland and the Priority Habitat by some type of legal protection such as a conservation easement.

    2) Measures to minimize the impacts of different land uses on wetlands, such as the examples summarized in Table 8C-8, are applied.

- For wetlands that score less than 20 points for habitat, the buffer width can be reduced to that required for moderate land-use impacts by applying measures to minimize the impacts of the proposed land uses (see examples in Table 8C-8).

Table 8C-8. Examples of measures to minimize impacts to wetlands from proposed change in land use that have high impacts. (This is not a complete list of measures.)

Examples of Disturbance	Activities and Uses that Cause Disturbances	Examples of Measures to Minimize Impacts
Lights	• Parking lots • Warehouses • Manufacturing • Residential	• Direct lights away from wetland
Noise	• Manufacturing • Residential	• Locate activity that generates noise away from wetland
Toxic runoff*	• Parking lots • Roads • Manufacturing • Residential areas • Application of agricultural pesticides • Landscaping	• Route all new, untreated runoff away from wetland while ensuring wetland is not dewatered • Establish covenants limiting use of pesticides within 150 ft of wetland • Apply integrated pest management
Stormwater runoff	• Parking lots • Roads • Manufacturing • Residential areas • Commercial • Landscaping	• Retrofit stormwater detention and treatment for roads and existing adjacent development • Prevent channelized flow from lawns that directly enters the buffer
Change in water regime	• Impermeable surfaces • Lawns • Tilling	• Infiltrate or treat, detain, and disperse into buffer new runoff from impervious surfaces and new lawns
Pets and human disturbance	• Residential areas	• Use privacy fencing; plant dense vegetation to delineate buffer edge and to discourage disturbance using vegetation appropriate for the ecoregion; place wetland and its buffer in a separate tract
Dust	• Tilled fields	• Use best management practices to control dust
* These examples are not necessarily adequate for minimizing toxic runoff if threatened or endangered species are present at the site.		

8C.2.4.2 Condition 2: Reductions in Buffer Widths Where Existing Roads or Structures Lie Within the Buffer

Where a legally established, non-conforming use of the buffer exists (e.g., a road or structure that lies within the width of buffer recommended for that wetland), proposed actions in the buffer may be permitted as long as they do not increase the degree of non-conformity. This means no increase in the impacts to the wetland from activities in the buffer.

For example, if a land use with high impacts (e.g., building an urban road) is being proposed next to a Category II wetland with a moderate level of function for habitat, a 150-foot buffer would be needed to protect functions (see Table 8C-6). If, however, an existing urban road is already present and only 50 feet from the edge of the Category II wetland, the additional 100 feet of buffer may not be needed if the road is being widened. A vegetated buffer on the other side of the road would not help buffer the existing impacts to the wetland from the road. If the existing road is resurfaced or widened (e.g., to add a sidewalk) along the upland edge, without any further roadside development that would increase the degree of non-conformity, the additional buffer is not necessary. The associated increase in impervious surface from widening a road, however, may necessitate mitigation for impacts from stormwater.

If, however, the proposal is to build a new development (e.g., shopping center) along the upland side of the road, the impacts to the wetland and its functions may increase. This would increase the degree of non-conformity. The project proponent would need to provide the additional 100 feet of buffer extending beyond the road or apply buffer averaging (see Section 8C.2.6).

8C.2.4.3 Condition 3: Reduction in Buffer Widths Through an Individual Rural Stewardship Plan

A Rural Stewardship Plan (RSP) is the product of a collaborative effort between rural property owners and a local government to tailor a management plan specific for a rural parcel of land. The goal of the RSP is better management of wetlands than what would be achieved through strict adherence to regulations. In exchange, the landowner gains flexibility in the widths of buffers required, in clearing limits, and in other requirements found in the regulations. For example, dense development in rural residential areas can be treated as having a low level of impact when the development of the site is managed through a locally approved RSP. The voluntary agreement includes provisions for restoration, maintenance, and long-term monitoring and specifies the widths of buffers needed to protect each wetland within the RSP.

8C.2.5 Conditions for Increasing the Width of, or Enhancing, the Buffer

8C.2.5.1 Condition 1: Buffer is Not Vegetated with Plants Appropriate for the Region

The recommended widths for buffers are based on the assumption that the buffer is vegetated with a native plant community appropriate for the ecoregion or with one that performs similar functions. If the existing buffer is unvegetated, sparsely vegetated, or vegetated with invasive species that do not perform needed functions, the buffer should either be planted to create the appropriate plant community or the buffer should be widened to ensure that adequate functions of the buffer are provided. Generally, improving the vegetation will be more effective than widening the buffer.

8C.2.5.2 Condition 2: Buffer Has a Steep Slope

The review of the literature (Volume 1) indicates that the effectiveness of buffers at removing pollutants before they enter a wetland decreases as the slope increases. If a buffer is to be based on the score for its ability to improve water quality (see Tables 8C-4 through 8C-7) rather than habitat or other criteria, then the buffer should be increased by 50% if the slope is greater than 30% (a 3-foot rise for every 10 feet of horizontal distance).

8C.2.5.3 Condition 3: Buffer Is Used by Species Sensitive to Disturbance

If the wetland provides habitat for a species that is particularly sensitive to disturbance (such as a threatened or endangered species), the width of the buffer should be increased to provide adequate protection for the species based on its particular, life-history needs. Some buffer requirements for priority species are available on the Washington State Department of Fish and Wildlife web page (http://wdfw.wa.gov/hab/phsrecs.htm). The list of priority species for vertebrates is at http://wdfw.wa.gov/hab/phsvert.htm; for invertebrates it is at http://wdfw.wa.gov/hab/phsinvrt.htm. Information on the buffer widths needed by some threatened, endangered, and sensitive species of wildlife is provided in Appendix 8-H.

8C.2.6 Buffer Averaging

The widths of buffers may be averaged if this will improve the protection of wetland functions, or if it is the only way to allow for reasonable use of a parcel. There is no scientific information available to determine if averaging the widths of buffers actually protects functions of wetlands. The authors have concluded that averaging could be allowed in the following situations:

Averaging may not be used in conjunction with any of the other provisions for reductions in buffers (listed above).

- Averaging to **improve wetland protection** may be permitted when **all** of the following conditions are met:
  - The wetland has significant differences in characteristics that affect its habitat functions, such as a wetland with a forested component adjacent to a degraded emergent component or a "dual-rated" wetland with a Category I area adjacent to a lower rated area
  - The buffer is increased adjacent to the higher-functioning area of habitat or more sensitive portion of the wetland and decreased adjacent to the lower-functioning or less sensitive portion
  - The total area of the buffer after averaging is equal to the area required without averaging
  - The buffer at its narrowest point is never less than 3/4 of the required width
- Averaging to **allow reasonable use** of a parcel may be permitted when **all** of the following are met:
  - There are no feasible alternatives to the site design that could be accomplished without buffer averaging
  - The averaged buffer will not result in degradation of the wetland's functions and values as demonstrated by a report from a qualified wetland professional (see Appendix 8-G for a definition of a qualified wetland professional)
  - The total buffer area after averaging is equal to the area required without averaging
  - The buffer at its narrowest point is never less than 3/4 of the required width

8C.2.7 Modifying Buffer Widths in Alternative 3 Using a Graduated Scale for the Habitat Functions (Alternative 3A)

Alternative 3 contains recommendations for protecting the habitat functions of wetlands using only three groupings of scores (0-19, 20-28, 29-36). As a result, a one-point difference between 28 and 29 can result in a 150-foot increase in the width of a buffer around a wetland. The habitat scores were divided into three groups to simplify the regulations based on this guidance. This division is not based on a characterization of risks since the scientific information indicates that the decrease in risk with increasing widths of buffers is relatively continuous for habitat functions.

Such a large increase in width with a one-point increase in the habitat score may be contentious. A jurisdiction may wish to reduce the increments in the widths for buffers by developing a more graduated (but inherently more complicated) scale based on the scores for habitat. Table 8C-9 provides one example of a graduated scale for widths of buffers where the width increases by 20 feet for every one point increase in the habitat score (Figure 8C-1 shows the buffer widths graphically).

Table 8C-9. Comparison of widths for buffers in Alternatives 3 (step-wise scale) and 3A (graduated scale) for proposed land uses with high impacts based on the score for habitat functions in western Washington

Points for Habitat from Wetland Rating Form	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Alternative 3	100	150	150	150	150	150	150	150	150	150	300	300	300	300	300	300	300	300
Alternative 3A	100	100	100	120	140	160	180	200	220	240	260	280	300	300	300	300	300	300

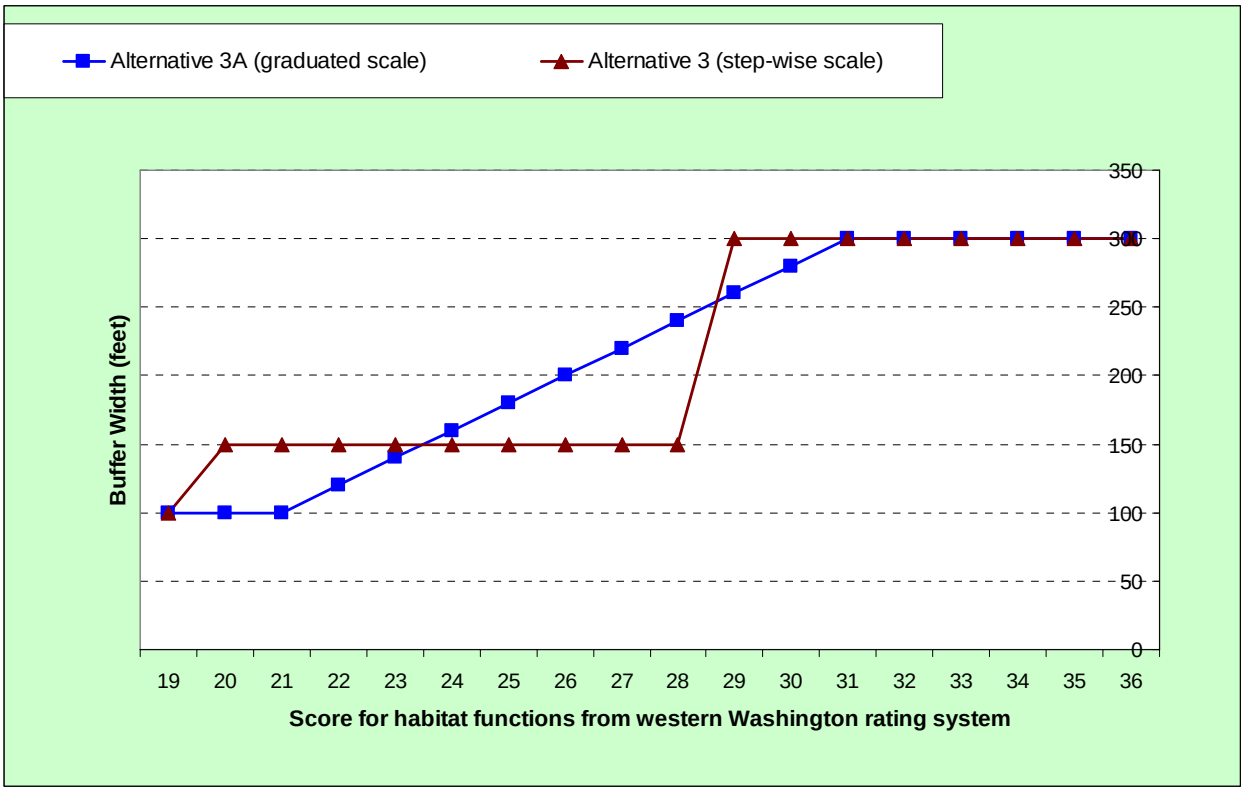


Figure 8C-1. Graphical comparison of widths for buffers in Alternative 3 and 3A for proposed land uses with high impacts based on the score for habitat functions in western Washington.

Other scales are possible as long as they keep within the limits established from the scientific information currently available: wetlands with scores for habitat that are higher than 31 points need buffers that are at least 300-feet wide; wetlands with a score of 26 points need buffers of at least 150 feet; and wetlands with a score of 22 points need buffers that are at least 100-feet wide.

These buffer widths can be further reduced by 25 percent if a proposed project with high impacts implements the mitigation measures such as those described in Table 8C-8. The measures are part of "Condition 1" in Section 8C.2.4 (Special Conditions for a Possible Reduction in Buffer Widths). The buffer widths under Buffer Alternatives 3 and 3A, and the corresponding 25 percent reduction (per buffer reduction condition 1) are shown in Table 8C-10 and represented graphically below in Figure 8C-2.

Table 8C-10. Comparison of widths for buffers in Alternatives 3 (step-wise scale) and 3A (graduated scale) for proposed land uses with high impacts based on the score for habitat functions in western Washington if the impacts are mitigated.

Points for Habitat from Wetland Rating Form	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Alternative 3 (**with** mitigation of impacts)	75	110	110	110	110	110	110	110	110	110	225	225	225	225	225	225	225	225
Alternative 3A (**with** mitigation of impacts)	75	75	75	90	105	120	135	150	165	180	195	210	225	225	225	225	225	225

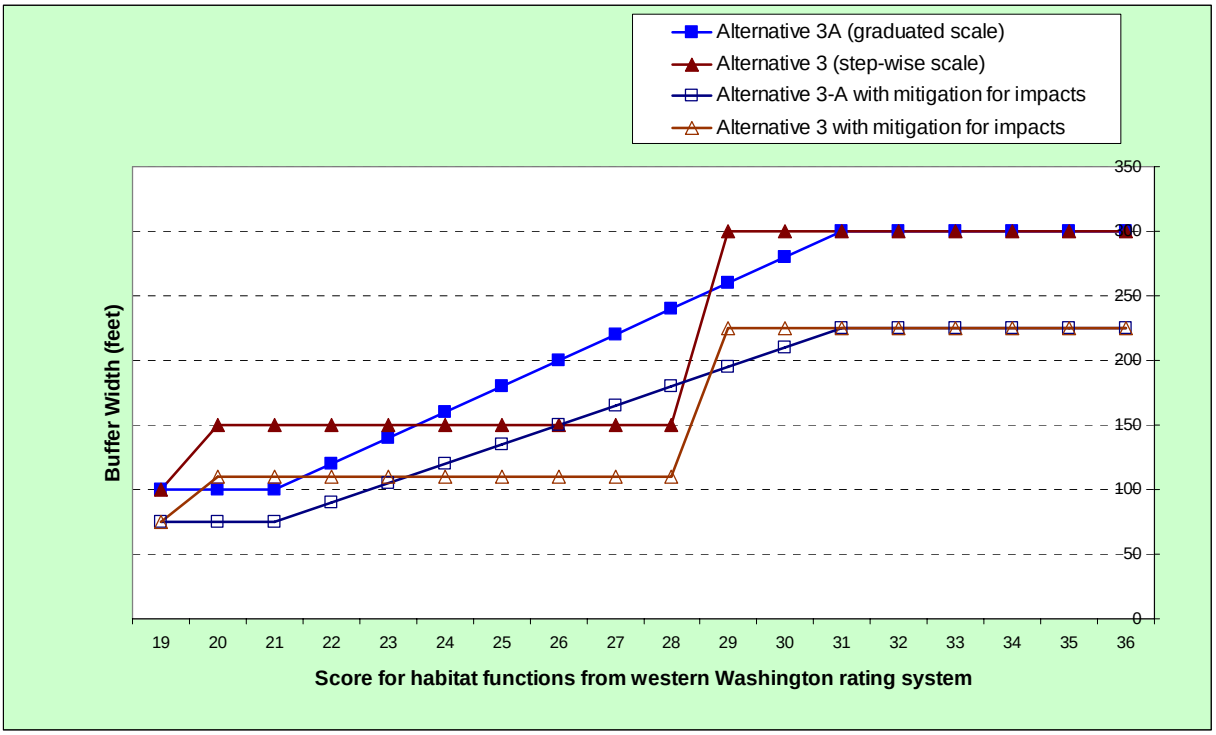


Figure 8C-2. Graphical comparison of widths for buffers in Alternatives 3 and 3A based on the score for habitat functions in western Washington with and without mitigating impacts of proposed development outside the buffer.

Alternatives 3 and 3A represent two separate approaches for determining widths of buffers for wetlands scoring between 20 and 31 points for the habitat functions. Local governments should select one of the two approaches and should not hybridize the approaches or adopt both at the same time.

8C.3 Ratios for Compensatory Mitigation

When the acreage required for compensatory mitigation is divided by the acreage of impact, the result is a number known variously as a *replacement, compensation,* or *mitigation* ratio. Compensatory mitigation ratios are used to help ensure that compensatory mitigation actions are adequate to offset unavoidable wetland impacts by requiring a greater amount of mitigation area than the area of impact. Requiring greater mitigation area helps compensate for the risk that a mitigation action will fail and for the time lag that occurs between the wetland impact and achieving a fully functioning mitigation site.

8C.3.1 Definitions of Types of Compensatory Mitigation

The ratios presented are based on the type of compensatory mitigation proposed (e.g., restoration, creation, and enhancement). In its *Regulatory Guidance Letter 02-02*, the U.S. Army Corps of Engineers provided definitions for these types of compensatory mitigation. For consistency, the authors of this document use the same definitions which are provided below.

Restoration: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into:

- **Re-establishment.** The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a **former** wetland. Re-establishment results in a gain in wetland acres (and functions). Activities could include removing fill material, plugging ditches, or breaking drain tiles.
- **Rehabilitation.** The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic functions of a **degraded** wetland. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres. Activities could involve breaching a dike to reconnect wetlands to a floodplain or return tidal influence to a wetland.

Creation (Establishment): The manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland or deepwater site where a wetland did not previously exist. Establishment results in a gain in wetland acres. Activities typically involve excavation of upland soils to elevations that will produce a wetland hydroperiod, create hydric soils, and support the growth of hydrophytic plant species.

Enhancement: The manipulation of the physical, chemical, or biological characteristics of a wetland site to heighten, intensify, or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for specified purposes such as water quality improvement, flood water retention, or wildlife habitat. Enhancement results in a change in some wetland functions and can lead to a

decline in other wetland functions, but does not result in a gain in wetland acres. Activities typically consist of planting vegetation, controlling non-native or invasive species, modifying site elevations or the proportion of open water to influence hydroperiods, or some combination of these activities.

Protection/Maintenance (Preservation): Removing a threat to, or preventing the decline of, wetland conditions by an action in or near a wetland. This includes the purchase of land or easements, repairing water control structures or fences, or structural protection such as repairing a barrier island. This term also includes activities commonly associated with the term *preservation.* Preservation does not result in a gain of wetland acres, may result in a gain in functions, and will be used only in exceptional circumstances.

Distinction between rehabilitation and enhancement

The distinction between rehabilitation and enhancement as defined above is not clear-cut and can be hard to understand. Actions that rehabilitate or enhance wetlands span a continuum of activities that cannot be defined by specific criteria.

Rehabilitation ⟷ *Enhancement*

In general, rehabilitation involves actions that are more sustainable and that reinstate environmental processes, both at the site and landscape scale (e.g., reinstating hydrologic processes in a diked floodplain by breaching the dikes). Rehabilitation actions often focus on restoring environmental processes that have been disturbed or altered by previous or ongoing, human activity. Ecology further defines *rehabilitation* as:

- Actions that restore the original hydrogeomorphic (HGM) class, or subclass, to a wetland whose current HGM class, or subclass, has been changed by human activities
- Actions that restore the water regime that was present and maintained the wetland before human activities changed it

Any other actions taken in existing wetlands would be considered *enhancement.* Enhancement typically involves actions that provide gains in only one or a few functions and can lead to a decline in other functions. Enhancement actions often focus on structural or superficial improvements to a site and generally do not address larger-scale environmental processes.

For example, a wetland that was once a forested, riverine wetland was changed to a depressional, emergent wetland by the construction of a dike and through grazing. Rehabilitating the wetland would involve breaching the dike so the wetland becomes a riverine wetland again, discontinuing the grazing, and reforesting the area. Discontinuing the grazing and reforesting the wetland without re-establishing the links to the riverine system would be considered enhancement.

Basic assumptions for using the guidance on ratios

- The ratios are for a compensatory mitigation project that is concurrent with impacts to wetlands. If impacts are to be mitigated by using an approved and established mitigation bank, the rules and ratios applicable to the bank should be used.
- The ratios are based on the assumption that the category (based on the rating system for western Washington) and hydrogeomorphic (HGM) class or subclass of the wetland proposed as compensation are the same as the category and HGM class or subclass of the affected wetland (e.g., impacts to a Category II riverine wetland are compensated by creating, restoring, or enhancing a Category II riverine wetland).
- Ratios for projects in which the category and HGM class or subclass of wetlands proposed as compensation is not the same as that of the wetland affected will be determined on a case-by-case basis using the recommended ratios as a starting point. The ratios could be higher in such cases.
- The ratio for using rehabilitation as compensation is 2 times that for using re-establishment or creation (R/C) (2 acres of rehabilitation are equivalent to 1 acre of R/C). The ratio for using enhancement as compensation is 4 times that for using R/C (4 acres of enhancement are equivalent to 1 acre of R/C).
- Re-establishment or creation can be used in combination with rehabilitation or enhancement. For example, 1 acre of impact to a Category III wetland would require 2 acres of R/C. If an applicant provides 1 acre of R/C (i.e., replacing the lost acreage at a 1:1 ratio), the remaining 1 acre of R/C necessary to compensate for the impact could be substituted with 2 acres of rehabilitation or 4 acres of enhancement.
- Generally the use of enhancement alone as compensation is discouraged. Using enhancement in combination with the replacement of wetland area at a minimum of 1:1 through re-establishment or creation is preferred.

These ratios were developed to provide a starting point for further discussions with each proponent of compensatory mitigation. They are based on the observations of the success and risk of compensatory mitigation, as reviewed in Volume 1, and do not represent the specific risk or opportunities of any individual project.

As noted above, the ratios for compensatory mitigation are based on the assumption that the category and hydrogeomorphic (HGM) class or subclass of the affected wetland and the mitigation wetland are the same. The ratios may be adjusted either up or down if the category or HGM class or subclass of the wetland proposed for compensation is different. For example, ratios may be lower if impacts to a Category IV wetland are to be mitigated by creating a Category II wetland. The same is true for impacts to wetlands that currently would be considered *atypical* (see definition below).

Also, compensatory mitigation should not result in the creation, restoration, or enhancement of an atypical wetland. An atypical wetland is defined as a wetland whose design does not match the type of wetland that would be found in the geomorphic setting

of the proposed site (i.e., the water source(s) and hydroperiod proposed for the mitigation site are not typical for the geomorphic setting). In addition, any designs that provide exaggerated morphology or require a berm or other engineered structures to hold back water would be considered atypical. For example, excavating a permanently inundated pond in an existing seasonally saturated or inundated wetland is one example of an enhancement project that could result in an atypical wetland. Another example would be excavating depressions in an existing wetland on a slope that required the construction of berms to impound water.

On a case-by-case basis, it is possible to use the scores from the Washington State wetland rating system to compare functions between the mitigation wetland and the impacted wetland. This information may also be used to adjust replacement ratios. Scores from the methods for assessing wetland functions (Hruby et al. 1999) provide another option to establish whether the functions lost will be replaced if both the affected wetland and the wetland used for compensation are of the same HGM class and subclass.

Mitigation ratios for projects in western Washington are shown in Table 8C-11. Refer to the text box on the basic assumptions on the previous page before reading the table. As mentioned previously, these ratios were developed to provide a starting point for further discussions with each proponent of compensatory mitigation. They only factor in the observations of mitigation success and risk at a programmatic level, and do not represent the specific risk or opportunity of any individual project.

Table 8C-11. Mitigation ratios for projects in western Washington.

Category and Type of Wetland Impacts	Re-establishment or Creation	Rehabilitation Only[4]	Re-establishment or Creation (R/C) and Rehabilitation (RH)[4]	Re-establishment or Creation (R/C) and Enhancement (E)[4]	Enhancement Only[4]
All Category IV	1.5:1	3:1	1:1 R/C and 1:1RH	1:1 R/C and 2:1 E	6:1
All Category III	2:1	4:1	1:1 R/C and 2:1 RH	1:1 R/C and 4:1 E	8:1
Category II Estuarine	Case-by-case	4:1 Rehabilitation of an estuarine wetland	Case-by-case	Case-by-case	Case-by-case
Category II Interdunal	2:1 Compensation has to be interdunal wetland	4:1 Compensation has to be interdunal wetland	1:1 R/C and 2:1 RH Compensation has to be interdunal wetland	Not considered an option[5]	Not considered an option[5]
All other Category II	3:1	6:1	1:1 R/C and 4:1 RH	1:1 R/C and 8:1 E	12:1
Category I Forested	6:1	12:1	1:1 R/C and 10:1 RH	1:1 R/C and 20:1 E	24:1
Category I based on score for functions	4:1	8:1	1:1 R/C and 6:1 RH	1:1 R/C and 12:1 E	16:1
Category I Natural Heritage site	Not considered possible[6]	6:1 Rehabilitation of a Natural Heritage site	R/C Not considered possible[6]	R/C Not considered possible[6]	Case-by-case
Category I Coastal Lagoon	Not considered possible[6]	6:1 Rehabilitation of a coastal lagoon	R/C not considered possible[6]	R/C not considered possible[6]	Case-by-case
Category I Bog	Not considered possible[6]	6:1 Rehabilitation of a bog	R/C Not considered possible[6]	R/C Not considered possible[6]	Case-by-case
Category I Estuarine	Case-by-case	6:1 Rehabilitation of an estuarine wetland	Case-by-case	Case-by-case	Case-by-case
NOTE: Preservation is discussed in the following section.					

[4] These ratios are based on the assumption that the rehabilitation or enhancement actions implemented represent the average degree of improvement possible for the site. Proposals to implement more effective rehabilitation or enhancement actions may result in a lower ratio, while less effective actions may result in a higher ratio. The distinction between rehabilitation and enhancement is not clear-cut. Instead, rehabilitation and enhancement actions span a continuum. Proposals that fall within the gray area between rehabilitation and enhancement will result in a ratio that lies between the ratios for rehabilitation and the ratios for enhancement.

[5] Due to the dynamic nature of interdunal systems, enhancement is not considered an ecologically appropriate action.

[6] Natural Heritage sites, coastal lagoons, and bogs are considered irreplaceable wetlands because they perform some special functions that cannot be replaced through compensatory mitigation. Impacts to such wetlands would therefore result in a net loss of some functions no matter what kind of compensation is proposed.

8C.3.2 Conditions for Increasing or Reducing Replacement Ratios

Increases in replacement ratios are appropriate under the following circumstances:

- Success of the proposed restoration or creation is uncertain
- A long time will elapse between impact and establishment of wetland functions at the mitigation site
- Proposed mitigation will result in a lower category wetland or reduced functions relative to the wetland being impacted
- The impact was unauthorized

Reductions in replacement ratios are appropriate under the following circumstances:

- Documentation by a qualified wetland specialist (see Appendix 8-H) demonstrates that the proposed mitigation actions have a very high likelihood of success based on prior experience
- Documentation by a qualified wetland specialist demonstrates that the proposed actions for compensation will provide functions and values that are significantly greater than the wetland being affected
- The proposed actions for compensation are conducted in advance of the impact and are shown to be successful
- In wetlands where several HGM classes are found within one delineated boundary, the areas of the wetlands within each HGM class can be scored and rated separately and the ratios adjusted accordingly, if **all of the following** apply:
  - The wetland does not meet any of the criteria for wetlands with "Special Characteristics" as defined in the rating system
  - The rating and score for the entire wetland is provided along with the scores and ratings for each area with a different HGM class.
  - Impacts to the wetland are all within an area that has a different HGM class from the one used to establish the initial category
  - The proponents provide adequate hydrologic and geomorphic data to establish that the boundary between HGM classes lies at least 50 feet outside of the footprint of the impacts

8C.3.3 Replacement Ratios for Preservation

In some cases, preservation of existing wetlands may be acceptable as compensation for wetland losses. Acceptable sites for preservation include those that:

- Are important due to their landscape position
- Are rare or limited wetland types
- Provide high levels of functions

Ratios for preservation in combination with other forms of mitigation generally range from 10:1 to 20:1, as determined on a case-by-case basis, depending on the quality of the wetlands being impacted and the quality of the wetlands being preserved. Ratios for preservation as the sole means of mitigation generally start at 20:1. Specific ratios will depend upon the significance of the preservation project and the quality of the wetland resources lost.

See Chapter 8 (Section 8.3.7.2) and Appendix 8-B for more information on preservation and the criteria for its use as compensation.

8C.3.4 Replacement Ratios for Temporal Impacts and Conversions

When impacts to wetlands are not permanent, local governments often require some compensation for the temporal loss of wetland functions. *Temporal impacts* refer to impacts to those functions that will eventually be replaced but cannot achieve similar functionality in a short time. For example, clearing forested wetland vegetation for pipeline construction could result in the temporal loss of functions, such as song bird habitat provided by the tree canopy. It may take over 20 years to re-establish the level of function lost as a result of clearing the trees. Although the wetlands will be re-vegetated and over time it is anticipated that their previous level of functioning will be re-established, a temporal loss of functions will occur. There is also some risk of failure associated with the impacts or alterations, especially when soil is compacted by equipment, deep excavation is required, and pipeline trenches alter the water regime at the site.

Therefore, in addition to restoring the affected wetland to its previous condition, local governments should consider requiring compensation to account for the risk and temporal loss of wetland functions. Generally, the ratios for temporal impacts to forested and scrub-shrub wetlands are one-quarter of the recommended ratios for permanent impacts (refer to Table 8C-11), provided that the following measures are satisfied:

- An explanation of how hydric soil, especially deep organic soil, is stored and handled in the areas where the soil profile will be severely disturbed for a fairly significant depth or time

- Surface and groundwater flow patterns are maintained or can be restored immediately following construction
- A 10-year monitoring and maintenance plan is developed and implemented for the restored forest and scrub-shrub wetlands
- Disturbed buffers are re-vegetated and monitored
- Where appropriate, the hydroseed mix to be applied on re-establishment areas is identified

When impacts are to a native emergent community and there is a potential risk that its re-establishment will be unsuccessful, compensation for temporal loss and the potential risk should be required in addition to restoring the affected wetland and monitoring the site. If the impacts are to wetlands dominated by non-native vegetation (e.g., blackberry, reed canarygrass, or pasture grasses), restoration of the affected wetland with native species and monitoring after construction is generally all that is required.

Loss of functions due to the permanent conversion of wetlands from one type to another also requires compensation. When wetlands are not completely lost but are converted to another type, such as a forested wetland converted to an emergent or shrub wetland (e.g., for a utility right-of-way), some functions are lost or reduced.

The ratios for conversion of wetlands from one type to another will vary based on the degree of the alteration, but they are generally one-half of the recommended ratios for permanent impacts (refer to Table 8C-11).

Refer to Appendix 8-F for the rationale for the ratios provided in this appendix.

Specific guidance has been developed for conversions of wetlands to cranberry bogs. Please refer to the 1998 *Guidelines for Implementation of Compensatory Mitigation Requirements for Conversion of Wetlands to Cranberry Bogs* for information on ratios associated with this activity (Washington State Department of Ecology, U.S. Environmental Protection Agency Region 10, U.S. Army Corps of Engineers Seattle District, and U.S. Fish and Wildlife Service. 1998. Special Public Notice: http://www.nws.usace.army.mil/publicmenu/DOCUMENTS/ACF101C.pdf).

Appendix 8-D

Guidance on Widths of Buffers and Ratios for Compensatory Mitigation for Use with the Eastern Washington Wetland Rating System

8D.1 Introduction

This appendix provides guidance on widths of buffers, ratios for compensatory mitigation, and other measures for protecting wetlands that are linked to the *Washington State Wetland Rating System for Eastern Washington-Revised* (Hruby 2004a). Refer to Appendix 8-C for guidance for western Washington. Appendices 8-C through 8-F have been formatted similar to the main text of this volume (i.e., with a numbering system) to help with organization.

The tables below list the recommended widths of buffers for various alternatives, examples of measures to minimize impacts, and ratios for compensatory mitigation.

- **Table 8D-1.** Width of buffers needed to protect wetlands in eastern Washington if impacts from land use and wetland functions are NOT incorporated (Buffer Alternative 1). [Page 4]
- **Table 8D-2.** Width of buffers based on wetland category and modified by the intensity of the impacts from changes in proposed land use (Buffer Alternative 2). [Page 5]
- **Table 8D-3.** Types of land uses that can result in high, moderate, and low levels of impacts to adjacent wetlands (used in Buffer Alternatives 2 and 3). [Page 5]
- **Table 8D-4.** Width of buffers needed to protect Category IV wetlands in eastern Washington (Buffer Alternative 3). [Page 6]
- **Table 8D-5.** Width of buffers needed to protect Category III wetlands in eastern Washington (Buffer Alternative 3). [Page 6]
- **Table 8D-6**. Width of buffers needed to protect Category II wetlands in eastern Washington (Buffer Alternative 3). [Page 7]
- **Table 8D-7.** Width of buffers needed to protect Category I wetlands in eastern Washington (Buffer Alternative 3). [Page 8]
- **Table 8D-8.** Examples of measures to minimize impacts to wetlands from different types of activities. [Page 10]

- **Table 8D-9.** Comparison of recommended buffer widths for high intensity land uses between Alternative 3 (step-wise scale) and Alternative 3A (graduated scale) based on score for habitat functions [Page 14].
- **Table 8D-10.** Comparison of recommended widths for buffers between Alternative 3 and Alternative 3A for proposed land uses with high impacts with mitigation for impacts. [Page 15]
- **Table 8D-11.** Mitigation ratios for projects in eastern Washington. [Page 21]

The guidance in this appendix can be used in developing regulations such as critical areas ordinances for protecting and managing the functions and values of wetlands. The recommendations are based on the analysis of the current scientific literature found in Volume 1. The detailed rationale for the recommendations is provided in Appendices 8-E and 8-F.

The recommendations on buffer widths and mitigation ratios are general, and there may be some wetlands for which these recommendations are either too restrictive or not protective enough. The recommendations are based on the assumption that a wetland will be protected only at the scale of the site itself. They do not reflect buffers and ratios that might result from regulations that are developed based on a larger landscape-scale approach.

8D.2 Widths of Buffers

Requiring buffers of a specific width has been one of the primary methods by which local jurisdictions in Washington have protected the functions and values of wetlands. Generally, buffers are the uplands adjacent to an aquatic resource that can, through various physical, chemical, and biological processes, reduce impacts to wetlands from adjacent land uses. The physical characteristics of buffers (e.g., slope, soils, vegetation, and width) determine how well buffers reduce the adverse impacts of human development. These characteristics are discussed in detail in Chapter 5, Volume 1.

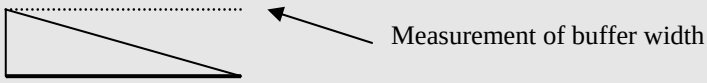
In addition to reducing the impacts of adjacent land uses, buffers also protect and maintain a wide variety of functions and values provided by wetlands. For example, buffers can provide the terrestrial habitats needed by many species of wildlife that use wetlands to meet some of their needs.

The review of the scientific literature has shown, however, that buffers alone cannot adequately protect all functions that a wetland performs. Additional guidance is, therefore, provided on other ways in which wetlands can be managed and regulated to provide some of the necessary protection that buffers alone do not provide. The following guidance for protecting the functions and values of wetlands is based on their category as determined through the rating system for eastern Washington.

Basic assumptions for using the guidance on widths for buffers

Recommendations for widths of buffers assume that:

- The wetland has been categorized using the *Washington State Wetland Rating System for Eastern Washington-Revised* (Hruby 2004a).
- The buffer is vegetated with native plant communities that are appropriate for the *ecoregion* or with a plant community that provides similar functions. Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. The U.S. Environmental Protection Agency maintains updated maps of ecoregions that are available at http://www.epa.gov/naaujydh/pages/models/ecoregions.htm . Ecoregions currently mapped for Washington are: Coast Range, Puget Lowland, Cascades, Eastern Cascades Slopes and Foothills, North Cascades, Columbia Plateau, Blue Mountains, and Northern Rockies.
- If the vegetation in the buffer is disturbed (grazed, mowed, etc.), proponents planning changes to land use that will increase impacts to wetlands need to rehabilitate the buffer with native plant communities that are appropriate for the ecoregion, or with a plant community that provides similar functions.
- The width of the buffer is measured in horizontal distance (see drawing below).



- The buffer will remain relatively undisturbed in the future within the width specified.

Three alternatives for protecting the functions of wetlands using buffers are described in the following sections:

- **Buffer Alternative 1.** Width based only on wetland category.
- **Buffer Alternative 2**. Width based on wetland category and the intensity of impacts from proposed changes in land use.
- **Buffer Alternative 3.** Width based on wetland category, intensity of impacts, and wetland functions or special characteristics. This alternative has two options for determining the widths of buffers when they are based on the score for habitat. Alternative 3 provides three buffer widths based on habitat scores, while Alternative 3A provides a graduated scale of widths for buffers based on habitat scores.

The buffer widths recommended for each alternative were based on the review of scientific information in Volume 1. The guidance in this appendix synthesizes the information about the types and sizes of buffers needed to protect the functions and special characteristics of wetlands.

Appendices 8-C and 8-D do not provide the metric equivalents for buffer widths even though most of the research on buffers uses the metric scale. This decision was made because most local governments use the English Standard measures. For example, a buffer width is set at 50 feet rather than 15 meters.

8D.2.1 Buffer Alternative 1: Width Based Only on Wetland Category

This alternative, in which the width of buffers is based only on the category of the wetland, is the simplest (Table 8D-1). The width recommended for each category of wetland in Alternative 1 is the widest recommended for that category in both Alternatives 2 and 3 (discussed below). Alternative 1 provides the least flexibility because many different types of wetlands and types of human impacts are combined. For example, not all wetlands that fall into Category I or II need a 300-foot buffer. If no distinctions are made between the wetlands that fall into Category I or II, all wetlands that fall into these categories have to be protected with a 300-foot buffer so adequate protection is provided for those wetlands that do need a buffer this wide. Also, the widths recommended for this alternative are those needed to protect the wetland from proposed land uses that have the greatest impacts since no distinctions between impacts are made.

Table 8D-1. Width of buffers needed to protect wetlands in eastern Washington if impacts from land use and wetland functions are NOT incorporated (Buffer Alternative 1).

Category of Wetland	Widths of Buffers
IV	50 ft
III	150 ft
II	200 ft
I	250 ft

8D.2.2 Buffer Alternative 2: Width Based on Wetland Category and Modified by the Intensity of the Impacts from Proposed Land Use

The second alternative increases the regulatory flexibility by including the concept that not all proposed changes in land uses have the same level of impact (Table 8D-2). For example, one new residence being built on 5 acres of land near a wetland is expected to have a smaller impact than 20 houses built on the same 5 acres. Three categories of impacts from proposed land uses are outlined: land uses that can create high impacts, moderate impacts, and low impacts to wetlands. Different land uses that can cause these levels of impacts are listed in Table 8D-3.

Table 8D-2. Width of buffers needed to protect wetlands in eastern Washington considering impacts of proposed land uses (Buffer Alternative 2).

Category of Wetland	Land Use with Low Impact *	Land Use with Moderate Impact *	Land Use with High Impact*
IV	25 ft	40 ft	50 ft
III	75 ft	110 ft	150 ft
II	100 ft	150 ft	200 ft
I	125 ft	190 ft	250 ft
* See Table 8D-3 in this appendix for types of land uses that can result in low, moderate, and high impacts to wetlands.			

Table 8D-3. Types of proposed land use that can result in high, moderate, and low levels of impacts to adjacent wetlands.

Level of Impact from Proposed Change in Land Use	Types of Land Use Based on Common Zoning Designations *
High	• Commercial • Urban • Industrial • Institutional • Retail sales • Residential (more than 1 unit/acre) • Conversion to high-intensity agriculture (dairies, nurseries, greenhouses, growing and harvesting crops requiring annual tilling and raising and maintaining animals, etc.) • High-intensity recreation (golf courses, ball fields, etc.) • Hobby farms
Moderate	• Residential (1 unit/acre or less) • Moderate-intensity open space (parks with biking, jogging, etc.) • Conversion to moderate-intensity agriculture (orchards, hay fields, etc.) • Paved trails • Building of logging roads • Utility corridor or right-of-way shared by several utilities and including access/maintenance road
Low	• Forestry (cutting of trees only) • Low-intensity open space (hiking, bird-watching, preservation of natural resources, etc.) • Unpaved trails • Utility corridor without a maintenance road and little or no vegetation management.
* Local governments are encouraged to land-use designations for zoning that are consistent with these examples.	

8D.2.3 Buffer Alternative 3: Width Based on Wetland Category, Intensity of Impacts, Wetland Functions, or Special Characteristics

The third alternative provides the most flexibility by basing the widths of buffers on three factors: the wetland category, the intensity of the impacts (as used in Alternative 2), and the functions or special characteristics of the wetland that need to be protected as determined through the rating system. The recommended widths for buffers are shown in Tables 8D-4 to 8D-7. Using this alternative, a wetland may fall into more than one category in the table. For example, a forested, riparian, wetland may be rated a Category II wetland because it is a riparian forest, but it may be rated a Category I wetland based on its score for functions.

If a wetland meets more than one of the characteristics listed in Tables 8D-4 to 8D-7, the buffer recommended to protect the wetland is the widest one. For example, if a Category I wetland (Table 8D-7) scores 32 points for habitat and 27 points for water quality functions, a 200-foot buffer is needed for land uses with high impacts because the widths needed to protect habitat are wider than those needed for the other functions.

Table 8D-4. Width of buffers needed to protect Category IV wetlands in eastern Washington (Buffer Alternative 3 for wetlands scoring less than 30 points for all functions).

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use	Other Measures Recommended for Protection
Score for all 3 basic functions is less than 30 points	Low - 25 ft Moderate – 40 ft High – 50 ft	No recommendations at this time[1]

Table 8D-5. Width of buffers needed to protect Category III wetlands in eastern Washington (Buffer Alternative 3 for wetlands scoring 30 – 50 points for all functions or isolated vernal pools).

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use	Other Measures Recommended for Protection
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[1]
Not meeting above characteristic	Low - 40 ft Moderate – 60 ft High – 80 ft	No recommendations at this time[1]

[1] No information on other measures for protection was available at the time this document was written. The Washington State Department of Ecology will continue to collect new information for future updates to this document.

Table 8D-6. Width of buffers needed to protect Category II wetlands in eastern Washington (Buffer Alternative 3 for wetlands scoring 51-69 points for all functions or having the "Special Characteristics" identified in the rating system).

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use (apply most protective if more than one criterion is met)	Other Measures Recommended for Protection
High level of function for habitat (score for habitat 29 - 36 points)	Low - 100 ft Moderate – 150 ft High – 200 ft	Maintain connections to other habitat areas
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low - 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[2]
High level of function for water quality improvement and low for habitat (score for water quality 24 - 32 points; habitat less than 20 points)	Low - 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Vernal pool	Low - 100 ft Moderate – 150 ft High – 200 ft OR Develop a regional plan to protect the most important vernal pool complexes – buffers of vernal pools outside protection zones can then be reduced to: Low - 40 ft Moderate – 60 ft High – 80 ft	No intensive grazing or tilling in the wetland
Riparian forest	Buffer width to be based on score for habitat functions or water quality functions	Riparian forest wetlands need to be protected at a watershed or sub-basin scale (protection of the water regime in the watershed) Other protection based on needs to protect habitat and/or water quality functions
Not meeting above characteristics	Low - 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time[2]

[2] See footnote on the previous page.

Table 8D-7. Width of buffers needed to protect Category I wetlands in eastern Washington (Buffer Alternative 3 for wetlands scoring 70 points or more for all functions or having the "Special Characteristics" identified in the rating system).

Wetland Characteristics	Buffer Widths by Impact of Proposed Land Use (apply most protective if more than one criterion is met)	Other Measures Recommended for Protection
Natural Heritage Wetlands	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries No septic systems within 300 ft Restore degraded parts of buffer
Bogs	Low - 125 ft Moderate – 190 ft High – 250 ft	No additional surface discharges to wetland or its tributaries Restore degraded parts of buffer
Forested	Buffer size to be based on score for habitat functions or water quality functions	If forested wetland scores high for habitat, need to maintain connectivity to other natural areas Restore degraded parts of buffer
Alkali	Low – 100 ft Moderate – 150 ft High – 200 ft	No additional surface discharges to wetland or its tributaries Restore degraded parts of buffer
High level of function for habitat (score for habitat 29 - 36 points)	Low – 100 ft Moderate – 150 ft High – 200 ft	Maintain connections to other habitat areas Restore degraded parts of buffer
Moderate level of function for habitat (score for habitat 20 - 28 points)	Low – 75 ft Moderate – 110 ft High – 150 ft	No recommendations at this time[3]
High level of function for water quality improvement (24 – 32 points) and low for habitat (less than 20 points)	Low – 50 ft Moderate – 75 ft High – 100 ft	No additional surface discharges of untreated runoff
Not meeting any of the above characteristics	Low – 50 ft Moderate – 75 ft High – 100 ft	No recommendations at this time[3]

[3] See footnote on page 6.

8D.2.4 Special Conditions for a Possible Reduction in Buffer Widths

8D.2.4.1 Condition 1: Reduction in Buffer Width Based on Reducing the Intensity of Impacts from Proposed Land Uses

The buffer widths recommended for proposed land uses with high-intensity impacts to wetlands can be reduced to those recommended for moderate-intensity impacts under the following conditions:

- For wetlands that score moderate or high for habitat (20 points or more for the habitat functions), the width of the buffer can be reduced if both of the following criteria are met:

  1) A relatively undisturbed, vegetated corridor at least 100 feet wide is protected between the wetland and any other Priority Habitats as defined by the Washington State Department of Fish and Wildlife ("relatively undisturbed" and "vegetated corridor" are defined in questions H 2.1 and H 2.2.1 of the *Washington State Wetland Rating System for Eastern Washington – Revised* (Hruby 2004a)). Priority Habitats in eastern Washington include:

     - Wetlands
     - Riparian zones
     - Aspen stands
     - Cliffs
     - Prairies
     - Caves
     - Stands of Oregon White Oak
     - Old growth forests
     - Talus slopes
     - Urban natural open space (for current definitions of Priority Habitats see http://wdfw.wa.gov/hab/phshabs.htm)

     The corridor must be protected for the entire distance between the wetland and the Priority Habitat by some type of legal protection such as a conservation easement.

  2) Measures to minimize the impacts of different land uses on wetlands, such as the examples summarized in Table 8D-8, are applied.

- For wetlands that score less than 20 points for habitat, the buffer width can be reduced to that required for moderate land-use impacts by applying measures to minimize the impacts of the proposed land uses (see examples in Table 8D-8).

Table 8D-8. Examples of measures to minimize impacts to wetlands from proposed change in land use that have high impacts. (This is not a complete list of measures.)

Examples of Disturbance	Activities and Uses that Cause Disturbances	Examples of Measures to Minimize Impacts
Lights	• Parking lots • Warehouses • Manufacturing • Residential	• Direct lights away from wetland
Noise	• Manufacturing • Residential	• Locate activity that generates noise away from wetland
Toxic runoff*	• Parking lots • Roads • Manufacturing • Residential areas • Application of agricultural pesticides • Landscaping	• Route all new, untreated runoff away from wetland while ensuring wetland is not dewatered • Establish covenants limiting use of pesticides within 150 ft of wetland • Apply integrated pest management
Stormwater runoff	• Parking lots • Roads • Manufacturing • Residential areas • Commercial • Landscaping	• Retrofit stormwater detention and treatment for roads and existing adjacent development • Prevent channelized flow from lawns that directly enters the buffer
Change in water regime	• Impermeable surfaces • Lawns • Tilling	• Infiltrate or treat, detain, and disperse into buffer new runoff from impervious surfaces and new lawns
Pets and human disturbance	• Residential areas	• Use privacy fencing; plant dense vegetation to delineate buffer edge and to discourage disturbance using vegetation appropriate for the ecoregion; place wetland and its buffer in a separate tract
Dust	• Tilled fields	• Use best management practices to control dust
* These examples are not necessarily adequate for minimizing toxic runoff if threatened or endangered species are present at the site.		

8D.2.4.2 Condition 2: Reductions in Buffer Widths Where Existing Roads or Structures Lie Within the Buffer

Where a legally established, non-conforming use of the buffer exists (such as a road or structure that lies within the width of buffer recommended for that wetland), proposed actions in the buffer may be permitted as long as they do not increase the degree of non-conformity. This means no increase in the impacts to the wetland from activities in the buffer.

For example, if a land use with high impacts (e.g., building an urban road) is being proposed next to a Category II wetland with a moderate level of function for habitat, a 150-foot buffer would be needed to protect functions (see Table 8D-6). If, however, an existing urban road is already present and only 50 feet from the edge of the Category II wetland, the additional 100 feet of buffer may not be needed if the road is being widened. A vegetated buffer on the other side of the road would not help buffer the existing impacts to the wetland from the road. If the existing road is resurfaced or widened (e.g., to add a sidewalk) along the upland edge, without any further roadside development that would increase the degree of non-conformity, the additional buffer is not necessary. The associated increase in impervious surface from widening a road, however, may necessitate mitigation for impacts from stormwater.

If, however, the proposal is to build a new development (e.g., shopping center) along the upland side of the road, the impacts to the wetland and its functions may increase. This would increase the degree of non-conformity. The project proponent would need to provide the additional 100 feet of buffer extending beyond the road or apply buffer averaging (see Section 8D.1.6).

8D.2.4.3 Condition 3: Reduction in Buffer Widths Through an Individual Rural Stewardship Plan

A Rural Stewardship Plan (RSP) is the product of a collaborative effort between rural property owners and a local government to tailor a management plan specific for a rural parcel of land. The goal of a RSP is better management of wetlands than would be achieved through strict adherence to regulations. In exchange, the landowner gains flexibility in the widths of buffers required, in clearing limits, and in other requirements found in the regulations. For example, dense development in rural residential areas can be treated as having a low level of impact when the development of the site is managed through a locally approved RSP. The voluntary agreement includes provisions for restoration, maintenance, and long-term monitoring and specifies the widths of buffers needed to protect each wetland within the RSP.

8D.2.5 Conditions for Increasing the Width of, or Enhancing, the Buffer

8D.2.5.1 Condition 1: Buffer is Not Vegetated with Plants Appropriate for the Region

The recommended widths for buffers are based on the assumption that the buffer is vegetated with a native plant community appropriate for the ecoregion or with one that performs similar functions. If the existing buffer is unvegetated, sparsely vegetated, or vegetated with invasive species that do not perform needed functions, the buffer should either be planted to create the appropriate plant community or the buffer should be widened to ensure that adequate functions of the buffer are provided. Generally, improving the vegetation will be more effective than widening the buffer.

8D.2.5.2 Condition 2: Buffer Has a Steep Slope

The review of the literature (Volume 1) indicates that the effectiveness of buffers at removing pollutants before they enter a wetland decreases as the slope increases. If a buffer is to be based on the score for its ability to improve water quality (see Tables 8D-4 through 8D-7) rather than habitat or other criteria, then the buffer should be increased by 50% if the slope is greater than 30% (a 3-foot rise for every 10 feet of horizontal distance).

8D.2.5.3 Condition 3: Buffer Is Used by Species Sensitive to Disturbance

If the wetland provides habitat for a species that is particularly sensitive to disturbance (such as a threatened or endangered species), the width of the buffer should be increased to provide adequate protection for the species based on its particular, life-history needs. Some buffer requirements for priority species are available on the Washington State Department of Fish and Wildlife web page (http://wdfw.wa.gov/hab/phsrecs.htm). The list of priority species for vertebrates is at http://wdfw.wa.gov/hab/phsvert.htm; for invertebrates it is at http://wdfw.wa.gov/hab/phsinvrt.htm. Information on the buffer widths needed by some threatened, endangered, and sensitive species of wildlife is provided in Appendix 8-H.

8D.2.6 Buffer Averaging

The widths of buffers may be averaged if this will improve the protection of wetland functions, or if it is the only way to allow for reasonable use of a parcel. There is no scientific information available to determine if averaging the widths of buffers actually protects functions of wetlands. The authors have concluded that averaging could be allowed in the following situations:

Averaging may not be used in conjunction with any of the other provisions for reductions in buffers listed above (listed above).

- Averaging to **improve wetland protection** may be permitted when **all** of the following conditions are met:
  - The wetland has significant differences in characteristics that affect its habitat functions, such as a wetland with a forested component adjacent to a degraded emergent component or a "dual-rated" wetland with a Category I area adjacent to a lower rated area
  - The buffer is increased adjacent to the higher-functioning area of habitat or more sensitive portion of the wetland and decreased adjacent to the lower-functioning or less sensitive portion
  - The total area of the buffer after averaging is equal to the area required without averaging
  - The buffer at its narrowest point is never less than 3/4 of the required width
- Averaging to **allow reasonable use** of a parcel may be permitted when **all** of the following are met:
  - There are no feasible alternatives to the site design that could be accomplished without buffer averaging
  - The averaged buffer will not result in degradation of the wetland's functions and values as demonstrated by a report from a qualified wetland expert (see Appendix 8-G for a definition of a qualified wetland expert)
  - The total buffer area after averaging is equal to the area required without averaging
  - The buffer at its narrowest point is never less than 3/4 of the required width

8D.2.7 Modifying Buffer Widths in Alternative 3 Using a Graduated Scale for the Habitat Functions (Alternative 3A)

Alternative 3 contains recommendations for protecting the habitat functions of wetlands using only three groupings of scores (0-19, 20-28, 29-36). As a result, a one-point difference between 28 and 29 can result in a 150-foot increase in the width of a buffer around a wetland. The habitat scores were divided into three groups to simplify the regulations based on this guidance. This division is not based on a characterization of risks since the scientific information indicates that the decrease in risk with increasing widths of buffers is relatively continuous for habitat functions.

Such a large increase in width with a one-point increase in the habitat score may be contentious. A jurisdiction may wish to reduce the increments in the widths for buffers by developing a more graduated (but inherently more complicated) scale based on the scores for habitat. Table 8D-9 provides one example of a graduated scale for widths of buffers where the width increases by 10 feet for every one-point increase in the habitat score. (Figure 8D-1 shows the buffer widths graphically.)

Table 8D-9. Comparison of widths for buffers in Alternatives 3 (step-wise scale) and 3A (graduated scale) for proposed land uses with high impacts based on the score for habitat functions in eastern Washington.

Points for Habitat from Wetland Rating Form	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Alternative 3	100	150	150	150	150	150	150	150	150	150	200	200	200	200	200	200	200	200
Alternative 3A	100	100	100	110	120	130	140	150	160	170	180	190	200	200	200	200	200	200

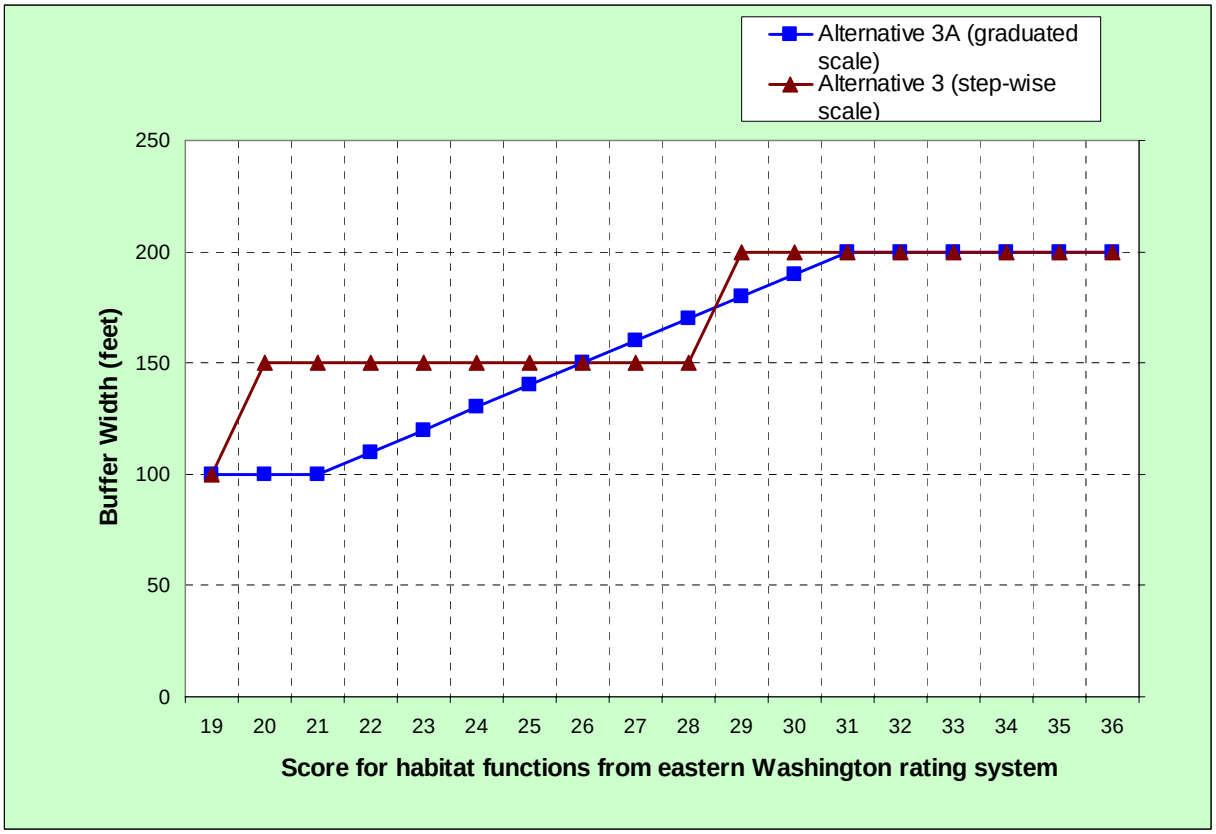


Figure 8D-1. Graphical comparison of widths for buffers in Alternative 3 and 3A for proposed land uses with high impacts based on the score for habitat functions in eastern Washington.

Other scales are possible as long as they keep within the limits established from the scientific information currently available: wetlands with scores for habitat that are higher than 31 points need buffers that are at least 200-feet wide; wetlands with a score of 26 points need buffers of at least 150 feet; and wetlands with a score of 22 points need buffers that are at least 100-feet wide.

These buffer widths can be further reduced by 25 percent if a proposed project with high impacts implements mitigation measures such as those described in Table 8D-8. The measures are part of "Condition 1" in Section 8D.1.4 (Special Conditions for a Possible Reduction in Buffer Widths). The buffer widths under Buffer Alternatives 3 and 3A, and the corresponding 25 percent reduction (per buffer reduction condition 1) are shown in Table 8C-10 and represented graphically below in Figure 8D-2.

Table 8D-10. Comparison of widths for buffers in Alternatives 3 (step-wise scale) and 3A (graduated scale) for proposed land uses with high impacts based on the score for habitat functions in eastern Washington if the impacts are mitigated.

Points for Habitat from Wetland Rating Form	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**
Alternative 3 (**with** mitigation of impacts)	75	110	110	110	110	110	110	110	110	110	150	150	150	150	150	150	150	150
Alternative 3A (**with** mitigation of impacts)	75	75	75	83	90	98	105	113	20	128	135	143	150	150	150	150	150	150

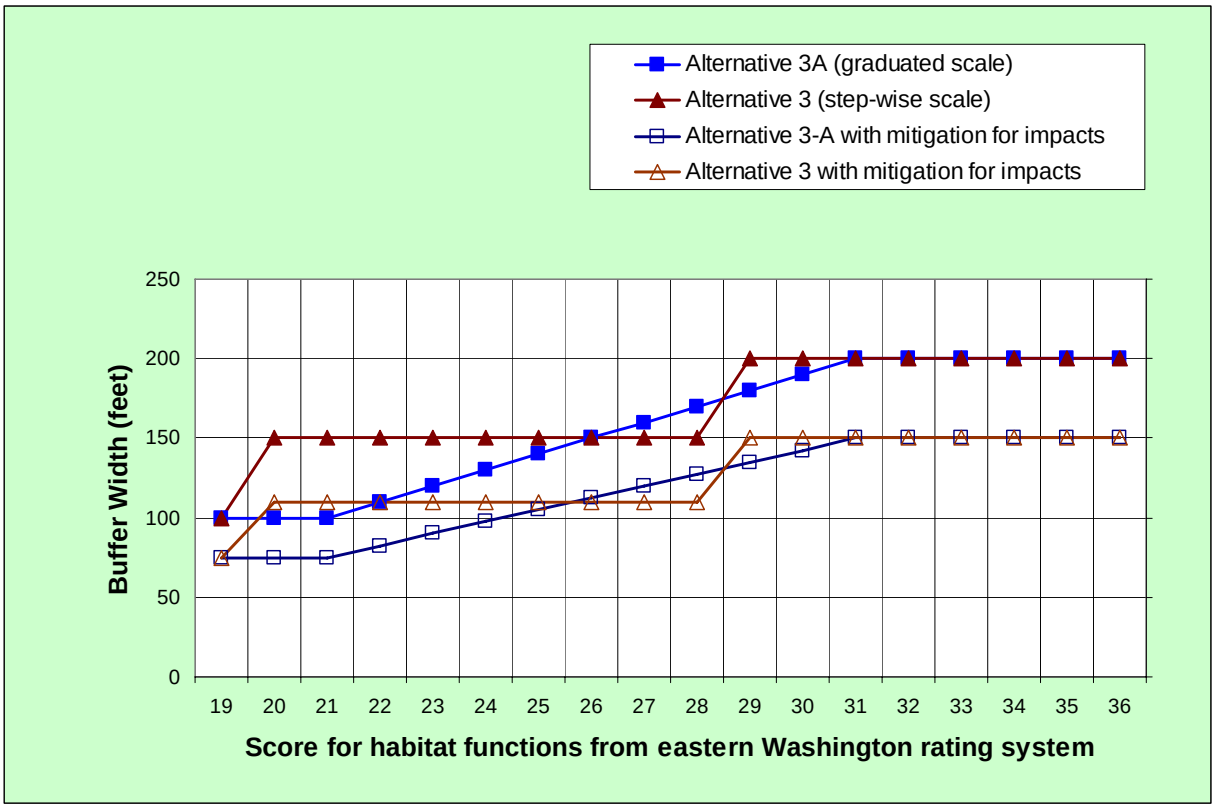


Figure 8D-2. Graphical comparison of widths for buffers in Alternatives 3 and 3A based on the score for habitat functions in eastern Washington with and without mitigating impacts of proposed development outside the buffer.

Alternatives 3 and 3A represent two separate approaches for determining widths of buffers for wetlands scoring between 20 and 31 points for the habitat functions. Local governments should select one of the two approaches and should not hybridize the approaches or adopt both at the same time.

8D.3 Ratios for Compensatory Mitigation

When the acreage required for compensatory mitigation is divided by the acreage of impact, the result is a number known variously as a *replacement*, compensation, or *mitigation* ratio. Compensatory mitigation ratios are used to help ensure that compensatory mitigation actions are adequate to offset unavoidable wetland impacts by requiring a greater amount of mitigation area than the area of impact. Requiring greater mitigation area helps compensate for the risk that a mitigation action will fail and for the time lag that occurs between the wetland impact and achieving a fully functioning mitigation site.

8D.3.1 Definitions of Types of Compensatory Mitigation

The ratios presented are based on the type of compensatory mitigation proposed (e.g., restoration, creation, and enhancement). In its *Regulatory Guidance Letter 02-02*, the U.S. Army Corps of Engineers provided definitions for these types of compensatory mitigation. For consistency, the authors of this document use the same definitions which are provided below.

Restoration: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a former or degraded wetland. For the purpose of tracking net gains in wetland acres, restoration is divided into:

- **Re-establishment**: The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural or historic functions to a **former** wetland. Re-establishment results in a gain in wetland acres (and functions). Activities could include removing fill material, plugging ditches, or breaking drain tiles.
- **Rehabilitation:** The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural or historic functions of a **degraded** wetland. Rehabilitation results in a gain in wetland function but does not result in a gain in wetland acres. Activities could involve breaching a dike to reconnect wetlands to a floodplain or return tidal influence to a wetland.

Creation (Establishment): The manipulation of the physical, chemical, or biological characteristics present to develop a wetland on an upland or deepwater site where a wetland did not previously exist. Establishment results in a gain in wetland acres. Activities typically involve excavation of upland soils to elevations that will produce a wetland hydroperiod, create hydric soils, and support the growth of hydrophytic plant species.

Enhancement: The manipulation of the physical, chemical, or biological characteristics of a wetland site to heighten, intensify, or improve specific function(s) or to change the growth stage or composition of the vegetation present. Enhancement is undertaken for specified purposes such as water quality improvement, flood water retention, or wildlife habitat. Enhancement results in a change in some wetland functions and can lead to a

decline in other wetland functions, but does not result in a gain in wetland acres. Activities typically consist of planting vegetation, controlling non-native or invasive species, modifying site elevations or the proportion of open water to influence hydroperiods, or some combination of these activities.

Protection/Maintenance (Preservation): Removing a threat to, or preventing the decline of, wetland conditions by an action in or near a wetland. This includes the purchase of land or easements, repairing water control structures or fences, or structural protection such as repairing a barrier island. This term also includes activities commonly associated with the term *preservation.* Preservation does not result in a gain of wetland acres, may result in a gain in functions, and will be used only in exceptional circumstances.

Distinction between rehabilitation and enhancement

The distinction between rehabilitation and enhancement as defined above is not clear-cut and can be hard to understand. Actions that rehabilitate or enhance wetlands span a continuum of activities that cannot be defined by specific criteria.

Rehabilitation ⟷ *Enhancement*

In general, rehabilitation involves actions that are more sustainable and that reinstate environmental processes, both at the site and landscape scale (e.g., reinstating hydrologic processes in a diked floodplain by breaching the dikes). Rehabilitation actions often focus on restoring environmental processes that have been disturbed or altered by previous or ongoing human activity. Ecology further defines *rehabilitation* as:

- Actions that restore the original hydrogeomorphic (HGM) class, or subclass, to a wetland whose current HGM class, or subclass, has been changed by human activities
- Actions that restore the water regime that was present and maintained the wetland before human activities changed it

Any other actions taken in existing wetlands would be considered *enhancement.* Enhancement typically involves actions that provide gains in only one or a few functions and can lead to a decline in other functions. Enhancement actions often focus on structural or superficial improvements to a site and generally do not address larger-scale environmental processes.

For example, a wetland that was once a forested, riverine wetland was changed to a depressional, emergent wetland by the construction of a dike and through grazing. Rehabilitating the wetland would involve breaching the dike so the wetland becomes a riverine wetland again, discontinuing the grazing, and reforesting the area. Discontinuing the grazing and reforesting the wetland without re-establishing the links to the riverine system would be considered enhancement.

Basic assumptions for using the guidance on ratios

- The ratios are for a compensatory mitigation project that is concurrent with impacts to wetlands. If impacts are to be mitigated by using an approved and established mitigation bank, the rules and ratios applicable to the bank should be used.
- The ratios are based on the assumption that the category (based on the rating system for eastern Washington) and hydrogeomorphic (HGM) class or subclass of the wetland proposed as compensation are the same as the category and HGM class or subclass of the affected wetland (e.g., impacts to a Category II, riverine wetland are compensated by creating, restoring, or enhancing a Category II riverine wetland).
- Ratios for projects in which the category and HGM class or subclass of wetlands proposed as compensation is not the same as that of the wetland affected will be determined on a case-by-case basis using the recommended ratios as a starting point. The ratios could be higher in such cases.
- The ratio for using rehabilitation as compensation is 2 times that for using re-establishment or creation (R/C) (2 acres of rehabilitation are equivalent to 1 acre of R/C). The ratio for using enhancement as compensation is 4 times that for using R/C (4 acres of enhancement are equivalent to 1 acre of R/C).
- Re-establishment or creation can be used in combination with rehabilitation or enhancement. For example, 1 acre of impact to a Category III wetland would require 2 acres of R/C. If an applicant provides 1 acre of R/C (i.e., replacing the lost acreage at a 1:1 ratio), the remaining 1 acre of R/C necessary to compensate for the impact could be substituted with 2 acres of rehabilitation or 4 acres of enhancement.
- Generally the use of enhancement alone as compensation is discouraged. Using enhancement in combination with the replacement of wetland area at a minimum of 1:1 through re-establishment or creation is preferred.

These ratios were developed to provide a starting point for further discussions with each proponent of compensatory mitigation. They are based on the observations of the success and risk of compensatory mitigation, as reviewed in Volume 1, and do not represent the specific risk or opportunities of any individual project.

As noted above, the ratios for compensatory mitigation are based on the assumption that the category and hydrogeomorphic (HGM) class or subclass of the affected wetland and the mitigation wetland are the same. The ratios may be adjusted either up or down if the category or HGM class or subclass of the wetland proposed for compensation is different. For example, ratios may be lower if impacts to a Category IV wetland are to be mitigated by creating a Category II wetland. The same is true for impacts to wetlands that currently would be considered *atypical* (see definition below).

Also, compensatory mitigation should not result in the creation, restoration, or enhancement of an atypical wetland. An atypical wetland is defined as a wetland whose design does not match the type of wetland that would be found in the geomorphic setting

of the proposed site (i.e., the water source(s) and hydroperiod proposed for the mitigation site are not typical for the geomorphic setting). In addition, any designs that provide exaggerated morphology or require a berm or other engineered structures to hold back water would be considered atypical. For example, excavating a permanently inundated pond in an existing seasonally saturated or inundated wetland is one example of an enhancement project that could result in an atypical wetland. Another example would be excavating depressions in an existing wetland on a slope that required the construction of berms to impound water.

On a case-by-case basis, it is possible to use the scores from the Washington State wetland rating system to compare functions between the mitigation wetland and the impacted wetland. This information may also be used to adjust replacement ratios. Scores from the methods for assessing wetland functions (Hruby et al. 1999) provide another option to establish whether the functions lost will be replaced if both the affected wetland and the wetland used for compensation are of the same HGM class and subclass.

Mitigation ratios for projects in eastern Washington are shown in Table 8D-11. Refer to the text box on the basic assumptions on the previous page before reading the table. As mentioned previously, these ratios were developed to provide a starting point for further discussions with each proponent of compensatory mitigation. They only factor in the observations of mitigation success and risk at a programmatic level, and do not represent the specific risk or opportunity of any individual project.

Table 8D-11: Mitigation ratios for projects in eastern Washington.

Category and Type of Wetland Impacts	Re-establishment or Creation	Rehabilitation Only[4]	Re-establishment or Creation (R/C) and Rehabilitation (RH) [4]	Re-establishment or Creation (R/C) and Enhancement (E)[4]	Enhancement Only[4]
All Category IV	1.5:1	3:1	1:1 R/C and 1:1 RH	1:1 R/C and 2:1 E	6:1
All Category III	2:1	4:1	1:1 R/C and 2:1 RH	1:1 R/C and 4:1 E	8:1
Category II Forested	4:1	8:1	1:1 R/C and 4:1 RH	1:1 R/C and 6:1 E	16:1
Category II Vernal pool	2:1 Replacement has to be seasonally ponded wetland	4:1 Replacement has to be seasonally ponded wetland	1:1 R/C and 2:1 RH	Case-by-case	Case-by-case
All other Category II	3:1	6:1	1:1 R/C and 4:1 RH	1:1 R/C and 8:1 E	12:1
Category I Forested	6:1	12:1	1:1 R/C and 10:1 RH	1:1 R/C and 20:1 E	24:1
Category I based on score for functions	4:1	8:1	1:1 R/C and 6:1 RH	1:1 R/C and 12:1 E	16:1
Category I Natural Heritage site	Not considered possible[5]	6:1 Rehabilitation of a Natural Heritage site	R/C Not considered possible[5]	R/C Not considered possible[5]	Case-by-case
Category I Alkali	Not considered possible[5]	6:1 rehabilitation of an alkali wetland	R/C Not considered possible[5]	R/C Not considered possible[5]	Case-by-case
Category I Bog	Not considered possible[5]	6:1 Rehabilitation of a bog	R/C Not considered possible[5]	R/C Not considered possible[5]	Case-by-case
NOTE: Preservation is discussed in the following section.					

[4] These ratios are based on the assumption that the rehabilitation or enhancement actions implemented represent the average degree of improvement possible for the site. Proposals to implement more effective rehabilitation or enhancement actions may result in a lower ratio, while less effective actions may result in a higher ratio. The distinction between rehabilitation and enhancement is not clear-cut. Instead, rehabilitation and enhancement actions span a continuum. Proposals that fall within the gray area between rehabilitation and enhancement will result in a ratio that lies between the ratios for rehabilitation and the ratios for enhancement.

[5] Natural Heritage sites, alkali wetland, and bogs are considered irreplaceable wetlands because they perform some special functions that cannot be replaced through compensatory mitigation. Impacts to such wetlands would therefore result in a net loss of some functions no matter what kind of compensation is proposed.

8D.3.2 Conditions for Increasing or Reducing Replacement Ratios

Increases in replacement ratios are appropriate under the following circumstances:

- Success of the proposed restoration or creation is uncertain
- A long time will elapse between impact and establishment of wetland functions at the mitigation site
- Proposed mitigation will result in a lower category wetland or reduced functions relative to the wetland being impacted
- The impact was unauthorized

Reductions in replacement ratios are appropriate under the following circumstances:

- Documentation by a qualified wetland specialist (see Appendix 8-H) demonstrates that the proposed mitigation actions have a very high likelihood of success based on prior experience
- Documentation by a qualified wetland specialist demonstrates that the proposed actions for compensation will provide functions and values that are significantly greater than the wetland being affected
- The proposed actions for compensation are conducted in advance of the impact and are shown to be successful
- In wetlands where several HGM classes are found within one delineated boundary, the areas of the wetlands within each HGM class can be scored and rated separately and the ratios adjusted accordingly if **all of the following** apply:
  - The wetland does not meet any of the criteria for wetlands with "Special Characteristics" as defined in the rating system
  - The rating and score for the entire wetland is provided as well as the scores and ratings for each area with a different HGM class
  - Impacts to the wetland are all within an area that has a different HGM class from the one used to establish the initial category
  - The proponents provide adequate hydrologic and geomorphic data to establish that the boundary between HGM classes lies at least 50 feet outside of the footprint of the impacts

8D.3.3 Replacement Ratios for Preservation

In some cases, preservation of existing wetlands may be acceptable as compensation for wetland losses. Acceptable sites for preservation include those that:

- Are important due to their landscape position
- Are rare or limited wetland types
- Provide high levels of functions

Ratios for preservation in combination with other forms of mitigation generally range from 10:1 to 20:1, as determined on a case-by-case basis, depending on the quality of the wetlands being impacted and the quality of the wetlands being preserved. Ratios for preservation as the sole means of mitigation generally start at 20:1. Specific ratios will depend upon the significance of the preservation project and the quality of the wetland resources lost.

Please see Chapter 8 (Section 8.3.7.2) and Appendix 8-B for more information on preservation and the criteria for its use as compensation.

8D.3.4 Replacement Ratios for Temporal Impacts and Conversions

When impacts to wetlands are not permanent, local governments often require some compensation for the temporal loss of wetland functions. *Temporal impacts* refer to impacts to those functions that will eventually be replaced but cannot achieve similar functionality in a short time. For example, clearing forested wetland vegetation for pipeline construction could result in the temporal loss of functions, such as song bird habitat provided by the tree canopy. It may take over 20 years to re-establish the level of function lost as a result of clearing the trees. Although the wetlands will be re-vegetated and over time it is anticipated that their previous level of functioning will be re-established, a temporal loss of functions will occur. There is also some risk of failure associated with the impacts or alterations, especially when soil is compacted by equipment, deep excavation is required, and pipeline trenches alter the water regime at the site.

Therefore, in addition to restoring the affected wetland to its previous condition, local governments should consider requiring compensation to account for the risk and temporal loss of wetland functions. Generally, the ratios for temporal impacts to forested and scrub-shrub wetlands are one-quarter of the recommended ratios for permanent impacts (refer to Table 8D-11), provided that the following measures are satisfied:

- An explanation of how hydric soil, especially deep organic soil, is stored and handled in the areas where the soil profile will be severely disturbed for a fairly significant depth or time

- Surface and groundwater flow patterns are maintained or can be restored immediately following construction
- A 10-year monitoring and maintenance plan is developed and implemented for the restored forest and scrub-shrub wetlands
- Disturbed buffers are re-vegetated and monitored
- Where appropriate, the hydroseed mix to be applied on re-establishment areas is identified

When impacts are to a native emergent community and there is a potential risk that its re-establishment will be unsuccessful, compensation for temporal loss and the risk should be required in addition to restoring the affected wetland and monitoring the site. If the impacts are to wetlands dominated by non-native vegetation (e.g., blackberry, reed canarygrass, or pasture grasses), restoration of the affected wetland with native species and monitoring after construction is generally all that is required.

Loss of functions due to the permanent conversion of wetlands from one type to another also requires compensation. When wetlands are not completely lost but are converted to another type, such as a forested wetland converted to an emergent or shrub wetland (e.g., for a utility right-of-way), some functions are lost or reduced.

The ratios for conversion of wetlands from one type to another will vary based on the degree of the alteration, but they are generally one-half of the recommended ratios for permanent impacts (refer to Table 8D-11).

Refer to Appendix 8-F for the rationale for the ratios provided in this appendix.

Appendix 8-E

Rationale for the Guidance on Recommended Widths of Buffers and Other Methods for Protecting Wetlands

8E.1 Introduction

This appendix provides the rationale for the widths of buffers and other measures recommended to protect and manage wetlands, specifically for Buffer Alternative 3 (Tables 4-7) in Appendices 8-C and 8-D. The rationale is based to a large degree on the synthesis of the scientific literature presented in Volume 1 (Sheldon et al. 2005), which will not be cited further. Other citations are included where they are relevant. The information provided here is also relevant to Alternatives 1 and 2 since these two alternatives are simplified versions of Alternative 3.

The authors recommend that the reader review and fully understand Appendices 8-C and 8-D, and particularly Alternative 3 (Tables 4-7), before reading this appendix. Each table associated with Alternative 3 provides guidance for widths of buffers and other measures for protecting each of the four categories of wetlands as determined by the wetland rating systems for eastern and western Washington (Hruby 2004 a,b). The tables also summarize the characteristics used to determine the recommended width or other measures for protection.

The guidance on wetland buffers is based closely on the scientific literature. This literature clearly recommends that buffers should be based on three primary factors: the type of wetland and the functions and values needing protection, the type of adjacent land use and its expected impacts, and the physical character of the buffer. The recommended buffer widths are based on these factors, and the guidance is based on the following elements that reflect this:

- Using the Washington State wetland rating systems to determine the wetland type and the functions and values needing protection
- Identifying three primary levels of land use based on the severity of potential impacts
- Assuming that the buffer is well vegetated and not on a steep slope

In addition, the guidance assumes that an approach to management that provides a moderate risk is appropriate. Since the scientific literature reports effective buffer widths in ranges, one must select buffer widths from within reported ranges that vary from 25 –

100 feet to protect some wetland functions such as coarse sediment removal, to 100 – 600 feet or more for functions such as wildlife habitat. The widths for buffers have deliberately been selected to fall in the middle of these published ranges. The assumption is that using buffers of these widths will provide a moderate risk to the resource. Using these variable criteria ensures that this guidance will work in a wide range of management settings, including rural, urban, and urbanizing environments.

The widths of buffers are based on the score a wetland receives, including the overall score (i.e., the wetland category), the score for the habitat functions, or the score for the functions that improve water quality. The widths of buffers can also be modified by the presence of special characteristics the wetland may have, as defined in the rating systems (e.g., bogs), as well as the expected impacts of proposed adjacent land uses.

For example, using Alternative 3, two wetlands in western Washington, one rated as a Category I and one as Category II, might both have the same high score (e.g., 31 points) for habitat functions. Both would need to be protected with the same width of buffer (300 feet, 225 feet, or 150 feet depending on the intensity of the impacts of the proposed land uses) because both wetlands have a high level of habitat functions that requires the same protection. If, however, a Category II wetland does not have a high or moderate score for habitat functions or a high score for the functions that improve water quality, it would only require buffers of 100 feet, 75 feet, or 50 feet depending on the proposed land uses.

The widths of buffers required to protect habitat are usually larger than those needed to protect functions that improve water quality. Thus, the highest widths are recommended for wetlands with high scores for habitat.

The score for the hydrologic functions (i.e., flood storage, groundwater recharge, and reducing erosion) is not part of the criteria used to determine buffer widths. The hydrologic functions are not significantly influenced by the width of the buffer. These functions need to be protected at the scale of the watershed or sub-basin in which the wetland is found. Measures to protect the hydrologic functions of wetlands need to be developed from a landscape analysis as described in Chapter 5 of this document.

This appendix is divided into two sections. The first addresses wetlands that provide a high or moderate level of functions for habitat and for improving water quality, and the second addresses wetlands with special characteristics such as bogs and vernal pools.

8E.2 Rationale for Protection Based on the Scores for Functions

8E.2.1 Protection for Wetlands that Provide a High Level of Habitat for Wildlife (Category I and II wetlands with a score of 29 – 36 points for the habitat functions in Tables 6 and 7 of Appendices 8-C and 8-D)

8E.2.1.1 Width of Buffers

In eastern Washington: 200 feet for proposed land uses with high impacts; 150 feet for moderate impacts; 100 feet for low impacts.

In western Washington: 300 feet for proposed land uses with high impacts; 225 feet for moderate impacts; 150 feet for low impacts.

A wetland with a high score for habitat functions (29 - 36 points) has both the physical structures (e.g., vegetation, open water, etc.) and the connections to other wildlife habitats that are necessary for a wide range of species, including birds, mammals and amphibians. This means that the wetland is very likely to be providing habitat for one or more species that needs a larger buffer. Without direct evidence that such species are not using the wetland, one should assume that wildlife species that require a large buffer are using it for habitat.

The review of the literature in Chapter 5 of Volume 1 indicates that the widths of buffers needed to protect wildlife using wetlands range from 100 to 600 feet or more. Most authors who have synthesized the literature on buffers with respect to wildlife habitat recommend buffers of 200 to 300 feet for wetlands that provide good habitat. One synthesis recommended that a buffer adjacent to high-intensity land uses of 200 feet is adequate for protecting most species found in wetlands in eastern Washington and 300 feet in western Washington (Castelle et al. 1992). This difference between eastern and western Washington was based on literature that showed that wildlife species tend to concentrate more around wetlands and streams in arid climates. The specific buffer widths proposed for the different types of land uses fall within the recommendations found in the review of the scientific literature (See Chapter 5 in Volume 1).

Thirteen of the 90 wetlands (14%) used to calibrate the rating system for eastern Washington had scores of 29 or higher for the habitat functions. These were judged to provide the best habitat potential and would require a buffer of 200 feet. Thirteen of the 122 wetlands in western Washington (11%) had scores of 29 or greater and would require a 300-foot buffer.

A 200 or 300-foot buffer alone will not protect the habitat functions of a wetland with a high score for habitat. The connection to other habitat areas also needs to be maintained (see below).

8E.2.1.2 Other Protection Needed for Wetlands that Provide a High Level of Habitat Functions

Maintaining Connections to other Habitat Areas

Wetlands with a high score for habitat functions have the connections to other wildlife habitats that are necessary for a wide range of species. The scientific information summarized in Chapter 3 of Volume 1 points out that fragmentation and disruption of the vegetated corridors between undeveloped areas are a major cause of the loss of species richness (i.e., biodiversity). Existing connections and corridors need to be protected. This can be done by regulating the type and nature of road crossings in the corridor and by limiting changes in land use in the corridor. Such protection is best accomplished through planning based on landscape analysis that identifies critical habitat corridors and protects the mosaic of different ecosystems (see Chapters 5-7 of this Volume).

8E.2.2 Protection for Wetlands that Provide a Moderate Level of Habitat for Wildlife (Category I, II, and III wetlands with a score of 20 - 28 points for the habitat functions in Tables 5, 6, and 7 of Appendices 8-C and 8-D)

8E.2.2.1 Width of Buffers

In both eastern and western Washington: 150 feet for proposed land uses with high impacts; 110 feet for moderate impacts; 75 feet for low impacts.

A wetland with a moderate score for its habitat functions (20 - 28 points out of 36) has some of the physical structures (e.g., vegetation, open water, etc.) and some connections to other wildlife habitats that are necessary for a wide range of species. This means that the wetland is less likely to provide habitat for species that need the largest buffers. On the other hand, wetlands that score in this range do provide habitat for a wide variety of species, some of which, such as waterfowl, still need a relatively large buffer to protect them from disturbance.

8E.2.2.2 Other Protection Needed for Wetlands that Provide a Moderate Level of Habitat Functions

No recommendations are made at this time.

8E.2.3 Wetlands that Provide a High Level of Functions in Improving Water Quality (Category I and II wetlands with a score of 24-32 points for improving water quality in Tables 6 and 7 of Appendices 8-C and 8-D)

8E.2.3.1 Width of Buffers

In both eastern and western Washington: 100 feet for proposed land uses with high impacts; 75 feet for moderate impacts; 50 feet for low impacts.

The functions of water quality improvement within a wetland can be degraded if excess pollutants (e.g., sediments, nutrients, toxic materials) enter the wetland. Buffers of 100 feet are recommended for wetlands that are currently performing these functions well, in order to prevent further degradation. Reviews of data indicate that a buffer of approximately 100 feet will remove 70% or more of the sediment and pollutants from surface runoff before they reach the wetland (Desbonnet et al. 1994). This was judged to be adequate to prevent further degradation even though specific experimental data are lacking to confirm this assumption.

8E.2.3.2 Other Protection Needed to Maintain Functions that Improve Water Quality

No Additional Surface Discharges of Untreated Runoff

Buffers will not adequately protect the water quality improvement functions of wetlands if polluted waters bypass the buffer and enter the wetland via pipes, ditches, or other channels. To protect these functions, it is necessary to limit the introduction of any additional pollutants, from new development or other activities (e.g. lawns, golf courses, etc.), that might enter the wetland through untreated runoff that bypasses the buffer. Changes in land uses adjacent to these wetlands should meet current stormwater detention and treatment requirements, and discharge of stormwater to the buffer diffused through spreaders or other means.

8E.2.4 Category I Wetlands that Do Not Score High Enough for Habitat and Improving Water Quality (Wetlands scoring 70 points or more overall but less than 20 points for habitat functions or less than 24 points for improving water quality in Table 7 of Appendices 8-C and 8-D)

8E.2.4.1 Width of Buffers

In both eastern and western Washington: 100 feet for proposed land uses with high impacts; 75 feet for moderate impacts; 50 feet for low impacts.

It is possible that a wetland could score 70 points or more (Category I) and not score at least 20 points for habitat or 24 points for improving water quality, although none were found in the 212 wetlands used to calibrate the rating system. If a Category I wetland does not meet the criteria for habitat or improving water quality, a standard buffer width of 100 feet for proposed land uses with high impacts is recommended in Alternative 3 as a default. This is based on the assumption that a Category I or II wetland scoring more than 50 points out of 100 will have some functions worth protecting that are not adequately identified using the rating system, especially if buffers are the only protection being provided. A 100-foot buffer provides protection with an overall moderate level of risk to the wetland from any change in land use that generally has a high impact to wetlands.

8E.2.4.2 Other Protection Needed for These Category I Wetlands

No recommendations are made at this time.

8E.2.5 Category II Wetlands that Do Not Score High Enough for Habitat or Improving Water Quality (Wetlands scoring 51-69 points overall but less than 20 points for the habitat functions or less than 24 points for improving water quality in Table 6 of Appendices 8-C and 8-D)

8E.2.5.1 Width of Buffers

In both eastern and western Washington: 100 feet for proposed land uses with high impacts; 75 feet for moderate impacts; 50 feet for low impacts.

If a Category II wetland does not meet the criteria listed for habitat or improving water quality, a standard buffer width of 100 feet for proposed land uses with high impacts is recommended in Alternative 3 as a default. This is based on the assumption that a Category II wetland, scoring more than 50 points out of 100, will have some functions worth protecting that are not adequately identified using the rating system, especially if buffers are the only protection being provided. A 100-foot buffer provides protection with an overall moderate level of risk to the wetland from any proposed land use that has a high impact on wetlands.

8E.2.5.2 Other Protection Needed for These Category II Wetlands

No recommendations are made at this time.

8E.2.6 Category III Wetlands that Do Not Score High Enough for Habitat (Wetlands scoring 30-50 points overall but less than 20 points for habitat functions in Table 5 of Appendices 8-C and 8-D)

8E.2.6.1 Width of Buffers

In both eastern and western Washington: 80 feet for proposed land uses with high impacts; 60 feet for moderate impacts; 40 feet for low impacts

When a Category III wetland does not meet the criteria for habitat, a standard buffer width of 80 feet for proposed land uses with high impacts is recommended in Alternative 3 as a default. This is based on the assumption that a wetland scoring more than 30 points out of 100 will have some functions worth protecting that are not adequately identified using the rating system, especially if buffers are the only protection being provided. Because the overall sensitivity of a Category III wetland is less than that of a Category II or I wetland, the default is set at 80 feet. An 80-foot buffer provides protection with an overall moderate level of risk to the wetland from any change in land use that generally has a high impact to wetlands.

8E.2.6.2 Other Protection Needed for These Category III Wetlands

No recommendations are made at this time.

8E.2.7 Category IV Wetlands (Wetlands scoring less than 30 points overall in Table 4 of Appendices 8-C and 8-D)

8E.2.7.1 Width of Buffers

In both eastern and western Washington: 50 feet for proposed land uses with high impacts; 40 feet for moderate impacts; 25 feet for low impacts.

Category IV wetlands do not meet the criteria listed for habitat or improving water quality so a default of 50 feet for proposed land uses with high impacts is recommended. This is based on the assumption that even low scoring wetlands will need some protection from encroachment, especially if buffers are the only protection being provided. A 50-foot buffer provides protection with an overall moderate level of risk to the wetland from proposed land uses that have a high impact on wetlands.

8E.2.7.2 Other Protection Needed for These Category IV Wetlands

No recommendations are made at this time.

8E.3 Rationale for Wetlands with Special Characteristics in the Rating Systems

The rating systems differentiate between wetlands based on their sensitivity to disturbance, their significance, their rarity, and our ability to replace them in addition to the functions they provide. These characteristics can be considered values that are somewhat independent of the functions provided by a wetland. Because different criteria were used to categorize these wetlands, recommendations for the protection they need has been based on protecting the special characteristics of the wetland, in addition to its functions.

8E.3.1 Natural Heritage Wetlands (Table 7 in Appendices 8-C and 8-D)

8E.3.1.1 Width of Buffers

In both eastern and western Washington: 250 feet for proposed land uses with high impacts; 190 feet for moderate impacts; 125 feet for low impacts.

Natural Heritage wetlands contain rare plants or those that are particularly sensitive to disturbance. These types of species are very sensitive to nutrient enrichment (eutrophication) from the input of nutrient-rich waters (see Chapter 4 of Volume 1). The buffer needs to remove excess nutrients before they reach the wetland. The most efficient vegetated buffer, based on width-to-removal ratios, is about 197 feet for removal of nitrogen and 253 feet for phosphorus (Desbonnet et al. 1994). A buffer of 250 feet, therefore, is recommended for Natural Heritage wetlands that could be affected by proposed land uses that have high impacts.

A 250-foot buffer alone may not protect the species that are rare or sensitive to disturbance if the watershed has high nutrient loadings or a water regime that is unstable. These factors may allow invasive plant species to become established and out-compete the species sensitive to disturbance.

8E.3.1.2 Other Protection Needed for Natural Heritage Wetlands

No Additional Surface Discharges to Wetland or its Tributaries

Buffers will not adequately protect rare plants or those sensitive to disturbance if polluted waters bypass the buffer and enter the wetland via pipes, ditches, or other channels. Furthermore, discharges of stormwater and changes in the water regime from development will change the wetland plant communities (see Chapter 4 of Volume 1). Such changes might reduce the populations of species in the wetland that are rare or sensitive to disturbance. To protect the plants, it is necessary to limit the introduction of additional nutrients that might bypass the buffer and enter the wetland through untreated runoff from new development or changes in land use.

No Septic Systems within 300 Feet of Wetland

Septic systems do not prevent nitrates, a major plant nutrient in wastewater, from entering groundwater. Many wetlands in Washington receive at least some of their water, if not all, from groundwater. This means that nutrients released by septic systems can enter a wetland and impact species that are rare or sensitive to disturbance in the same way as surface water. By keeping septic systems at least 300 feet from the wetland edge (usually called a *setback* in regulations) there is a better chance that impacts from nutrients will be minimized. There is no "safe" setback, however, for septic systems if there is a direct groundwater connection (underground flow) between the septic system and the wetland. A 300-foot distance, however, will increase the chance that the nitrogen will be diluted before it reaches the wetland.

8E.3.2 Bogs (Table 7 in Appendices 8-C and 8-D)

8E.3.2.1 Width of Buffers

In both eastern and western Washington: 250 feet for proposed land uses with high impacts; 190 feet for moderate impacts; 125 feet for low impacts

Bogs are particularly sensitive to nutrient enrichment (eutrophication) from the input of nutrient-rich waters because they contain plant species that have adapted to very low nutrient levels. A vegetated buffer, therefore, is needed to remove excess nutrients before they reach the bog. The most efficient vegetated buffer, based on width-to-removal ratios, is about 197 feet for removal of nitrogen and 253 feet for phosphorus (Desbonnet et al. 1994).

A 250-foot buffer alone may not protect the bog and its species if the watershed has high nutrient loadings, and nutrients are transported into the bog in a stream.

8E.3.2.2 Other Protection Needed for Bogs

No Surface Discharges to Wetland or its Tributaries

Buffers will not adequately protect the functions of a bog if polluted waters bypass the buffer and enter the wetland via pipes, ditches, or other channels. It is necessary to limit the introduction of additional nutrients that might be transported through untreated runoff that bypasses the buffer.

8E.3.3 Category I Forested Wetlands and Category II Riparian Forest (Table 7 in Appendices 8-C and 8-D and Table 6 in Appendix 8-D)

8E.3.3.1 Width of Buffers

In both eastern and western Washington: Buffer widths for mature or old-growth forested wetlands that are Category I, or for Category II riparian forest in eastern Washington, are based on the score for habitat functions or water quality functions described in Section 8E.2.

Forested wetlands are given special consideration because they are hard to replace through compensatory mitigation. This is especially true for mature or old-growth forests which can not be replaced in a human life-time. The protection they need should be based on the functions they provide. Therefore, buffers and other measures to protect their functions should be based on how well the wetland scores for habitat or water quality functions.

8E.3.3.2 Other Protection Needed for Forested Wetlands

Protect Water Regime in Watershed

Riparian forested wetlands, whether a mature forest or not, need protection at a watershed scale. Buffers alone will not protect riparian forested wetlands because they are directly connected to the water flow and dynamics in the watershed. Changes in the water regime of the watershed that result from changes in land use can have a significant impact on all types of riparian wetlands.

8E.3.4 Alkali Wetlands (Table 7 in Appendix 8-D)

8E.3.4.1 Width of Buffers

In eastern Washington: 200 feet for proposed land uses with high impacts; 150 feet for moderate impacts; 100 feet for low impacts.

The ecological process that maintains an alkali wetland is the dynamic interaction between water inflow and evaporation. Buffers have little effect on this process. The 200-foot buffer recommended for alkali wetlands is based on their habitat functions. Alkali wetlands in eastern Washington are a major resource for migratory shorebirds and other water-dependent birds. The 200-foot buffer recommended is intended to protect these birds and minimize disturbance during migration and feeding (see Chapter 5 in Volume 1).

8E.3.4.2 Other Protection Needed for Alkali Wetlands

No Additional Surface Discharges to Wetland or its Tributaries

The routing of additional surface water into alkali wetlands will change the balance between inflow and evaporation because the incoming water will usually be less salty than that in the wetland. This may lower the alkalinity (salt content) and change the highly specialized fauna and flora that inhabit these systems. No specific information was found on the impacts this may have on the ecosystem in the alkali wetland. In the absence of direct information, we can assume that there is a risk to the ecosystem in alkali wetlands if discharges are allowed. The recommendation is that no surface discharges (e.g., stormwater, irrigation, etc.) be allowed into alkali wetlands.

8E.3.5 Category II Vernal Pools (Tables 6 in Appendix 8-D)

8E.3.5.1 Width of Buffers

In eastern Washington: 200 feet for proposed land uses with high impacts; 150 feet for moderate impacts; 100 feet for low impacts.

As an alternative, a jurisdiction may wish to develop a regional plan to protect the most important complexes of vernal pools. If a plan is developed, buffers of vernal pools outside the protection zones can then be reduced to 80 feet for proposed land uses with high impacts, 60 feet for moderate impacts, and 40 feet for low impacts.

Vernal pools that are currently relatively undisturbed are very important for migratory waterfowl during a short period in the early spring. The review of the literature indicates that waterfowl need at least 200 feet of buffer during that short period to protect them from the disturbance that can occur from land uses with high impacts. The rest of the time the vernal pools provide little habitat for animals that require larger buffers. Because the requirement for a 200-foot buffer around a very small wetland for only a very short time may seem to be excessive, Ecology and the Washington Department of Fish and Wildlife (WDFW) strongly recommend that local jurisdictions identify the complexes of vernal pools that are the most important for waterfowl and develop a plan to protect them.

8E.3.5.2 Other Protection Needed for Vernal Pools

No recommendations are made at this time.

8E.3.6 Estuarine Wetlands and Wetlands in Coastal Lagoons (Tables 6 and 7 in Appendix 8-C)

Although wetlands in estuaries and coastal lagoons were not a focus of the synthesis of the science in Volume 1, some information about these wetlands is included because they

are included in the Washington State wetland rating systems, which have identified these aquatic resources as needing protection. Some recent scientific information on coastal and estuarine wetlands has been summarized by Ecology, WDFW, and other agencies through the Aquatic Habitat Guidelines Project (see www.wa.gov/wdfw/hab/ahg).

8E.3.6.1 Width of Buffers

In western Washington: 200 feet for proposed land uses with high impacts; 150 feet for moderate impacts; 100 feet for low impacts.

It is not possible to make recommendations on buffers that reflect an extensive review of the current scientific information since that review was not done. However, the buffers recommended in Tables 6 and 7 of Appendix 8-C for estuarine wetlands and coastal lagoons in western Washington are based on generally accepted habitat functions.

Estuarine wetlands and coastal lagoons are a major resource for migratory shorebirds and other water-dependent birds (Simenstad 1983). In estuarine systems, buffers provide a source of wood and sediment that nourish the beaches. In addition, estuaries and coastal lagoons have a high density of fish and wildlife and high species diversity, provide important breeding habitat, and serve as movement corridors (see Washington Department of Fish and Wildlife web page, http://wdfw.wa.gov/hab/phshabs.htm). Both types of wetlands are also a habitat that has been significantly impacted by human activities and are highly vulnerable to alteration. Therefore, the width of buffers needed to protect these wetlands will have to be based on protecting a wide range of functions. The widths of buffers recommended (150 feet, 125 feet, and 75 feet respectively for proposed land uses with different levels of impacts) are intended to protect these birds and minimize disturbance during migration and feeding (see Chapter 5 in Volume 1).

8E.3.6.2 Other Protection Needed for Estuarine Wetlands and Wetlands in Coastal Lagoons

No recommendations are made at this time.

8E.3.7 Category II Interdunal Wetlands (Table 6 in Appendix 8-C)

8E.3.7.1 Width of Buffers

In western Washington: 150 feet for proposed land uses with high impacts; 110 feet for moderate impacts; 75 feet for low impacts.

Wetlands in coastal dune systems were excluded from the synthesis of the scientific literature in Volume 1 (see Chapter 1). The recommendations, therefore, do not reflect an extensive review of the current scientific information. However, buffer recommendations in Table 6 of Appendix 8-C for interdunal wetlands in western Washington are based on generally accepted habitat functions. These wetlands are

considered to be a major resource for migratory shorebirds (Wiedemann 1984). The buffers recommended are intended to protect these birds and minimize disturbance during migration and feeding (see Chapter 5 in Volume 1 for a discussion of buffers generally needed to protect birds).

8E.3.7.2 Other Protection Needed for Interdunal Wetlands

No recommendations are made at this time.

References

Castelle, A.J., C. Conolly, M. Emers, E.D. Metz, S. Meyer, M. Witter, S. Mauermann, M. Bentley, D. Sheldon, and D. Dole. 1992. Wetland Mitigation Replacement Ratios: Defining Equivalency. Publication # 92-08. Washington Department of Ecology, Olympia, WA.

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated Buffers in the Coastal Zone: A Summary Review and Bibliography. Coastal Resources Center Technical Report No. 2064. University of Rhode Island. 72pp.

Sheldon, D., T. Hruby, P. Johnson, K. Harper, A. McMillan, T. Granger, S. Stanley, and E. Stockdale. 2005. Freshwater Wetlands in Washington State, Volume 1: A Synthesis of the Science. Publication #05-06-006. Washington State Department of Ecology, Olympia, Washington.

Simenstad, C.A. 1983. The Ecology of Estuarine Channels of the Pacific Northwest coast: A Community Profile. U.S. Fish and Wildlife Service FWS/OBS-83/05.

Wiedemann, A.M. 1984. The Ecology of Pacific Northwest Coastal Sand Dunes: A Community Profile. U.S. Fish and Wildlife Service FWS/OBS-84/04.

Appendix 8-F

Rationale for the Guidance on Recommended Ratios for Compensatory Mitigation

8F.1 Introduction and Background on Mitigation Ratios

This appendix provides some background information on ratios for compensatory mitigation (mitigation ratios), and the rationale and assumptions used in establishing ratios based on the Washington State wetland rating systems in Appendices 8-C and 8-D. The reader should become familiar with Appendices 8-C and 8-D before reading the rationale in this appendix.

The acreage of creation, restoration (re-establishment or rehabilitation), and enhancement that is required by regulatory agencies, including local governments, to compensate for impacts to wetlands is usually greater than the acreage of impact. This difference is expressed as a ratio (a mitigation ratio) of the area required for compensation vs. the area of impact. For example, a ratio of 3:1 means that 3 acres of compensatory mitigation are required for every acre of impact to a wetland.

> See Appendices 8-C or 8-D for definitions of creation, re-establishment, rehabilitation, and enhancement as types of compensatory mitigation.

There are two major reasons why the ratios are greater than 1:1. The first is based on the risk of failure of a project designed to compensate for impacts to wetlands (hereafter called *mitigation project*), and the second is based on the loss or reduction of functions during the time it takes a mitigation project to achieve the targeted level of performance for all of its functions (called "temporal loss").

First, all of the studies of compensatory mitigation summarized in Volume 1 (see Chapter 6) indicate that a fairly large percentage of mitigation projects do not successfully replace all the functions lost. The result is an overall net loss of wetlands and their functions. Thus, at a programmatic level, more wetland area should be created or restored than is impacted to ensure that wetland functions and area are adequately replaced.

Secondly, the studies reviewed in Volume 1 also indicate that functions in wetlands may take decades, if not centuries, to develop fully. By requiring a ratio greater than 1:1, the temporal loss of functioning is addressed by providing more acreage of wetland that may not be performing as well as the impacted wetland. The trade-off is that a smaller wetland with a higher level of functioning is replaced with a larger wetland that does not function as well for many years.

Therefore, higher ratios should be set if there is an increasing risk of not adequately compensating for the functions lost, and as the time needed to establish the lost functions increases. If, however, compensatory mitigation is done in advance of impacts and is fully successful, it is reasonable to reduce the ratios to as low as 1:1.

Kusler (2003) has summarized some of the factors that should be considered in evaluating the risks of success or failure of compensatory mitigation and temporal loss and thereby establishing an appropriate mitigation ratio:

1. **The functions present in the impacted wetland and those proposed for the "replacement" wetland.** Larger ratios are justified where a replacement wetland will have fewer functions and values or perform the functions at a lower level. The net loss of function per acre of wetland has to be compensated by increasing the area of compensation required.

2. **The overall ecological conditions of the impacted wetland and the "replacement" wetland.** Larger ratios are justified where a "replacement" wetland will be less persistent, diverse, or has less ecological integrity than the original wetland. The risk of losing "ecological integrity" has to be compensated by increasing the area of mitigation required.

3. **The probable success for wetlands of the type proposed as "replacement."** Larger ratios are justified for wetland types that have proven to be difficult to restore or create, thereby increasing the risk of failure.

4. **The expertise and experience of the agency or consultant proposing to carry out the project.** Larger ratios are justified for proponents who are less expert and less experienced. Lack of experience increases the risk that the project will not be successful.

5. **Threats to the "replacement" site.** Larger ratios are justified where there are threats to the site such as possible changes to the water regime, sedimentation, or pollution. These threats increase the risk that functions will be impaired in the future (See Chapters 3 and 4 in Volume 1).

6. **Whether the site will be susceptible to "mid-course" corrections.** Larger ratios are justified when there is little capability for correcting problems as they develop, and smaller ratios are justified where that capability exists. Projects where problems have been corrected tend to be more successful than those that have not (See Chapter 6 in Volume 1).

The ratios discussed in this appendix were developed to provide a starting point for further discussions with each proponent of compensatory mitigation. The ratios provided as guidance are based on the factors discussed in this appendix including the likelihood of success of compensatory mitigation, the amount of temporal loss, and the risk at a programmatic level. They <u>DO NOT</u> address the specific considerations and risks of any particular individual project.

8F.2 Assumptions Used in Establishing the Recommended Ratios

8F.2.1 Baseline Ratios for Creation and Re-establishment

Creation and re-establishment both lead to the formation of wetlands in areas that are currently not wetlands. As a result, there can be a no net loss of wetland area if the area of compensatory mitigation is at least as large as the area of impact. However, the study by Johnson et al. (2002), summarized in Chapter 6 of Volume 1, found that only about half of the mitigation projects in Washington State that created or re-established wetlands were "moderately successful" or "successful" at replacing the functions lost. This means that overall there is about a 50 percent risk of failure. Other studies of the success of mitigation projects, summarized in Chapter 6 of Volume 1, suggest the risk of failure is even higher. These data suggest that a minimum ratio of 2:1 is needed to ensure no net loss of functions at a programmatic level.

As previously mentioned, this ratio also needs to be adjusted to account for the temporal loss of functions. There are no scientific studies that have quantified the temporal loss in terms of how many acres of additional wetlands are required. Trying to quantify this experimentally is not possible because the data are not compatible; one cannot equate time with area.

As a result, the additional area required to compensate for the temporal loss of functions is a value judgment. *How highly do we value the loss of some functions for 5 to 10 years, some for 30 years, and others for 100 years or more?* As a starting point for discussion, it is suggested that the compensation for the temporal loss of functions be equal to the area of impact**.** Thus, the basic 2:1 ratio proposed to compensate for the risk of failure should be increased to 3:1 to account for the temporal loss of functions**.**

Thus, one-third of the ratio is assigned to the temporal loss of function. In the case of temporal losses of functions due to conversion of vegetation, however, we recommend a ratio for temporal losses of functions that is one-quarter that of creation or re-establishment (e.g., in the construction of pipelines – see section 8C.2.4 or 8D.2.4). The ratios recommended are different because in the case of creation or re-establishment, most of the functions (e.g., improving water quality and hydrologic) will also take some time to develop. In the case of a pipeline construction and conversion of forest to emergent, we do not expect to have a temporal loss of these other functions because the wetland already exists.

The basic 2:1 ratio proposed to compensate for the risk of failure should be increased to 3:1 to account for the temporal loss of functions.

8F.2.2 Baseline Ratios for Rehabilitation and Enhancement

Rehabilitation and enhancement of existing wetlands (see Appendices 8-C or 8-D for definitions) are also used in compensatory mitigation. Rehabilitation and enhancement activities are conducted on an existing wetland, therefore if either of these types is used as the only form of compensation, there will always be a net loss of wetland area. Thus the ratios for these two types of compensatory mitigation will need to be higher than for creation or re-establishment since a net loss of wetland area will result.

Furthermore, the information on the risks associated with enhancement indicates this type of compensatory mitigation has even a lower rate of success than creation or re-establishment. Only about 10% of the enhancement projects analyzed in Washington State were even moderately successful at replacing the functions lost (Johnson et al. 2002). No data were available on the success of rehabilitation.

The recommended ratio for using rehabilitation as compensation is two times that for using re-establishment or creation based on the need to compensate for the loss of wetland area. Thus, two acres of rehabilitation are equivalent to one acre of re-establishment or creation in determining the acreage needed to replace an impacted wetland.

The recommended ratio for using enhancement alone as compensation is four times that for using re-establishment or creation based on the need to compensate for the loss of wetland area and the fact that enhancement tends to be even less effective at replacing the functions lost. This means that four acres of enhancement are equivalent to one acre of re-establishment or creation in determining the acreage needed to replace an impacted wetland.

The ratio for rehabilitation is less than that for enhancement alone because the former often focuses on restoring environmental or hydrologic processes that have been disturbed or altered by previous or ongoing human activity. These actions are more likely to replace a full suite of wetland functions than enhancement. Enhancement typically involves actions that provide gains in only one or a few functions and can lead to a decline in other functions.

The recommended ratios for rehabilitation or enhancement are based on a multiplication factor that is applied to the ratio for creation or re-establishment (2x for rehabilitation and 4x for enhancement). This applies to all the different ratios for creation and rehabilitation recommended in Tables 8C-9 and 8D-9.

8F.2.3 Adapting the Ratios Based on the Wetland Functions

The baseline ratios for each type of compensatory mitigation described above can be applied to or modified based on the four categories in the rating systems for Washington State (Hruby 2004 a,b). It is assumed, first, that the basic ratios described above apply to mitigation projects where the proposed compensatory mitigation site is the same category as the affected wetland (e.g., impacts to a wetland rated Category II for its functions are compensated by creating, re-establishing, rehabilitating or enhancing a wetland that will become a Category II wetland based on its score for functions). Second, it is assumed that the hydrogeomorphic (HGM) class or subclass of the wetland proposed as compensation is the same as the category and class or subclass of the wetland being altered (e.g., impacts to a Category II riverine wetland are compensated by a Category II riverine, wetland). This is considered to be the *average condition*.

The studies of compensatory mitigation by Johnson et al. (2002) found that the highest rating that could usually be expected in a compensatory project was a Category II when the wetland was rated based on its functions, and this category was chosen as the average from which to develop the ratios for other categories.

The basic ratios may be modified if the conditions for the proposed mitigation project are different from the average condition. For example, the ratios recommended for compensating impacts to Category III wetlands (based on the score for functions) in Tables 8C-9 and 8D-9 are lower (2:1 instead of 3:1). The ratios are lower because it is assumed that the risks are lower with mitigating impacts to a Category III wetland. First, it is assumed that there is a better chance for a successful creation or re-establishment of a Category III wetland than a Category II wetland because the wetland does not have to function at the same level. Second, Category III wetlands usually have simpler structure, and it may take less time to establish the required level of functions (i.e., temporal losses of functions are reduced). The ratios for rehabilitation and enhancement only are also lower because they are based on the lower ratio for creation and re-establishment. At present, however, these are assumptions that need to be validated by more thorough monitoring.

The recommended ratio to compensate for impacts to Category IV wetlands is even lower (1.5:1 rather than 3:1) because it is assumed that the risks and temporal losses are less than with creation or restoration of a Category III wetland.

On the other hand, the ratio for impacts to a Category I wetland are higher (4:1 rather than 3:1) for the opposite reasons. First, it is assumed that there is a reduced chance for successful creation or restoration of a Category I wetland than a Category II wetland because the wetland has to function at the highest levels. The data from existing studies (see Chapter 6 in Volume 1) indicates that creation or re-establishment to these levels rarely, if ever, happens. Second, Category I wetlands usually have a more complex structure, and it may take more time to establish these structures and the resulting functions (i.e., temporal losses are increased).

8F.2.4 Adapting the Ratios Based on Special Characteristics Defined in the Rating System

8F.2.4.1 Ratios for Category I Forested Wetlands

Studies of mitigation projects (see Chapter 6 in Volume 1) have shown that forested wetlands may take over 100 years to become established (the studies didn't specifically state if the forests were mature or old-growth). The recommended ratio (6:1) is designed to compensate for the additional temporal loss of the functions of a Category I mature or old-growth forested wetland during the long time it takes to establish this type of wetland.

8F.2.4.2 Ratios for Wetlands that are Difficult to Create (Natural Heritage, Bogs, Alkali Wetlands, Estuarine Wetlands, Wetlands in Coastal Lagoons)

No data are available for mitigation projects that involved creating Natural Heritage wetlands, alkali wetlands, estuarine wetlands, or wetlands in coastal lagoons from uplands. Bogs are the only type of wetland for which studies on compensation through creation have been attempted. This information indicates that it is not possible to re-create the necessary physical, hydrologic, and chemical conditions needed to replace a bog through compensatory mitigation (see Chapter 6 in Volume 1).

Until more data are available, the authors of Volume 2 assume that, in addition to bogs, it is not possible to create Natural Heritage wetlands, alkali wetlands, estuarine wetlands, or wetlands in coastal lagoons from uplands or to enhance wetlands of other types to reproduce their special characteristics and functions. We do not fully understand the hydrologic and biological conditions that lead to the formation of these wetlands, so we cannot assume that it is possible to create them without this understanding.

As a result, the authors of Volume 2 recommend that compensation for impacts to these types of wetlands should involve the rehabilitation of degraded wetlands of a similar type, rather than creation or enhancement. Rehabilitation has proven to be successful for estuarine wetlands (Simenstad and Thom 1992), and it is assumed that rehabilitation of the other types is also feasible. It is more feasible, at least, than attempting to create these wetlands or enhance a wetland of another type in order to try to recreate the necessary ecological conditions.

In the absence of any definitive information on the success of such rehabilitation, the recommended ratio for rehabilitation is 6:1 to be consistent with the other ratios. Mitigation projects that propose enhancement as compensation for impacts to these wetlands will have to be evaluated on a case-by-case basis. Enhancement would involve a net loss of acreage as well as an extremely high risk that the functions represented by these wetland types will not be replaced.

References

(Hruby, T. 2004a) Hruby, T. 2004. Washington State Wetland Rating System for Eastern Washington – Revised. Washington State Department of Ecology Publication #04-06-015. Olympia, WA.

(Hruby, T. 2004b) Hruby, T. 2004. Washington State Wetland Rating System for Western Washington – Revised. Washington State Department of Ecology Publication #04-06-025. Olympia, WA.

Johnson, P., D.L. Mock, A. McMillan, L. Driscoll, and T. Hruby. 2002. Washington State Wetland Mitigation Evaluation Study Phase 2: Evaluating Success. Washington State Department of Ecology. Publication #02-06-009. Olympia, WA.

Kusler, J. 2003. Integrating Wetland Assessment into Regulatory Permitting. Final Report 3: Wetland Assessment for Regulatory Purposes. Institute for Wetland Science and Public Policy, Association of State Wetland Managers.

Simenstad, C. A., and R. M. Thom. 1992. Restoring wetland habitats in urbanized Pacific Northwest estuaries. Pp. 423-472 in G. W. Thayer (ed.), Restoring the Nation's Marine Environment, Maryland Sea Grant, College Park, Maryland. 716 pp.

Appendix 8-G

Widths of Buffers Needed to Protect Some Threatened/Endangered/Sensitive Wildlife Species Associated with Wetlands

The following table lists information regarding the widths of buffers needed by legally protected wildlife species associated with wetlands (as defined below). The species in the table are Federal Candidate, Federal Threatened, Federal Endangered, Federally Warranted But Precluded, State Sensitive, State Threatened, and State Endangered found in Washington as of February 4, 2005. These species are collectively called Threatened, Endangered, or Sensitive (T/E/S) species in this appendix. Although this information is not directly linked to the guidance provided in Appendices 8-C and 8-D, it can be useful to local governments developing a program to protect and manage wetlands. The T/E/S species for which wetlands provide habitat, as well as the other functions as established by the rating systems, need to be addressed in protection measures.

The list of species and their level of association with wetlands in Johnson and O'Neil's (2001) *Wildlife-Habitat Relationships in Oregon and Washington* (see Appendix 2-B in Volume 1) was used to identify only the T/E/S species that are *Closely Associated* with wetlands in Washington (the first column in the matrix). A species *Closely Associated* with wetlands is defined as a species that is widely known to depend on a habitat for part or all of its life history requirements. Identifying this association implies that the species has an essential need for this habitat for its maintenance and viability.

The Washington Department of Fish and Wildlife (WDFW) identified two additional species that should be considered as associated with wetlands based on their expertise in Washington (the second column) (E. Neatherlin, WDFW, personal communication 2005). The fourth column (activity in wetlands) is also from Johnson and O'Neil (2001). The fifth column includes widths of buffers needed by these species and was derived from the scientific literature as cited in the table and listed at the end of the appendix. Finally, WDFW provided additional notes/comments for some of the species (sixth column).

Buffers alone may not provide adequate protection for some of these species. Please check with the Washington Department of Fish and Wildlife for more details on what is needed to protect individual Threatened/Endangered/Sensitive species.

Table 8G-1. Width of buffers needed to protect Threatened/Endangered/Sensitive wildlife species associated with freshwater wetlands in Washington.

T/E/S Species Identified as *Closely Associated* with Wetlands in WA from Johnson and O'Neil (2001)	T/E/S Species Associated with Wetlands in Washington Based on WDFW Expertise	Status*	Activity in Wetlands	Widths of Buffers Reported in the Scientific Literature as Needed to Protect the Species	Notes/Comments (Provided by WDFW biologists)
Oregon Spotted Frog		FC, SE	Feeds and Breeds	No information	Only 3 known populations in WA - Dempsey Creek, Trout Lake, and Conboy Lake (McAllister and Leonard 1997). Emerging data suggests that some frogs cannot persist through time without landscape connectivity between uplands and wetlands. Buffers are often inadequate and ineffective.
	Great Basin Spotted Frog	FWP		No information	One small population in SE Washington. Emerging data suggests that some frogs cannot persist through time without landscape connectivity between uplands and wetlands. Buffers are often inadequate and ineffective.
Northern Leopard Frog		SE	Feeds and Breeds	> 120 m (395ft) impacts noted up to 3000 m (1.9 miles) (Houlahan and Findlay 2003)	Emerging data suggests that some frogs cannot persist through time without landscape connectivity between uplands and wetlands. Buffers are often inadequate and ineffective.

* Status: FC = Federal Candidate, FT = Federal Threatened, FE = Federal Endangered, FWP = Federally Warranted But Precluded, SS = State Sensitive, ST = State Threatened, SE = State Endangered

T/E/S Species Identified as *Closely Associated* with Wetlands in WA from Johnson and O'Neil (2001)	T/E/S Species Associated with Wetlands in Washington Based on WDFW Expertise	Status*	Activity in Wetlands	Widths of Buffers Reported in the Scientific Literature as Needed to Protect the Species	Notes/Comments (Provided by WDFW biologists)
Western Pond Turtle		SE	Feeds	400-500m (1300-1600ft) (Larsen 1997 citing Holland 1994)	
	American White Pelican	SE		400-800m (1312-2624ft) around breeding colonies (WDFW 2004)	
Sharp-tailed Grouse		SE	Feeds	1.2 miles during breeding and rearing season (WDFW 2004)	
Fisher		SE	Feeds and Breeds	No information	Not useful to generate buffer database for fishers until their populations increase. Despite extensive surveys, WDFW has been unable to confirm the existence of a fisher population in the state (Stinson and Lewis 1998).
Common Loon		SS	Feeds and Breeds	492 ft. April 1 to July 15 (WDFW 2004)	
Sandhill Crane		SE	Feeds and Breeds	400m (1312ft) during breeding season (WDFW 2004); buffer roosts (roost, nest, and loaf in wetlands) by >500m (1640ft) from new roads or buildings, and buffer feeding areas (includes wetlands) by >800m (2624ft) from new construction, road building or traffic increases (Bettinger and Milner 2000 in Littlefield and Ivey 2001); >300m from roads and human activity elicited no disruption in feeding, roosting, loafing (Burger and Gochfeld 2001)	

References Cited in the Table

Bettinger, K.A. and R. Milner. 2000. Sandhill Crane (*Grus canadensis*). In E.M. Larsen and N. Nordstrom, editors. Management Recommendations for Washington's Priority Species, Volume IV: Birds [Online]. Available: http://www.wa.gov/wdfw/hab/phs/vol4/sndhlcrn.htm.

Burger, J. and M. Gochfeld. 2001. Effect of human presence on foraging behavior of sandhill cranes (Grus canadensis) in Nebraska. Bird Behavior 14(2):81-87.

Houlahan, J.E. and C.S. Findlay. 2003. The effects of adjacent land use on wetland amphibian species richness and community composition. Canadian Journal of Fisheries and Aquatic Sciences 60: 1078-1094.

Johnson, D.H. and T.A. O'Neil (eds.). 2001. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press. Corvallis, OR. 736pp.

Larsen, E.M. editor. 1997. Management recommendations for Washington's priority species, Volume III: Amphibians and reptiles. Washington Department of Fish and Wildlife, Olympia, WA.

Littlefield, C.D. and G.L. Ivey. 2001. Draft Washington State Recovery Plan for the Sandhill Crane. Washington Department of Fish and Wildlife, Olympia, WA. 62 pp.

McAllister, K.R. and W.P. Leonard. 1997. Washington State status report for the Oregon Spotted Frog. Washington Department of Fish and Wildlife., Olympia, WA. 38 pp.

Stinson, D.W. and J.C. Lewis. 1998. Washington State status report for the fisher. Washington.Department of Fish and Wildlife. Olympia, WA. 64 pp.

(WDFW) Washington Department of Fish and Wildlife. 2004. Management recommendations for Washington's priority species – Volume IV: Birds. E.M. Larsen, J.M. Azzerad, and N. Nordstrom (technical editors), Washington Department of Fish and Wildlife. Olympia, WA.

Appendix 8-H

Hiring a Qualified Wetland Professional

This appendix contains recommendations to help locate and select a professional who is qualified to assist with wetland issues. Wetland professionals are usually hired to identify and delineate wetlands, rate them, assess functions and values, and provide assistance with wetland regulations and permits. They often complete the necessary application forms and studies needed to meet regulations and also provide advice about designing and implementing compensatory mitigation projects that are needed to replace wetlands if they are impacted.

Wetland professionals are generally hired by landowners or developers who want to do something on their property that may affect a wetland. In addition, many local governments hire professionals to provide review as a third party. Some professionals are self-employed; others work for larger environmental or engineering consulting firms.

What is a Qualified Wetland Professional?

There is no government sanctioned program for certifying someone as a "qualified wetland professional" or "qualified wetland specialist." Generally, the term means a person with professional experience and comprehensive training in wetland issues, including experience performing wetland delineations, assessing wetland functions and values, analyzing wetland impacts, and recommending and designing wetland mitigation projects.

The Society of Wetland Scientists administers a professional certification program for wetland scientists that has two levels of certification: Professional Wetland Scientist (PWS) and Wetland Professional In-Training (WPIT). A person certified as a PWS would be considered a qualified wetlands expert. This program is discussed further in the shaded box at the end of this appendix.

If the person is not a certified PWS, there is no simple means of determining if they are adequately qualified to undertake the tasks listed above. However, the following criteria are indicators of someone who may be qualified to perform the wide range of tasks typically required of a wetland professional:

- At a minimum, **a Bachelor of Science or Bachelor of Arts** or equivalent degree in hydrology, soil science, botany, ecology, resource management, or related field. A graduate degree in one of these fields is usually an indication of more advanced expertise.

- At least **two years of full-time work experience** as a wetland professional; including delineating wetlands using the state or federal manuals, preparing wetland reports, conducting function assessments, and developing and implementing mitigation plans. Generally, the more years of experience, the greater the expertise.

- **Completion of additional wetland-specific training programs**. This could include a more comprehensive program such as the University of Washington Wetland Science and Management Certificate Program or individual workshops on wetland delineation, function assessment, mitigation design, hydrophytic plant or hydric soil identification, etc.

Keep in mind that most people engaged in professional wetland work have greater expertise in some aspects of the field than others. A person may have in-depth training in plant ecology or soils or hydrology, but few people have all three. A person may have extensive experience in wetland delineation or function assessment and have little experience in designing and implementing mitigation projects. Thus, it is important to be clear what specific tasks need to be completed and make sure the person or firm being hired has the specific expertise needed. Generally, more complex projects require multiple individuals that provide collective expertise to address all aspects of the project.

How to Find a Qualified Wetland Professional

There are a number of ways to find the names of wetland professionals. Finding a qualified one, however, can be difficult since this group of professionals is not required to be certified, licensed, or bonded in the State of Washington. One approach is to look in the Yellow Pages under *Environmental and Ecological Services*. You can also contact the local government planning office and ask for a list of professionals that work in their jurisdiction. Some local governments maintain lists of wetland professionals they consider to be well qualified.

Wetland professionals may also be found by requesting the advice of associations or businesses that commonly encounter wetlands in their work, such as the Building Industry Association and Association of Washington Business. Finally, state and federal resource agencies can be asked for referrals. Be aware, however, that most agencies will not be able to provide recommendations because of questions of fairness.

How to Select a Qualified Wetland Professional

A number of factors should be considered before hiring a wetlands professional. When interviewing professionals, their qualifications should be carefully considered (see above for the minimum recommended). Be sure to ask the following questions before making a selection:

- **Does the professional have training or experience in the use of the 1987 federal or 1997 Washington State wetland delineation manuals?** The selected professional should have the ability to apply the methods for identifying wetlands used by state and federal agencies. Make sure that the professional can identify wetlands and their boundaries consistent with regulating agencies.

- **Has the professional had additional training or expertise in related fields** such as hydrology, soil science, botany, or ecology?

- **Is the professional familiar with local, state, and federal wetland regulation**s?

- **How long has the professional been doing wetlands work?** How much experience do they have delineating wetlands in the field, assessing wetlands functions and values, or working with wetland regulations? Has the person worked in the part of the state where you propose to develop? Ask the professional for examples of previous work similar to the services being requested. Can the professional take you to a successful wetland mitigation project they designed and/or implemented?

- **Does the professional have experience working with regulatory agencies?** Ask the professional to describe their working relationship with the agencies that will be reviewing and/or permitting your project.

- **Does the professional have experience working on a team?** Given the complexity of some projects, it is expected that a wetland professional will team up with others who have experience in related fields such as water quality, wildlife, stormwater management, and hydrogeology. Ask the professional for a list of people with whom they have worked on a team in the past.

- **Who were some of the professional's past clients?** Request referrals and ask clients if they were satisfied with the professional's work. Ask whether there were any problems that occurred during or after the project, how the professional handled those problems, and what they charged for their work. Find out what type of track record the company has with local, state, and federal agencies. Be sure to ask for references that include clients who have had projects reviewed and approved by the regulatory agencies (Corps, Ecology, and local government).

- **Talk with colleagues and other businesses**, such as real estate, land development, homebuilding, etc. that are routinely involved in wetland concerns. Ask them about their experiences and knowledge regarding the professional being considered.

- **If you are considering a consulting firm, find out exactly who will be working on your project.** Will it be the principal professional with the years of experience, or someone with less experience who works for them?

- **Get an estimate of how much the professional will charge.** Compare rates but do not let cost be the sole criterion. Be sure to consider training, experience, and the other factors as well. A good professional who charges more may end up saving money by reducing permit processing delays.

Society of Wetland Scientists Professional Certification Program

The Society of Wetland Scientists keeps a list of those who have qualified for their professional certification program for wetland scientists. The certification program website http://www.wetlandcert.org allows you to search by name, city, and/or state.

As explained in the Professional Wetland Scientist program overview:

Certification is not required by any agency and has no official or legal standing. However, certification signifies that the academic and work experience of a Professional Wetland Scientist (PWS) meets the standards expected by his or her peers of a practicing wetland professional and provides acknowledgment to his or her peers of adherence to standards of professional ethics with regard to the conduct and practice of wetland science.

Wetland Professional in Training (WPIT) is considered a preliminary step for persons who meet the requirements for either (but not both) education and experience. Professional Wetland Scientist (PWS) certification is awarded for those meeting both educational and experience requirements.

Minimum degree requirements for WPIT and PWS are the BA or BS degrees, with course distribution of 15 semester hours each in biological and physical sciences and 6 hours in quantitative areas. For certification as a PWS, an additional 15 semester hours in wetland-related courses are required. In addition to comprehensive training in wetland science, a PWS is expected to have professional experience of at least 5 years as a wetland scientist, demonstrating the application of current technical knowledge dealing with wetland resources and activities.

Appendix 9-A

Additional Information on Preservation, Conservation, and Restoration

This appendix provides additional background information in three areas: the significant role local government can play in conservation and preservation; land trusts as potential partners for local governments; and considering threshold effects for planning restoration.

A Role for Local Governments: Conservation and Preservation in Lower Elevation Lands

Local governments and private landowners must be included when creating a diversified system of preserved areas. The lands owned by these two groups encompass the most underrepresented areas of the landscape in systems of land preservation. The legacy of land preservation in the United States has been weighted toward high-elevation or least productive lands (Scott et al. 2001). A recent study conducted by the State of Washington's Interagency Committee for Outdoor Recreation (IAC) (2001) found that over half of all public and tribal reservation lands are located above 3,000 feet. However, species richness tends to be greatest at lower, more productive elevations. More than 60% of the federally listed threatened and endangered species occur on private, lower elevation lands.

In addition, the IAC (2001) found that 40% of the state's 45.9 million acres are owned by federal, state, tribal, and local public entities, with federal lands making up the bulk of public land ownership. Only 6% of this acreage is aquatic, while 94% is upland. It is interesting to note that, as stated in IAC's report, Washington has the smallest amount of major public and tribal lands in the 11 western states, as well as the second lowest overall percentage of public and tribal lands following Montana. They add that although Washington is the smallest of the 11 western states, it has the second highest population in the West and the second highest population density following California.

Local governments could play a key role in conserving and preserving important lands in the lower elevations. In their paper *The Role of Local Government in the Conservation of Rare Species*, Press et al. (1996) make three claims about the need for local government involvement in land preservation:

> *(1) the scale of local and regional land use control and open-space acquisitions matches the range sizes of many rare, endemic species, (2) land acquisition is the most attractive approach to conserving many rare taxa, especially endangered flora, and (3) at least some local governments and non-governmental organizations have the policy capacity necessary to identify, acquire, and manage critical habitats for endangered species.*

They go on to acknowledge that conservation is always a land-use matter that requires local support. Local governments have the benefit of being able to broker larger land deals with other partners than they themselves could purchase alone. They can also acquire some smaller areas of habitat that add to a larger conservation landscape, fostering local sympathies for wildlife and habitats.

DeFreese (1995) recognizes that partnership with local government complements and enhances state and federal initiatives in conservation efforts. Brumback and Brumback (1988) critique early land acquisition programs in three states (New Jersey, Florida, and California), concluding that land acquisition efforts can overcome the legal and sociopolitical constraints of regulation and make it possible to reserve environmentally significant lands for the future.

Ian McHarg in 1969 was an early proponent of acquiring development rights, maintaining that "planned growth is more desirable, and just as profitable, as unplanned growth." He saw purchase as a way to make plans for development more acceptable to the public (Buckland 1987). "The need is growing for policies and institutions that can balance the requirements of economic development with the benefits of species, habitat, and open-space conservation" (Boyd et al. 1999).

Land Trusts Are Growing and Can Help

National land trusts such as The Nature Conservancy (TNC) and The Trust for Public Land (TPL) are working more closely in partnerships with local communities. Land trusts provide an opportunity for partnerships since they are growing in popularity and in numbers, thereby being able to preserve and manage more lands.

A census of land trusts by the National Land Trust Alliance counted 1,263 land trusts in existence across the country, a 42% increase from the decade before (www.lta.org). The census documented that permanently-preserved private land was approximately 6.4 million acres by the end of 2000. This was triple the 1.9 million acres preserved nationally by 1990. Of the 6.4 million acres, 52% was wetland. In Washington State, land trusts have also grown significantly. There are now 29 land trusts, while only 19 existed a decade ago.

The Nature Conservancy notes that the work of preservation is changing. They identify the need to target larger, and presumably more functional, preservation sites and to place a greater emphasis on representing all communities and ecological systems (Czech 2002).

Considering Threshold Effects for Restoration

In examining efforts in the Pacific Northwest to recover salmon habitat, Wu and Skelton-Groth (2002) offer some insights to the preservation and restoration efforts now underway. Conducting an empirical analysis that focuses on investments in riparian habitat for salmon recovery, they show that a large portion of conservation benefits would be lost when "threshold effects" are ignored. To explain the threshold effect, imagine a stream temperature that is necessary for healthy salmon populations. Until that

temperature is reached, salmon populations cannot survive, so the habitat has no value to salmon until the threshold is achieved.

Wu and Skelton-Groth state, "When a threshold effect is present, the marginal benefits of conservation efforts may be zero or increase slowly at first, and then more rapidly as conservation efforts approach the threshold. After the threshold is reached, additional efforts may have little effect on environmental benefits." They add, "When threshold effects are ignored, funds may be overly dispersed geographically, and funding levels in any given program area may be inadequate to reach the threshold needed for a significant environmental improvement." They argue that funds should be allocated so that the total value of environmental benefits is maximized, not the total amount of resources protected. To target funding based on physical criteria measured on site (such as erosion or water quality) ignores the threshold effect of conservation efforts in degraded systems.

For example, when addressing temperatures in streams, priority would be given to streams closer to threshold levels rather than those far from it unless, of course, enough funding were available to do additional work in a stream with significantly warmer temperatures to successfully reach the threshold level.

References

Boyd, J., K. Caballero, and R.D. Simpson. 1999. Carving out some space: A guide to land preservation strategies. Resources 136:10-13.

Brumback, B., and R. Brumback. 1988. Protecting resources through land acquisition. Forum for Applied Research and Public Policy. Fall 1988:92-99.

Buckland, J.G. 1987. The history and use of purchase of development rights in the United States. Landscape and Urban Planning 14:237-252.

Czech, B. 2002. A transdisciplinary approach to conservation land acquisition. Conservation Biology 16:1488-1497.

De Freese, D.E. 1995. Land acquisition: A tool for biological diversity protection in the Indian River Lagoon, Florida. Bulletin of Marine Science 57:14-27.

Interagency Committee for Outdoor Recreation. 2001. The 1999 Public and Tribal Land Inventory, Final Report. December 2001. Olympia, WA.

Press, D., D.F. Doak, and P. Steinberg. 1996. The role of local government in the conservation of rare species. Conservation Biology 10:1538-1548.

Scott, J.M., J.F.R. Abbitt, and C.R. Groves. 2001. What are we protecting? Conservation Biology in Practice 2:18-19.

Wu, J., and K. Skelton-Groth. 2002. Targeting conservation efforts in the presence of threshold effects and ecosystem linkages. Ecological Economics 42:313-331.

Appendix 10-A
Example of a Characterization of the Risks to Wetlands

As part of revisions to its critical areas ordinance, King County has prepared an *Assessment of Proposed Ordinances* that describes the risks to resources from the county's proposed regulatory and non-regulatory actions. This appendix reproduces Section 2.9 from Chapter 2 of the King County report, which describes the risks to the wetland resource from actions such as specified buffers, allowed alterations, classification (rating), and mitigation requirements. It is offered here as an example of characterizing risks as discussed in Chapter 10 of this volume. The full report by King County is available on the web at http://www.metrokc.gov/ddes/cao/.

POLICY DISCUSSION:

King County has an obligation to protect wildlife species through Federal, State and local regulations. The King County Comprehensive Plan requires a comprehensive approach to protecting wildlife species while balancing other requirements.

2.9 WETLANDS

Wetland Classification

Standard –Wetland Classification:

> *Wetlands are categorized based on the Washington State Wetland Rating System for Western Washington (DOE #93-74, 1993).*

The standard wetland protection proposed for the CAO is in large part based on the Department of Ecology's classification and rating system for wetlands. Although DOE's classification system is more comprehensive than King County's current SAO system, this proposed DOE method is outdated and does not accurately reflect the current state of scientific understanding i.e., BAS of wetland ecology and conservation. Recognizing this weakness DOE is reviewing wetland BAS and concomitantly revising the rating system with expected completion by late 2004 (McMillan pers. com.). King County has tried to overcome weaknesses in the DOE method by augmenting the existing classification-only approach with additional regulations covering wetland complexes, and landscape approaches including clearing and impervious area restrictions.

There are many ways of classifying wetlands for ecological and regulatory purposes with no one method being, or remaining, the optimum method. As scientists learn more about wetland characteristics and functions, classification and ranking methods change accordingly to better protect wetland functions. Currently, the science of classification is moving from the more descriptive historical assessment methods towards newer process-oriented, functional methods. The proposed CAO does not reflect this more comprehensive and empirical approach of classifying wetlands and consequently there is a high certainty that King County's chosen classification system will not adequately protect certain wetland types (e.g., fragmented wetlands, bogs) or some wetland functions (e.g., wildlife habitat).

In general, the level of risk to wetland functions and values will decrease from existing levels because the proposed CAO standards are more restrictive than the current SAO standards. However, risks remain because additional buffer widths may not provide adequate protection depending on wetland, adjoining area and watershed topography, soils, ground water, surface hydrology and vegetation conditions. The proposed DOE's ranking and classification system is also based mainly on habitat functions, with little emphasis on other wetland functions, which are important to protect. Hence these other functions may not be protected by fixed buffers to the extent that habitat is protected.

It is difficult to assess the potential effect of implementing the proposed CAO Classification System and its associated buffers on wetland functions, as King County's current information regarding wetland distribution, abundance, and characterization is incomplete. This fact is especially true for smaller wetlands and for forested wetlands, which are difficult to find through remote sensing techniques. There is little information regarding the functions that wetlands provide. Reasonably reliable habitat classification data exists (Cowardin et al., 1979) for most large, open water wetlands and select other wetlands that were surveyed in the past. Specific data on wetland habitat condition and data on other wetland functions are unavailable because formalized functional analysis did not exist during King County's historical wetland surveys in the late 1980s. Since these surveys, adjoining area and watershed development suggest that wetlands may be much different than twenty years ago. As a result, much of King County's assessment of wetland functions is based on historical descriptions and extrapolations, augmented by more recent remote sensing interpretations. Site-specific data can be gleaned from some project (e.g., development, restoration) specific reports, however, the overall lack of critical data necessary to assess specific wetland functions results in uncertainty when assessing the adequacy of fixed buffers for protecting wetland functions, and other standards, in the proposed CAO.

In summary, the chosen wetland rating system poses risks to wetland protection because it does not identify, consider, or rank the multiple functions that wetlands may exhibit. Included are relatively few and are biased towards habitat characteristics. Therefore the associated fixed-buffer widths and mitigation measures that are based on classification and rating may fail to adequately protect those functions not identified. Without adequate information on the additional functions needing protection, the level of risk remains high.

Buffers

Standard – Minimum Buffer Widths:

> *Minimum buffer widths of 300, 200, 100, and 50 ft. shall protect Category I-IV wetlands, respectively, in rural areas or within the Urban Growth Area if not a subdivision, short subdivision, urban planned development or binding site plan, with the exception of permitted alterations.*
>
> *Minimum buffer widths of 100, 50, 50, and 25 ft. shall protect Category I-IV wetlands, respectively, within the Urban Growth Area provided a functional assessment of the wetland and buffers is provided and approved. Restoration and enhancement will be required to restore the wetlands and its buffer to a fully functioning condition.*

Assessment:

This standard for minimum buffer widths in rural areas is within the range of recommendations in the BAS literature, while the standard in urban areas are lower and depart from the larger buffers suggested by BAS. However, BAS also indicates that wetland protection by fixed buffer widths alone may be insufficient. Specifically, fixed buffers are essential but inadequate to protect wetland functions because the buffers may not encompass the processes that drive respective wetland functions. Moreover, fixed buffers also allow development and other disturbances to completely encircle wetlands, thereby isolating such wetlands and segregating them from other

wetlands, aquatic habitats, and from essential upland habitats. Eventually such isolation leads to a shift in their wildlife and possibly the alteration of hydrology and other wetland functions.

Under ideal geologic, soil, and vegetation conditions, BAS suggests the recommended fixed buffers may be sufficiently wide to protect water quality of Category I and II wetlands in rural areas or Category I wetlands that have been enhanced per the report requirements in the urban areas. Buffers adjoining Category III, and IV wetlands in rural areas and Category II, III and IV in urban areas are at the narrow width limit for protecting wetlands from anthropogenic water quality impacts. Moreover, proposed buffers widths are insufficient to protect unique wetland vegetation and fragile wildlife that are sensitive to microclimatological changes associated with clearing or altering adjoining land. Proposed buffers may also not protect certain features of wetland hydrology and groundwater interactions, as these functions (given all conditions being equal) are proportional to buffer widths.

Level of Risk to Function and Values

In general, most wetland functions may be at some risk by only protecting wetlands in rural areas with standard, fixed 50 to 300 ft. wide buffers. Wetlands in urban areas will be at high risk for most or all wetland functions even with the enhanced buffer approach with the possible exception of water quality enhancement under unique conditions. Water quality enhancement functions on level terrain and for a well-vegetated, grass, shrub, and tree buffers, would exhibit the least level of risk. For wetlands greater than 500 feet from each other (i.e., non-complex wetlands), the greatest risk would be to maintain the full suite of wildlife functions as fixed buffers may not provide sufficient habitat for wetland species if development encircles wetlands. This level of risk in the rural area would be more difficult to judge because narrower buffers than in the urban area provide less remaining habitat and greater edge effect, although enhancement of the buffer itself could provide habitat features of benefit to some wildlife. Clearly, it would depend on the condition of the adjoining area, as a high quality, narrow rural buffer would not benefit from enhancement and would only be detrimentally impacted by narrower widths.

The risk of declines and local extinctions of native species increases as wetlands get physically isolated from each other by roads, development, and other potential barriers to migration. These risks would be greatest for amphibian and mammal populations as development, agriculture, forest practices, roads and other actions encircle entire wetlands, thereby isolating them from life-support habitat found at other wetlands and in upland watershed locations. The risk of declines would accelerate as populations become increasingly smaller from deterministic (e.g., pollution), and random (e.g., drought, freezing), and inbreeding. The risk to amphibians, birds, small mammals may also increase with urbanization beyond fixed buffers as bullfrogs, rats, cats, and dog populations increase and roam through buffers to prey on, or "play" with vulnerable wetland wildlife. The risk is highest in the urban areas where buffer widths are inadequate to provide protection from non-native wildlife.

BAS also suggests that the proposed maximum 300-ft buffer for rural areas is inadequate in most situations to protect microclimate (wind, humidity, temperature, soil moisture, etc.) within these and narrower buffers. Microclimate can not be protected in the urban area, even with the maximum 100-foot buffers for wetlands. Hence the existing soil conditions (e.g., organics, bacteria, mycorrhizal associates and fungi of decomposition) and vegetation associations in the buffer (mosses, herbs) most likely will change in proportion to buffer width. Often these climatological and soil changes enable non-indigenous species to outcompete and replace the

original biota. The risk to wetland groundwater and hydrological functions will vary widely depending on geology, soils, vegetation, topography and watershed size and condition. Therefore, the risk to wetland functions by the proposed buffers is conjectural, although with all things being equal, the least risk occurs to either of these two functions, microclimate and hydrology, when the buffers are largest and the greatest risk occurs in the urban areas.

Level of Uncertainty

Specific information relative to urbanization impacts to wetlands in King County does not exist regarding the optimum widths of buffers adjacent to wetlands and their respective effectiveness in protecting wetland functions. The best information covers buffer widths required to protect water quality enhancement functions of streams but even this data is mostly extrapolated from agricultural and silvicultural studies. Some data exists on the widths of various stream buffers and their wildlife following clearcutting of adjacent forests however these studies are relatively recent and therefore have not yet monitored wildlife for sufficient lengths of time. Moreover, clearcutting and subsequent reforestation impacts are significantly different than the permanent primary and secondary impacts of urbanization. Consequently, there is a high degree of uncertainty regarding the ability of 50-300-ft. buffer widths in rural areas to protect wetland hydrology, groundwater interchange, and fish, wildlife and habitat functions of specific wetlands from adjoining area and watershed urbanization. In contrast for wetlands in general within an urbanizing area, BAS suggests that wetland functions will definitely decline with only fixed buffers of 25 to 100 ft.

Standard – Buffer Averaging:

> *Minimum buffer widths may be modified on a case-by-case basis. There would be no net loss of buffer area and the buffer width is not reduced to less than 75 percent of the standard buffer width.*

Assessment:

Buffer averaging is consistent with BAS if implemented to increase widths and wetland functions at specific sites and concurrently not harm functions from reduced widths elsewhere. For this select situation, there would be equal total buffer area and a net increase in select functions, a goal supported by BAS.

Level of Risk to Function and Values

Buffer averaging provides the opportunity to decrease the level of risk to wetland functions if buffer widths are reduced where they are not necessary and increased where they would be beneficial. However, buffer averaging could pose an increased risk to functions if averaging increased buffers for one function at the expense of another. For example, at a wetland with low flood control function and high wildlife function, buffer averaging to increase the flood control function could pose a risk to wildlife function.

Level of Uncertainty

The implementation of ecologically supported buffer averaging may prove difficult without standardized empirically and scientifically accepted methods of consistently identifying and determining functions. In general, wetland ecologists do not have the tools to trade off buffer widths with a high degree of certainty unless adequate information has been obtained. Any certainty that does exist depends on function to be gained by increasing buffers. Consequently, the certainty of improved water quality enhancement function by wider grass, shrub, and tree buffer is greater than the certainty of improving groundwater recharge or wildlife functions. Clearly, it would take considerable studies of groundwater recharge capacities, including the presence and flow of aquifers, to reduce the uncertainty in providing groundwater interchange functions within an enlarged buffer. Finally, the increase in wetland buffers allowed by buffer averaging might only marginally benefit functions. For example, wildlife may additionally be protected from adjoining noises and other disturbances by wider buffer widths at certain locations but most likely will not benefit appreciably by the relatively small increases in habitat from buffer averaging.

Standard – Grazed and Tilled Wet Meadows:

Existing grazing and tilling activities may continue in wet meadows.

Assessment:

Wet meadows exhibit the ability to provide significant groundwater recharge, flood control, water quality enhancement, and wildlife functions depending on their vegetation, morphometry, soil porosity and subsurface geology. BAS suggests that grazing in wet meadows is compatible with BAS if best management practices (BMPs) are used (see Chapter 3, Section 3.2 Farm Planning). For example, if meadows are used for nesting or foraging by waterfowl and waterbirds, grazing may only be permitted at times when wildlife is not present or at locations where livestock will not harm wildlife.

Level of Risk to Function and Values

The timing and density of grazing can significantly increase the risk to wet meadow functions, particularly to water quality and wildlife functions The timing of grazing is controlled by the proposed BMPs therefore the risk from livestock may be low if animal units, timing and other aspects of meadow use are appropriate for the site. High livestock numbers however, can result in high nutrient concentrations within meadows and in runoff, potentially causing large algal blooms, anoxic conditions (of detriment to macrophytes, invertebrates, waterfowl and other taxa) and other eutrophic situation in nearby wetlands and other aquatic areas. Overgrazing may also lead to increase soil compaction, soil erosion and other disturbances leading to higher water quality and associated ecological risks from sediment runoff.

Level of Uncertainty

Compliance with BMPs would provide important certainty to protecting wet meadows from overgrazing and other detrimental agricultural effects. Storage sheds barns and additional

residences however may continue to be built on wet meadows reducing or eliminating the functions the replaced wet meadows may have been serving.

Mitigation

Standard – Mitigation Ratios:

> *Under special situations mitigation ratios shall be used to mitigate adverse impacts and will vary based on wetland location and category.*

Assessment:

The proposed CAO provides restoration and replacement ratios for wetland impacts and losses that are based on "best professional judgement", as there are no scientific studies that identify empirically determined mitigation ratios. The NRC (2001) references studies that imply a '1.5 to 1' ratio of 'mitigation to lost acreage' would be needed to equal the area lost (if all other permit conditions are met including functional equivalency). However, these ratios are often additionally adjusted to reflect temporal loss of wetland functions, functional values of the impact site, and other factors. Specifically, replacement ratios increase proportionately with the length of time it takes to reach equivalent function. Higher ratios are also suggested for replacing pristine wetlands with higher functional values than that for mitigating severely degraded wetlands, which essentially reflects scientific uncertainties in replicating certain kinds of wetlands. King County's proposed mitigation ratios are within the ratio range of BAS by requiring equivalent or greater function for impacts. However, King County ratios may be lower than what is implied by BAS when recognizing and considering the temporal lag in replacement of wetland functions. It is also lower than BAS in situations were equivalent or greater function is not possible, as for example, when replacing a mature forested wetland with a new shrub-scrub wetland.

The proposed CAO standard also differs from BAS in that it is based on wetland category, with the assumption that wetland category is a surrogate for function which may not necessarily be the case. BAS further notes that preferences for on-site and in-kind mitigation should not be automatic, but rather based on an analytical assessment method of the wetland needs in the watershed, and the potential for the compensatory wetland to persist over time (NRC 2001). Although King County has considered similar functional criteria in their mitigation process no formalized assessment tool is currently proposed.

Level of Risk to Function and Values

Mitigating for lost wetland acreage is difficult and highly risky. Functional replacement is even more difficult and requires extensive training, information gathering and monitoring. BAS indicates that mitigated wetlands have not yet succeeded in replacing lost acreage or functions with any predictability. Consequently the risk to replacement of wetland acreage and their functions and values remains high. Mitigation has not met the "no-net loss of area, function and values" goal in King County's Comprehensive Plan and if past performance is an indicator of future success the risks remain high. Wetland enhancement and restoration, regardless of proposed ratio, as mitigation for wetland losses always results in a decline of wetland acreage.

The risks of replacing lost functions and values depend at least on two factors: (1) the availability of restoration sites; and (2) the complexity of functions and values required to be replaced. If restoration sites are unavailable within the same basin as the impacted wetland then the risk is high that some of the irreplaceable functions that the wetland provided (e.g., groundwater interactions, habitat for wildlife, vegetation, recreation etc.) will be lost to that basin. It also remains uncertain whether flood control, water quality enhancement and other wetland functions that are lost by permitted activities can adequately be replaced through engineered projects. Regardless, a loss of functions remains between the time the permitted wetland is altered and the mitigated wetland provides the full capacity of the suite of functions of the original wetland.

Level of Uncertainty

The level of uncertainty in wetland mitigation in general does not lie in the ratios. Rather, to a large degree, success lies in the extent of project planning, construction, monitoring, and overall oversight. Consequently, with proper funding and other resources the uncertainty of success can be decreased and minimized regardless of ratios.

Standard – Mitigation Banking:

> *The department may approve mitigation in advance of unavoidable adverse impacts to wetlands caused by the development activities through an approved wetland mitigation bank.*

Assessment:

Wetland mitigation banking is a valuable compensatory mitigation tool to stem the loss of wetland functions and values. Mitigation Banking has been implemented in other regions in the U.S. and in Washington is being used by the Department of Transportation (WSDOT). King County has one mitigation bank. As recommended in the BAS literature, banks are established and fully functional prior to permitted losses at existing sites. In practice however, credits are released incrementally as hydrological performance and other developmental and functional stages are attained. When done carefully and according to specified standards such as those developed in the King County Mitigation Banking Rules, mitigation banking may successfully implement siting as recommended by BAS literature. The replacement of small, marginal wetlands of low, single function such as small totally isolated wetlands and those adjacent to roads and highways with larger wetlands of higher and potentially multiple functions is consistent with BAS. Nevertheless, concerns regarding replacement ratios (see previous section), in-kind versus out-of-kind replacement and bank sighting when projects are permitted that harm or destroy higher quality wetlands remain. Although BAS suggests that a wide diversity of banks, bank sizes and bank functions should be created, the economy of scale benefits may not be realized unless banks are of certain minimum size and in certain economically-determined locations. The proposed CAO provides the flexibility to mitigate with a diversity of bank sizes and functions and hence there is no departure from BAS. In practice however, market forces result in larger, easily constructed wetland types. Finally, mitigation banks are relatively new and have not been monitored long enough to ecologically assess their success or failures. Although wetland losses are mitigated by mitigation banking, empirically determined success of specific targeted goals for hydrology, water quality, vegetation, and wildlife functions are limited to only a few sites and not commonly undertaken.

Level of Risk to Function and Values

Decreases in total wetland acreage always occur when wetland enhancement and restoration mitigate wetland acreage loss. Otherwise mitigation banking poses a low level of risk as full functions are required to be demonstrated at the bank site prior to loss of any wetland functions at the permitted site. Currently however, restoration is not ideal, and credits are released prior to full wetland mitigation resulting in loss of wetland acreage and functions. Moreover, wetlands may not be replaced within the watershed in which they are situated; thereby posing risks to the remaining watersheds for unreplaced transferred functions. Risks of lost functions may accrue in areas of high mitigation pressure such as in urban areas as mitigation for lost functions moves elsewhere.

Level of Uncertainty

Generally there is less compliance uncertainty with mitigation banks than other wetland restoration programs because of their larger size and diverse institutional oversight. Larger sites also provide a greater economy of scale than smaller projects and potentially enables a more carefully thought out process considering all aspects of project design, construction and monitoring presumably leading to greater certainty in success. Uncertainty increases with respect to bank complexity and habitat types with permanent, smaller seasonal and semi-permanently flooded banks being difficult to create. Scientific uncertainty remains high regarding the best method for achieving overall functional benefits.

Allowed Alteration

Standards – Development Standards and Alterations:

> *Alterations identified in the proposed CAO (K.C.C. 21A.24.) are allowed within a wetland or wetland buffer if the alteration complies with all applicable requirements, standards, and mitigation requirements established in the proposed CAO.*

Assessment:

The County allows numerous actions that allow activities within a wetland or wetland buffer. For some situations, these allowed alterations might be inconsistent with recommendations suggested by BAS. These include some rural activities and the building of roads, utilities, and other necessary infrastructure. Data to the extent to which these activities influence wetland functions and are adequately mitigated is unavailable. Tree removal in buffers, for whatever reason, influences water budgets through transpiration and nutrient storage as mentioned in the literature review. The removal of trees and other vegetation influences microclimate, which in turn influences remaining plants and wildlife. Incrementally, and collectively these exemptions continue to erode the wetland base in King County and therefore reduce the multiple functions they may provide.

Reasonable Use Exemptions also may enable encroachment on wetlands and their functions if no other on-site development possibilities are available. Consequently, the non-mitigated exemptions and allowed alterations are not consistent with BAS for wetland protection if they

lead to incremental, cumulative losses in wetland area, functions and values. Conditions on allowed alterations may lessen these impacts but do not mitigate for their losses.

Level of Risk to Functions and Values

Individually departures under exemptions and allowed alterations are small and may seem not to pose any risk. Collectively however, they contribute to the cumulative loss of wetland functions and values because for the most part, these losses are permitted without mitigation. Consequently the immediate risk to wetlands may be small and localized although cumulatively over many years the risks increase and spread over larger areas. For many allowed alterations such as the construction of large roads and powerline corridors the impacts to wetland functions and values may not be mitigatable. For example, the groundwater interchange and wildlife functions of roads cannot readily be mitigated on site or replaced elsewhere. Roads and utility corridors may result in permanent habitat loss, reduced habitat quality and permanently fragment wildlife habitat resulting in smaller isolated populations and therefore increased risks of extinction. Roads additionally kill wildlife through animal vehicle collisions or harm animals through altered wildlife behavior. Roads and utility corridors also indirectly pose high risk to wetlands because of their large direct and indirect watershed and landscape effects.

In summary, BAS indicates that permitted activity whether residential, non-residential, silvicultural, agricultural or infrastructure related may have negative impacts on wetlands and their functions. In King County, some of these impacts do not have to be mitigated, and for the ones that do have to be mitigated, information indicates that the existing mitigation strategy is not working. Without specific assessments of departures, we should assume that larger projects and cumulatively smaller projects might continue to lead to wetland aerial and functional loss.

Level of Uncertainty:

Data on the number of exemptions and allowed alterations and their influence on wetland acreages and functions and values are unavailable. Hence the prevalence of risk to wetland functions and values remain undetermined. Conditions on allowed alterations may lessen these impacts but impacts nevertheless occur. There is little uncertainty in the ongoing and cumulative loss of wetland functions and values from unmitigated permitted activities.

POLICY DISCUSSION:

Buffers are one tool that King County is proposing in conjunction with clearing restrictions, rural stewardship, and other regulatory and incentive based provisions. The adopted King County Comprehensive Plan provides guidance as to the management strategy for protection of wetland functions:

> E- 132 King County's overall goal for the protection of wetlands is no net loss of wetland functions within each drainage basin. Acquisition, enhancement, regulations, and incentive programs shall be used independently or in combination with one another to protect and enhance wetland functions.
>
> E- 133 Development adjacent to wetlands shall be sited such that wetland functions are protected, an adequate buffer around the wetlands is provided, and significant adverse impacts to wetlands are prevented

The proposed ordinance requires that within the Urban Growth Area the applicant complete a critical area report showing that the wetland and its adjoining buffer are fully functioning, or have a restoration/ enhancement plan that will be implemented to achieve a fully functioning wetland and buffer.

Balancing of King County's other responsibilities under the Growth Management Act further influence the widths of buffers proposed, particularly within the Urban Growth Area. These responsibilities, outlined in the King County Comprehensive Plan are:

- ***Preserve the high quality of life*** by balancing infrastructure needs with social, cultural, educational, recreational, civic, health and safety needs.

- ***Spend money wisely and deliver services efficiently*** by:

- Concentrating infrastructure investments and service delivery to support the regional development pattern near cities where a full range of local services are located or can be made available;

- Solving service deficiencies within the County to meet existing service needs and phasing service improvements for the needs of future growth;

- Looking to King County to provide countywide facilities and services, and;

- Relying primarily upon cities and special purpose districts as the providers of local facilities and services appropriate to serve those local needs, except where the County is the local service provider (e.g., Rural Area).

- ***Continue our economic prosperity*** by promoting a strong and diverse economy for King County residents through policies and programs that encourage new business opportunities, increase family wage jobs and create a predictable regulatory environment for businesses and citizens.

- ***Increase the housing choices for all residents*** by permitting a wide variety of home styles and by increasing housing opportunities for all residents in locations closer to jobs.

- ***Ensure that necessary transportation facilities and services are available to serve development at the time of occupancy and use*** by targeting road and transit investments where growth is desired and for equitable contributions to the transportation system by new development.

- ***Balance urban uses and environmental protection*** through careful site planning that maximizes developable land while respecting natural systems.

- ***Preserve rural, resource and ecologically fragile areas for future generations*** by maintaining low residential densities in the rural areas and in areas containing regionally and nationally important ecosystems for fish and wildlife and by recognizing that resource lands, such as farms and forests, provide economic, social and environmental benefits.

With regard to grazed wet meadows and other agricultural practices, the proposed ordinance exempts existing agricultural activities. To apply standards retroactively would not only be detrimental to existing agricultural enterprises but also inconsistent with how other existing activities are regulated by this ordinance. In addition, King County Comprehensive Plan policies support ongoing agricultural activities as part of a diverse landscape.

> R- 503 King County shall promote and support forestry, agriculture, mining and other resource-based industries as a part of a diverse, regional and sustainable economy.
>
> R- 504 Well-managed forestry and agriculture practices are encouraged because of their multiple benefits, including natural resource protection.

FACET

Critical Areas Ordinance Update

Best Available Science Review

WALLA WALLA COUNTY

JUNE 16, 2026

Prepared for:

Walla Walla County Community
Development Services
310 W Poplar Street, Suite 200
Walla Walla, WA 99362

Facet Number:
2405.0337.00

FACET

Spokane Office
601 W Main Ave, Suite 617
Spokane, WA 99201
509.606.3600

The information contained in this report is based on the application of technical guidelines currently accepted as the best available science. All discussions, conclusions, and recommendations reflect the best professional judgment of the author(s) and are based upon information available at the time the study was conducted. All work was completed within the constraints of budget, scope, and timing. The findings of this report are subject to verification and agreement by the appropriate local, state, and federal regulatory authorities. No other warranty, expressed or implied, is made.

Acronyms and Abbreviations

BAS	Best Available Science
BMP	Best Management Practices
CAO	Critical Areas Ordinance
CARA	Critical Aquifer Recharge Area
Commerce	Washington State Department of Commerce
CRB	Columbia River Basalt
CMZ	Channel Migration Zone
DNR	Washington State Department of Natural Resources
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FFA	Frequently Flooded Area
FIRM	Flood Insurance Rate Map
FWHCA	Fish and Wildlife Habitat Conservation Area
GIS	Geographic Information System
GMA	Growth Management Act
HUC	Hydrologic Unit Code
LID	Low Impact Development
MAR	Managed Aquifer Recharge
OHWM	Ordinary High Water Mark
WWBWC	Walla Walla Basin Watershed Council
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries Service
PCBs	Polychlorinated Biphenyls
PHS	Priority Habitats and Species
RMZ	Riparian Management Zone
RCW	Revised Code of Washington
SPTH	Site Potential Tree Height
USACEs	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code

Table of Contents

1. Introduction 1

1.1 Best Available Science 1

1.2 Climate Change 2

2. Critical Aquifer Recharge Areas 3

2.1 Definitions 3

2.2 Existing Conditions 4

2.3 Functions and Values 4

2.4 Key Protection Strategies 5

2.5 Climate Change Effects 6

2.5.1 Strategies to Manage Climate Change Impacts on CARAs 7

3. Wetlands 7

3.1 Definitions 7

3.2 Existing Conditions 8

3.3 Functions and Values 9

3.4 Key Protection Strategies 9

3.4.1 Identification and Classification 9

3.4.2 Wetland Buffers 10

3.4.2.1 Buffer Approaches 11

3.4.2.2 Functionally Disconnected Buffer Areas 11

3.4.3 Mitigation 12

3.4.3.1 Mitigation Sequencing 12

3.4.3.2 Compensatory Mitigation 12

3.5 Climate Change Effects 13

3.5.1 Strategies to Manage Climate Change Impacts on Wetlands 14

4. Frequently Flooded Areas 14

4.1 Definitions 14

4.2 Existing Conditions 15

4.3 Functions and Values 15

4.4 Key Protection Strategies 16

4.5 Climate Change Effects 17

4.5.1 Strategies to Manage Climate Change Impacts on FFAs 17

5. Geologically Hazardous Areas 18

5.1 Definitions 18

5.2 Existing Conditions 18

5.3 Key Protection Strategies 19

5.4 Climate Change Effects 20
5.4.1 Strategies to Manage Climate Change Impacts on Geologically Hazardous Areas 20
6. Fish and Wildlife Habitat Conservation Areas 21
6.1 Definition 21
6.2 Existing Conditions 23
6.3 Functions and Values 27
6.4 Key Protection Strategies 28
6.4.1 Water Type Classification 28
6.4.2 Riparian Management Zones in the Dryland Ecoregion 28
6.4.3 Shrub-steppe Habitat 31
6.4.3.1 Landscape-scale Mapping 31
6.4.3.2 Site-scale Identification and Classification 31
6.4.3.3 Shrub-steppe Mitigation 33
6.4.3.4 Corridor Mapping 33
6.5 Climate Change Effects 34
6.5.1 Strategies to Manage Climate Change Impacts on FWHCAs 34
7. References 1

Tables

Table 1. WDFW Designated PHS that Occur in Walla Walla County. 25
Table 2. Water type classification. 28

Figures

Figure 1. The "FEMAT Curves" is a conceptual model of the contributions of key riparian ecosystem functions that influence aquatic ecosystems by distance and cumulative effectiveness. Tree height refers to the average relative height of the site potential tree height (reproduced from FEMAT 1993) 30

Appendices

APPENDIX A. Ecology's Wetland Buffer Width Recommendations
APPENDIX B. Ecology's Recommended Wetland Mitigation Ratios for Eastern Washington
APPENDIX C. Critical Areas Maps

1. INTRODUCTION

This review of the Best Available Science (BAS) was compiled to support the update of Walla Walla County's Critical Areas Ordinance (CAO). As mandated by the Washington State Growth Management Act (GMA), cities and counties must periodically update their comprehensive plans and development regulations. Walla Walla County's Comprehensive Plan underwent a complete update in 2019. This document establishes the framework for planned updates to the CAO, serving as a basis for a gap analysis that identifies areas where current critical area regulations should be prioritized for consistency with BAS.

Under the GMA, Walla Walla County must incorporate the "best available science" (BAS) when developing policies and regulations to protect the functions and values of critical areas. Additionally, "special consideration" must be given to conservation or protection measures necessary to preserve or enhance anadromous fisheries (WAC 365-195-900). Anadromous fish spend portions of their lifecycle in fresh and saltwaters, entering freshwater from the ocean to spawn. Regulated critical areas include wetlands, areas critical for aquifer recharge used for potable water (i.e., critical aquifer recharge areas), fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas (RCW 36.70A.030).

While this BAS review serves as a resource for critical area management, it is not designed to provide definitive answers for all policy and regulatory decisions. Policies and regulations should incorporate BAS and require decision-making processes grounded in societal values. Additionally, ecological systems are complex, and scientific knowledge continually evolves with new research and technology. Despite these advancements, there are limits to what is currently understood, and specific topics may remain ambiguous. Where scientific uncertainty exists in the literature about a particular subject, this review presents a range of potential ideas, theories, or findings. According to WAC 365-195-920, decision-makers may adopt a precautionary or no-risk approach when scientific information is incomplete.

1.1 Best Available Science

Best Available Science (BAS) refers to the most current and credible information developed through a valid scientific process as specified in WAC 365-195-900 through WAC 365-195-925. Characteristics of a valid scientific process include peer review, standardized methods, logical conclusions and reasonable inferences, quantitative analysis, proper context, and relevant references. Common sources of scientific information are research, monitoring, inventory, modeling, assessment, and synthesis (WAC 365-195-905). BAS literature reviews synthesize the current scientific knowledge, and only resources meeting these criteria are included as references for this BAS.

Walla Walla County adopted the most recent CAO in 2019. HDR prepared a BAS review in 2008. Various memoranda and reports were prepared to supplement the 2008 BAS review. Today, much of the

foundational science regarding critical areas remains valid. This BAS review does not aim to repeat information that has already been comprehensively addressed. Instead, it summarizes or references established science or previous findings where applicable. The previously referenced studies are listed below:

- Best Available Science Review, 2008- HDR, Inc.
- Frequently Flooded Areas Map, 2019- Walla Walla Community Development Department
- Geologically Hazardous Areas Map, 2019- Walla Walla Community Development Department
- Seismic Hazard Areas Map, 2019- Walla Walla Community Development Department
- Wetland Areas Map, 2019- Walla Walla Community Development Department
- Critical Aquifer Recharge Areas Map, 2019- Walla Walla Community Development Department
- BAS Update for CARA (Shallow Gravel Aquifer), Walla Walla County, 2011- Golder Associates
- Technical Memorandum: Response to Compliance Issues From Eastern Washington Region Growth Management Hearings Board-Walla Walla County Critical Aquifer Recharge Area, 2012- Golder Associates (includes map exhibits)

1.2 Climate Change

As of July 2023, with the passage of Washington House Bill 1181: Climate Change in Local Comprehensive Planning, the GMA requires jurisdictions to incorporate and evaluate the effects of climate change in long-range planning. Climate change is anticipated to have a profound influence on natural systems. Addressing anticipated climate change impacts on critical areas enables decision-makers to incorporate climate resilience into policies and regulations. This section provides an overview of predicted climate change effects in Washington State that can alter the critical area functions and values in Walla Walla County. These predicted effects are referenced and expanded upon throughout the document.

Increasing air temperatures and more extreme heat

- Long-term warming, a lengthening of the frost-free season, and more frequent nighttime heat waves have been observed (Mauger et al. 2015).
- Models predict more "hot days" each year (Ecology 2024).
- Global warming of about 1°C has already occurred. Warming may exceed 1.5°C (2.7°F) by 2030 (Snover 2019).

Seasonal changes to precipitation patterns

- Increases in both the frequency and intensity of heavy rainfall events have been documented in Washington (Mauger et al. 2015).
- Summer precipitation will decrease (Mauger et al. 2015), and droughts will be more common (Ecology 2024).

- An observed and projected decrease in snowpack is anticipated to result in reduced stream flows later in the year (Ecology 2024).
- With less snow and more frequent, heavier precipitation events, increasingly large and more frequent floods are predicted (Ecology 2024).
- Changes in precipitation patterns, snowmelt intensity, and timing, combined with increased summer demand from people and ecosystems, are anticipated to reduce groundwater availability (Ecology 2024).

Increasing risk of wildfire and smoke

- Hotter, drier summers and snowpack loss are projected to result in conditions that increase the likelihood of wildfires (Mauger et al. 2015).
- Smoke from wildfires elsewhere often moves into adjacent areas. Projections for future changes in the frequency or intensity of wildfire smoke are unavailable (Ecology 2024). The impact of wildfire smoke on natural systems is not fully understood (Voisin et al. 2023).

Changing environmental conditions for flora, fauna, and pathogens

- Climate change effects are anticipated to alter the timing of biological events, species' geographic distributions, productivity, and resilience of terrestrial ecosystems (Mauger et al. 2015).
- The prevalence and location of certain pests and pathogens will likely shift. Responses are likely species- and host-specific (Mauger et al. 2015).
- Introduced, adaptable species may experience greater opportunity to become established and spread after disturbance, while locally evolved flora and fauna may experience stress from environmental changes that exceed historic ranges/thresholds. Plant and animal adaptability and resilience to climate change vary by species.

2. CRITICAL AQUIFER RECHARGE AREAS

2.1 Definitions

Critical aquifer recharge areas (CARAs) are defined in WAC 365-190-030(3) as follows:

> *Critical aquifer recharge areas are areas with a critical recharging effect on aquifers used for potable water, including areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water, or is susceptible to reduced recharge.*

The Walla Walla County CAO defines CARAs as follows (WWMC 18.08.020):

> *Areas designated under WAC 365-190-080 that are determined to have a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030(3).*

2.2 Existing Conditions

As stated in the 2008 *Walla Walla County; Critical Areas Ordinance Best Available Science Review*, the Walla Walla Basin contains two principal aquifers: 1. The shallow gravel aquifer, which is made up of unconsolidated sediments located above a clay layer in the county's south-central lowland region and extends across the state line into Oregon, and 2. The underlying basalt aquifer spans Walla Walla County and the Walla Walla River basin. The gravel aquifer covers approximately 190 square miles, with about a third of that area in Oregon. In contrast, the basalt aquifer system in the Walla Walla River basin encompasses roughly 2,500 square miles, including the portion located in Oregon. (HDR 2008)

The gravel aquifer typically occurs under unconfined or water-table conditions, though there are a few exceptions. This shallow aquifer has moderate to high permeability, meaning it can transmit water effectively. The highest permeabilities are found in the sands and gravels near stream and river channels. The gravel aquifer is also hydraulically connected to the streams, canals, and ditches above it. Water moves into and out of the gravel aquifer through various mechanisms, including rainfall, snowmelt, rivers, streams, ditches, and irrigation, which allows water to infiltrate and percolate through the ground. (HDR 2008)

The Columbia River Basalt (CRB) formation beneath Walla Walla County consists of three major formations separated by sedimentary interbeds that generally impede water movement but can act as aquifers. These formations are combined and referred to as the "basalt aquifer." This aquifer comprises interconnected layers of basalt flows, typically ranging from 5 to 150 feet thick, with only 5 to 10 percent of the thickness contributing to water transmission. The basalt aquifer has high permeability, with groundwater flow following low-lying areas where most groundwater storage occurs. The depth to water-bearing zones varies widely, and groundwater is generally found under confined conditions. The basalt aquifer discharges primarily into streams, maintaining summer flows in Mill Creek and the Walla Walla River, and contributes to the Columbia and Snake Rivers. Generally, recharge occurs from the Blue Mountains and the Walla Walla River Basin. (HDR 2008)

The hydraulic connection between the gravel and basalt aquifers is not fully understood. Some evidence suggests upward and downward flow through the clay layers, but modeling estimates indicate a predominance of upward movement from basalt to gravel. This connection may be less direct than previously thought, suggesting that changes in basalt pumping may have less impact on gravel aquifer levels and flow patterns. (Golder 2007).

2.3 Functions and Values

CARA functions and values include drinking water supply, base flow to streams, discharge to and recharge from wetlands, and storage of infiltrated precipitation.

Agricultural, residential, commercial, and industrial development can disrupt the natural hydrologic cycle. Removing vegetative cover, damaging native soil structure, altering surface drainage patterns, and introducing impervious surfaces such as roads and compacted soils can cause these disruptions.

Additionally, the loss of water in stream channels and riparian areas due to withdrawals and consumptive use further decreases groundwater recharge (Ecology 2021a).

These changes significantly affect groundwater flow and storage through interactions among land use, vegetation, and the soil-root zone. Vegetation plays a significant role in groundwater recharge through evapotranspiration. Grasslands generally demonstrate higher recharge levels than forests (Kim and Jackson 2012). Beyond this, vegetation enhances groundwater recharge by reducing runoff and increasing soil porosity (Xiao et al. 2024). Observed declines in groundwater levels are primarily attributed to changes in recharge rates and withdrawals from wells.

The Hirst Decision (Whatcom County vs. Hirst) is a landmark 2016 case in which the Washington State Supreme Court ruled that water is not legally available for new wells if their use would impact a protected river or stream or an existing senior water right. In response to this ruling, the Washington State Department of Ecology collaborated with local partners to develop watershed plans and implement the Streamflow Restoration Act (RCW 90.94) in the affected Water Resource Inventory Areas (WRIAs).

The federal Safe Drinking Water Act empowers the Environmental Protection Agency (EPA) to designate certain aquifers as sole or principal drinking water sources for specific areas. To qualify for this designation, a sole source aquifer must provide at least 50 percent of the drinking water for the people living above it, and there must be no viable alternative sources of drinking water available. Currently, no sole source aquifers have been designated in Walla Walla County. (HDR 2008)

2.4 Key Protection Strategies

Walla Walla County regulations, including classification, prohibited activities, site assessment requirements, and mitigation for impacts, are specified in WWMC 18.08.200-.270.

Key protection strategies for CARAs are based on identifying and protecting CARAs through regulations and educational community outreach. The 2021 Ecology CARA Guidance recommends the following eight steps to characterize and protect CARAs in a local community (Ecology 2021).

1. *Identify where groundwater resources are located.*
2. *Analyze the susceptibility of the natural setting where groundwater occurs.*
3. *Inventory existing potential sources of groundwater contamination.*
4. *Classify the relative vulnerability of groundwater to contamination events.*
5. *Designate areas that are at risk of contamination events.*
6. *Protect by minimizing activities and conditions that pose contamination risks.*
7. *Ensure that contamination prevention plans and best management practices (BMPs) are implemented and followed. Review BMPs for infiltration designs with water quality treatment. Stormwater control usually affects the vadose zone and seasonal water tables with low risk to deeper water supply aquifers. Some exceptions are those glacial outwash plains with extensive deposits of coarse gravels near the surface.*

8. *Manage groundwater withdrawals and recharge impacts to maintain availability for drinking water sources and maintain stream base flow from groundwater to support in-stream flows, especially for salmon-bearing streams.*

Watershed planning is recommended to maintain in-stream flow, as required by the 2018 Streamflow Restoration Act, and to support water supply planning under the 1998 Watershed Planning Act (Ecology 2021). In addition, remediation of contaminated sites and groundwater, and the treatment of existing sources of pollution, should be a primary focus for Walla Walla County.

2.5 Climate Change Effects

As summarized below, regional trends influence climate change and impact groundwater quality and quantity. Changes in surface water inputs can alter the timing, frequency, and duration of surface water presence and are projected to alter hydrologic patterns, potentially affecting interactions with groundwater.

- Changes in precipitation levels in summer may reduce ground surface saturation during the growing season (Mauger and Won 2019). Higher temperatures will also increase the rate of evaporation in surface waters. This will likely reduce wetland areas and the groundwater recharge they provide during the dry season. In addition to anthropogenic consumption, this can affect streams, wetlands, and other surface waters that are impacted by groundwater.
- Wildfires will introduce more particulates and contaminants into the environment, which settle on surface water and infiltrate into groundwater (Burton et al. 2016; Mansilha et al. 2020).
- Increased winter flooding increases the likelihood of overwhelming stormwater treatment facilities and flooding roads. This results in the transportation of contaminants into surface water, including local streams and wetlands, that can infiltrate and contaminate aquifers (Mauger and Won 2019).
- Demand for aquifers may increase as crops require greater groundwater consumption to compensate for changes in precipitation levels.

Altered precipitation patterns resulting from climate change are projected to include earlier peak stream flows, increased flooding frequency and extent, and reduced summer flows (Mauger et al. 2015). Groundwater is believed to be more resilient to the effects of climate change relative to surface water resources (HDR 2019). Changes in the timing and amount of groundwater recharge, and increased pressure to use groundwater as surface water conditions change, are the primary stressors to aquifers. Ecology recommends understanding water resources, tracking water levels and recharge sources, and focusing on water conservation to plan for climate change impacts (Ecology 2021).

Other stressors on CARAs that may require further study include reclaimed water use and temporary construction dewatering. Ecology recommends that jurisdictions conduct a multi-year infiltration study (Ecology 2021). The Walla Walla Basin Watershed Council (WWBWC) and Ecology jointly manage the Washington managed aquifer recharge (MAR) sites and monitor water quality associated with the groundwater recharge project, including polychlorinated biphenyls (PCBs), nitrogen, phosphorus, total

suspended solids, and turbidity. This information primarily comes from four MAR sites and is used to assess whether additional PCB monitoring will be required (Ecology 2021c). Population growth also challenges the protection of CARAs as land use increases (Ecology 2021). For example, multi-year droughts can increase reliance on groundwater sources, lead to reductions in groundwater tables, aquifer depletion, and potentially result in saltwater intrusion (Asinas, Raymond, and Mehta 2022).

2.5.1 Strategies to Manage Climate Change Impacts on CARAs

- Manage and treat stormwater runoff to maintain groundwater recharge and preserve water quality in CARAs. Utilize a 20-year planning horizon to manage supply and demand, given climate trends and projections (Asinas, Raymond, and Mehta 2022).
- Design stormwater systems to better mimic natural systems and mitigate some functions lost elsewhere in the landscape due to surface and groundwater input changes. For example, the use of roadside bioswales may be expanded. Stormwater treatment capacity may be increased to protect water quality and manage water quantity.
- Planning and implementing flood mitigation strategies can reduce the likelihood of contaminated runoff events.
- Preserve open space and concentrate urban development away from CARAs.
- If necessary, strengthen regulatory protection of CARAs. For example, the County may review the CARA mapping, determine the highest risk to drinking water, and prioritize protecting those areas. The County can reduce the risk of groundwater contamination by prohibiting high-risk land uses within high-priority areas. Public outreach education on best management practices (BMPs) for spills and leaks can also be improved.
- Maintain updated CARA maps and classifications.
- Review regulatory requirements for reclaimed water use and temporary dewatering during construction to ensure adequate protection. This may involve additional County-specific studies.
- Continue to modify public outreach efforts to educate residents about best practices in CARAs and promote water conservation and use efficiency programs.
- Promote and incentivize low-impact development, specifically infiltration of clean runoff to support aquifer recharge.
- Balance growth and development with preserving and restoring open spaces and native vegetation tracts.

3. WETLANDS

3.1 Definitions

Washington State defines wetlands in WAC 365-190-030(24) as follows:

"Wetland" or "wetlands" means areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. However, wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate conversion of wetlands, if permitted by the county or city.

The Walla Walla County CAO defines wetlands as follows (WWMC 18.08.020):

Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do not include those artificial wetlands intentionally created from non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from non-wetland areas to mitigate the conversion of wetlands. For identifying and delineating a wetland, local government shall use the approved federal wetland delineation manual and applicable regional supplements, as amended.

3.2 Existing Conditions

Walla Walla County is situated within the rain shadow of the Cascade Mountains, resulting in mainly semi-arid conditions. Wetlands, predominantly riparian wetlands, form along perennial drainageways due to limited water availability. Major drainage corridors in Walla Walla County are the Walla Walla River, Touchet River, Mill Creek, Yellowhawk Creek, and the Snake and Columbia Rivers. Wetlands also tend to be located in depressions, at the base of slopes, and along the margins of lakes and ponds.

While isolated wetlands are less common in Walla Walla County, unmapped vernal pools may be present in this landscape setting. Vernal pools are a special type of wetland that occur in eastern Washington. They are seasonal wetlands that form when small depressions in scabrock or shallow soils fill with rain or snowmelt in the spring, then dry out by the summer. Vernal pools and other wetlands provide important habitat for migratory birds and other wildlife (Hruby 2014).

Agricultural activities, such as surface water diversion for irrigation, also have the potential to influence the distribution and types of wetlands in the county. For example, return flows from agriculture can create wetland conditions in low areas. Wetlands provide essential benefits to humans and wildlife. Wetland locations in the county are shown in the 2019 Critical Areas Maps (Appendix C).

3.3 Functions and Values

Wetland processes provide a range of functions that offer significant social, ecological, and economic benefits. This analysis focuses on three key functional categories—water quality, hydrology (water quantity), and habitat—that greatly influence natural and built environments. Wetland values refer to the resources that wetlands provide, which society values for their ecological, economic, recreational, or aesthetic benefits.

The functions of wetlands are influenced by their hydrogeomorphic characteristics, which affect water movement through the wetland system (Brinson and Vicksburg 1993). For example, wetlands located in depressions (depressional wetlands) have a greater capacity for floodwater retention than slope or flat wetlands. Additionally, landscape and site-scale characteristics—including vegetation structure, hydroperiods, proximity to potential pollution sources, and connectivity to priority habitat corridors—can impact wetland functions. Many of the services that wetlands provide benefit society, such as water storage, flood protection, pollutant and nutrient reduction, and habitat support for fisheries (Hattermann, Krysanova, and Hesse 2008). Since these functions occur naturally or through restoration projects, they are often less expensive than engineered solutions (Hattermann, Krysanova, and Hesse 2008).

In Washington, wetland functions and values are typically categorized using a rating system for regulatory purposes. The most widely accepted rating system, the *Washington State Wetland Rating System for Eastern Washington: 2014 Update,* was developed by the Department of Ecology and is the regional standard utilized by all regulating agencies (Hruby 2014). This rating system serves as a rapid assessment tool that evaluates wetland functions of water quality, hydrology, and habitat within a framework that considers site potential, landscape potential, and societal value (Hruby 2014). The rating system also accounts for classification of wetlands based on special characteristics rather than functions; vernal pools are a type of wetland that is rated based on special characteristics.

3.4 Key Protection Strategies

Wetlands are protected through local, state, and federal regulations that require impact avoidance, minimization, and mitigation. Effective wetland protection strategies include regulatory protocols to identify and classify wetlands, assign buffer widths, and require impact avoidance and compensatory mitigation for any wetland or buffer impacts. Additionally, local and landscape-scale corridors can be protected by establishing corridor-related regulations for developments near wetlands.

3.4.1 Identification and Classification

To protect wetlands, they must first be identified by a qualified professional. The nationwide standard for wetland delineations is the 1987 U.S. Army Corps of Engineers (USACE) *Wetlands Delineation Manual*, with the *Regional Supplement to the Corps of Engineers Delineation Manual: Arid West Region (Version 2.0)* (USACE 2008) applicable to delineating wetlands in Walla Walla County. The Regional Supplements provide greater detail on determining the presence or absence of wetlands specific to the land resource regions.

The *Ecology Wetland Rating System for Eastern Washington* was first issued in 2004, annotated in 2006, and revised in 2014. One significant change during the 2014 update was the addition of intermediate categories for each assessed function, with high, medium, or low rankings. These were thought to reflect the tool's coarseness better. Additional clarifications were added to the rating system guidance in Version 2 to incorporate annotations from the prior version (Hruby 2014).

The jurisdictional status of a wetland can vary depending on the government agency and the applicable statutory regulations. For example, the CWA applies only to wetlands that meet specific criteria for connectivity to water in the U.S. and does not apply to isolated wetlands. Local and state wetland regulations are more broadly encompassing but generally exclude artificially created stormwater features.

3.4.2 Wetland Buffers

Wetlands in Washington are protected from surrounding land uses through buffer requirements based on recommendations from the Department of Ecology. Like wetlands, buffers also provide functions that have ecological, sociological, and economic benefits. Wetland buffer functions include moderation of stormwater inputs, sediment removal, pollutant abatement, microclimate, habitat for wetland-dependent fauna, habitat connectivity, and disturbance screening (Sheldon et al. 2005). Buffer functions vary depending on factors such as vegetation community, gradient, soil conditions, and adjacent land-use intensity (Sheldon et al. 2005).

In 2005, Sheldon et al. synthesized the science for wetlands in Washington, including buffer width efficacy. The synthesis discusses buffer widths relative to water quality functions, hydrologic maintenance, wildlife habitat, and the effectiveness of disturbance barriers. Due to the similarity of processes and functions, studies on stream buffer widths were compiled into the synthesis (Sheldon et al. 2005). In 2013, Hruby developed the *Update on Wetland Buffers: The State of the Science* report to update the science related to wetland buffers. While most of the conclusions from the 2005 literature review are still valid, the following is a summary of the key findings of the 2013 review:

- Many factors contribute to a wetland buffer's effectiveness in protecting water quality, including width, slope, vegetation type, soil geochemical and physical properties, source and concentration of pollutants, and the path of surface water through the buffer.
- In general, wider buffers provide greater functions than narrower buffers.
- Buffer processes depend on site-specific environmental factors, meaning different buffer widths may be needed to achieve the same level of protection.
- Protecting wetland-dependent wildlife requires a broad, landscape-based approach that considers habitat corridors and connections.
- Undisturbed upland habitats are necessary for many animal species, specifically amphibians (Hruby 2013).

3.4.2.1 Buffer Approaches

Ecology recommends wetland buffers framed around several alternatives in *Wetlands in Washington State - Volume 2: Guidance for Protecting and Managing Wetlands– Protecting and Managing Wetlands, Appendix 8-D* (Granger et al. 2005) and the 2022 Ecology *Guidance for Critical Area Ordinance Updates*. Both guidance documents provide similar but slightly differing approaches and are consistent with BAS.

Current Ecology wetland guidance documents outline the following primary factors to consider when determining buffer widths (Ecology 2022):

- The wetland type and the functions needing protection (buffers filter sediment, excess nutrients, and toxics; screen noise and light; provide forage, nesting, or resting habitat for wetland-dependent species, etc.),
- The types of adjacent land use and their expected impacts, and
- The characteristics of the buffer area (slope, soils, vegetation)

The current Ecology guidance for CAO updates presents three alternatives for wetland buffers. See Appendix A of this report for a detailed summary.

As buffer determination options are reviewed, it is essential to note that "Ecology's buffer width recommendations are based on the assumption that the buffer area is well vegetated with native species appropriate to the ecoregion." (Ecology 2022). Those buffer options are summarized below and provided in Appendix A.

- **Option 1.** Width is based on wetland category and habitat score if minimization measures are applied and a habitat corridor is provided. If minimization measures are not implemented and a habitat corridor is not included for wetlands with moderate to high habitat scores, then buffer width requirements increase. Modified buffers should not exceed 75 percent of the otherwise required buffer. Option 1 provides the most flexibility.
- **Option 2.** Width is based on wetland category and modified by the intensity of the impacts from proposed land use. Option 2 decreases regulatory flexibility and eliminates buffer averaging and reduction provisions by applying corridors and minimization measures.
- **Option 3.** Width is based on wetland category only. Option 3 is the least flexible and simplest to administer.

3.4.2.2 Functionally Disconnected Buffer Areas

Standard buffer widths are sometimes interrupted by existing development. When a buffer area is functionally disconnected from a wetland by legally established development, Ecology recommends providing clear direction on how buffer regulations address this condition, with specific criteria. A distinction between the uses associated with different types of developments is central to determining if a functional barrier is present (Ecology 2022). Developments such as trails, accessory structures, and driveways for a single residence are generally not considered interruptions because they typically do not completely block wetland buffer functions (Ecology 2022). Developments associated with the

complete loss of buffer functions include public infrastructure (paved roads, railroads), housing, and commercial structures. An interruption may affect all or part of a buffer area (Ecology 2022).

3.4.3 Mitigation

3.4.3.1 Mitigation Sequencing

Mitigation sequencing is the structured process of avoiding, minimizing, and mitigating all impacts to a particular resource. Walla Walla County has incorporated mitigation sequencing into its existing wetland regulations, as outlined in WWMC 18.08.346-.350. This is intended to align with directives to achieve no net loss of wetland functions and values. Mitigation sequencing is also required by the 2008 Wetlands Compensatory Mitigation Rule issued by the U.S. Environmental Protection Agency (2008) and WAC 197-11-768. Per current Ecology guidance for CAO updates, mitigation sequencing must be applied in the following order (Ecology 2022):

- *Avoiding the impact altogether by not taking a certain action or parts of an action;*
- *Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts;*
- *Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;*
- *Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action;*
- *Compensating for the impact by replacing, enhancing, or providing substitute resources or environments; and/or*
- *Monitoring the impact and taking appropriate corrective measures.*

3.4.3.2 Compensatory Mitigation

Compensatory mitigation may be achieved through a programmatic approach or an approved permittee-responsible mitigation (PRM) plan. Programmatic approaches use third-party sponsors to obtain mitigation credits, such as through a mitigation bank or an in-lieu fee (ILF) program. PRM is an applicant-managed mitigation project. PRM is typically developed and implemented concurrently with wetland impacts, but may be done in advance. Mitigation banks are state-certified to ensure ecological function replacement is achieved. ILF programs collect fees and allocate funds to restoration projects within their service areas. The USACE and Ecology review and approve ILF programs. To achieve approved mitigation plan goals and performance standards, PRM applicants must complete installation, site maintenance, monitoring, and adaptive management (Ecology 2021b).

Ecology's recommendations for mitigation ratios for projects in Eastern Washington depend on the wetland category and the type of mitigation action (Granger et al. 2005). Mitigation ratios for direct wetland impacts are increased for temporal losses (Ecology 2021b). Current mitigation ratios recommended by Ecology are provided in Appendix B of this report. When applying advanced mitigation, the Ecology-recommended ratios account for the wetland category and proposed mitigation actions (Ecology 2021b).

Ecology has developed additional guidance and tools for applicants to address ecological priorities in Washington State's watersheds. These include details on using a watershed approach for mitigation site selection and the credit-debit method (Hruby 2012; Hruby, Harper, and Stanley 2009). The credit-debit method is a system that calculates the mitigation credits needed for a given project. Credit calculations can be used to determine compensation when utilizing in-situ mitigation, a mitigation bank, or an in-lieu fee program. Depending on specific site conditions, this may result in less or more mitigation than required under a set traditional mitigation ratio guidance (Hruby 2012).

Compensatory wetland mitigation methods in order of preference are (Ecology 2021b):

1) Restoration: Re-establishment,
2) Restoration: Rehabilitation- hydrologic processes restored,
3) Creation (establishment),
4) Preservation, and
5) Enhancement

Preservation and enhancement-only mitigation are least preferred since they result in a net loss of wetland area. Ecology prefers to see preservation or enhancement in combination with a no net loss mitigation method, such as wetland creation (Ecology 2021b).

Ecology recommends applying at least a one-to-one ratio to buffer impacts (Ecology 2022). A ratio greater than 1:1 may be required to replace all lost critical area functions. Ecology also recommends evaluating indirect wetland impacts for appropriate compensatory mitigation (Ecology 2021b).

3.5 Climate Change Effects

Climate change is predicted to significantly impact wetland ecosystems by altering hydrology, reducing biodiversity, disrupting carbon storage, modifying community composition, and increasing disease rates (Aukema et al. 2017; Burkett and Kusler 2000). Altered hydrology and precipitation patterns from climate change can result in earlier drawdowns of wetlands during droughts. This process will likely result in significant wetland loss where hydrologic conditions modify community composition. (Gallagher, Zhang, and Chuan 2022). Wetlands may also experience greater polarity in seasonal water levels, with increased ponding during wet seasons and decreased water levels during dry seasons (Halabisky 2017). Climate change impacts biodiversity through various effects that alter habitats relative to historical baselines and reduce biodiversity (Aukema et al. 2017). Furthermore, warming effects may disrupt carbon storage by reducing storage rates or even reverting some wetlands from carbon sinks to carbon sources, particularly in boreal peatlands (Burkett and Kusler 2000).

Wetlands also provide functions that help mediate climate change impacts. Wetlands and wetland buffers, like riparian corridors, support a shaded and cool microclimate that provides refuge for wildlife from higher temperatures and wildlife corridors at a local or landscape scale (ASWM 2015). Additionally, wetlands help offset climate change through carbon storage by protecting the remineralization of organic stocks and sequestering greenhouse gas emissions (Gallagher, Zhang, and Chuan 2022). Carbon stocks in undisturbed wetlands are approximately twice as high as carbon storage

in wetlands disturbed by human-driven land use changes. However, it is uncertain whether this is a causal relationship or influenced by human settlement patterns in avoiding the wettest sites, which are challenging to develop (Nahlik and Fennessy 2016). If disturbed, bogs and peatlands are important carbon sinks that could release hundreds of years of stored carbon (Nahlik and Fennessy 2016).

Although wetlands are dynamic by nature, the ability to adapt to change is limited. Alterations in stormwater runoff conditions and changes to seasonal wetland hydrologic cycles can reduce the ability of wetland soil bacteria and plants to retain, process, and sequester pollutants (EPA 2015). Seasonal changes in snow pack and precipitation can impact vernal pools, an important source of early spring water and food for waterfowl (Hruby 2014). Climate change impacts native plant species distribution; adaptive potential and climate tolerance are being studied in the scientific community (Vose et al. 2012). For example, native plant source information on adaptation and genetic diversity is generally lacking (Kramer et al. 2019). Strategies in agriculture, such as elements of the Climate Resilience Plan for Washington Agriculture (WSDA 2025) may also benefit native plants.

3.5.1 Strategies to Manage Climate Change Impacts on Wetlands

- Continue encouraging and incentivizing direct wetland impact avoidance to maintain existing carbon storage.
- Continue to regulate wetland buffers to promote and require retention or limitations of width, and to enhance with native vegetation. Both the voluntary planting of restoration and the planting of restoration needed can be paired with monitoring and maintenance that allow for dry-season irrigation and adaptive management. Monitoring voluntary planting is not required, however can be done on a good faith effort.
- Continue to manage and regulate stormwater infrastructure to avoid and minimize discharges of untreated runoff to wetlands.
- Consider selecting native plants from locations better adapted to future climate conditions, such as locally adapted plants (Baughman et al. 2019).

4. FREQUENTLY FLOODED AREAS

4.1 Definitions

Frequently flooded areas (FFAs) are defined in WAC 365-190-030(8) as follows:

> *Frequently flooded areas are lands in the flood plain subject to at least a one percent or greater chance of flooding in any given year, or within areas subject to flooding due to high groundwater. These areas include, but are not limited to, streams, rivers, lakes, coastal areas, wetlands, and areas where high groundwater forms ponds on the ground surface.*

The Walla Walla County CAO defines FFAs as follows (WWMC 18.08.400):

A. *All areas within the county meeting the frequently flooded definition, regardless of any formal identification, are hereby designated critical areas and are subject to the provisions of this Chapter. The flood areas are classified as either one of two types:*

    1. *Floodway: Floodways are defined as the channel of a stream and adjacent land areas which are required to carry and discharge the flood water or flood flows of any river or stream associated with a regulatory flood.*

    2. *Floodway Fringe: The flood fringe is defined as that land area which is outside a stream's floodway, but is subject to periodic inundation due to flooding, associated with a regulatory flood.*

B. *These flood areas have been accurately delineated based on hydrologic and hydraulic studies completed by the Federal Emergency Management Agency in 1983, and as subsequently revised and amended.*

4.2 Existing Conditions

In 2024, Walla Walla County, in collaboration with local officials and the cities of College Place, Prescott, Waitsburg, and Walla Walla, updated the 2010 Walla Walla County Multi-Jurisdictional Hazard Mitigation Plan. The Mill Creek Flood Control Zone District and Walla Walla Public Schools were also involved in this update, alongside various local, state, and federal agencies. FEMA approved the finalized plan in October 2018. The current Flood Insurance Rate Maps (FIRMs), effective December 1, 1983, serve as the basis for identifying flood-prone areas and regulating development in the County's floodplains. While three individual panels were updated on January 18, 2002, FEMA is modernizing all FIRMs through its Map Modernization program. However, it does not currently have plans to update Walla Walla County's Flood Insurance Study and FIRMs. As a result, the existing FIRMs will likely remain the County's primary resource for the next several years. In the early 1980s, Walla Walla County and Waitsburg received FIRMs and Flood Boundary and Floodway Maps (FBFMs). College Place and Prescott received mapping efforts in 2001 and 2002, respectively, while Walla Walla was never mapped. These tools help identify flood risks and define river channels and adjacent areas needed to manage floodwaters effectively.

4.3 Functions and Values

Floods are regularly occurring weather events that can destroy property and cause loss of life, but are also responsible for ecological processes that sustain river systems. Floods typically occur following significant storm events but may also result from impounded water collapsing, such as from a dam or levee failure or beaver activity. FFAs are dynamic and ecologically productive environments that provide essential habitats for fish and wildlife and floodplain storage that alleviates downstream flood zone impacts. These processes overlap with many of the functions of Fish and Wildlife Conservation Areas (FWHCAs) as discussed in Section 6.3, so this section briefly summarizes processes related to floodplain dynamics.

Dynamic hydrologic processes, including the mobilization of large woody debris and other allochthonous[1] inputs, can be critical to maintaining fish and wildlife habitat (Naiman and Decamps 1997; Petts et al. 2005). High-flow channels carved into floodplains provide essential habitat for various fish species and create refuges from high-velocity flows. Streams overtop their banks during high flow periods and deposit sediment load, cumulatively forming a floodplain (Dunne and Leopold 1978; Knighton 1998). Floodplains also store floodwaters, which can reduce flooding in other areas of the watershed and contribute to infiltration and aquifer recharge.

Streams are often modified to protect development from destructive floods, typically through channel straightening and armoring. These modifications can cause rivers to become disconnected from their natural floodplains and associated wetlands (Booth 1990). Other land-use changes related to urbanization, such as impervious surfaces and deforestation, also influence floodplains by increasing the magnitude and frequency of flooding (Booth et al. 2002). In landscape-level assessments, patterns of urban development, particularly impervious surface area and distribution, have been demonstrated to influence watershed functions (Alberti et al. 2006). Among these are stream channel downcutting, a process associated with watersheds with frequent and short-duration high peak flows, which further disconnects floodplains, increases in-stream erosion, and deposits sediment in downstream environments, leading to blocked culverts (Booth 1990). Stream incision also affects surface and groundwater interactions and may lower water table levels (Petralia 2022).

Flooding can result in significant economic costs from damaged homes and infrastructure, business disruption, and loss of life. Floodplains have been used for agriculture, residential development, and urbanization for centuries because their locations tend to be well-suited for development between floods. The proximity of development to rivers and large water bodies, and the advantages in travel, transport, and waste discharge, otherwise provide ideal settlement locations. Dikes, levees, and associated floodplain fill have been historically common approaches to protecting development, which has consequently worsened flood impacts to some downstream areas and sometimes failed to protect the intended areas. Altered river dynamics, including sediment deposition, considerable woody debris accumulation, and increased flows associated with upstream land use changes, have overwhelmed some aging flood control works that have not been maintained or improved. The human and societal costs of flooding have increased over time as populations and infrastructure in floodplains have grown, and as a result of climate change.

4.4 Key Protection Strategies

Floodplain protection strategies serve the dual purpose of protecting property and infrastructure, as well as the ecological integrity of streams and watersheds. The National Flood Insurance Program

[1] "Allochthonous riparian" refers to the resources that originate from outside the immediate stream but are delivered via the riparian zone, the land along a body of water. This includes terrestrial material like leaves, twigs, and fallen trees that are crucial to the aquatic ecosystem's energy and structure.

(NFIP) and Flood Insurance Rate Maps (FIRMs) are the primary basis for identifying and regulating flood areas in Walla Walla County.

Participants in the NFIP must regulate development in floodplain areas in accordance with NFIP criteria. Before issuing a permit to build in a floodplain, Walla Walla County must ensure that three criteria are met: new buildings and those undergoing substantial improvements must, at a minimum, be elevated to protect against damage by the 100-year flood, new floodplain development must not aggravate existing flood problems or increase damage to other properties, and new floodplain development must exercise a reasonable and prudent effort to reduce its adverse impacts on threatened salmonid species.

Floodplain management is generally based on a no-adverse-impact strategy (ASFPM 2003). This approach requires floodplain property owners to ensure that their land use does not adversely affect flood storage or flood risk for others, including flow velocities and erosion risks. This is commonly achieved by requiring no net increase in flood elevations. This approach protects natural floodplain processes and encourages restoration by reconnecting side channels and reducing armoring.

4.5 Climate Change Effects

Climate change in the Pacific Northwest is anticipated to result in wetter autumns and winters and drier summers (Mote et al. 2003). Climate change models predict that the frequency of atmospheric rivers, which contribute to severe deluges in rainwater and other extreme weather events, will become more frequent and severe (Mauger and Kennard 2017; Salathe et al. 2014). Greater flood risks are predicted due to increased precipitation and the frequency and intensity of extreme weather events (Ecology 2021a). The resulting increase in floodwater elevation and the expansion of flooding into new areas pose a risk to property and public safety. Stream channel migration can also drastically alter flood risks, and migration dynamics are expected to shift because of climate change (Mauger and Kennard 2017).

Extreme floods impose both positive and negative effects on stream health. Impacts include physical trauma and stress to aquatic organisms, displacement or stranding, erosion and sedimentation, loss of vegetation, pollution, disruptions to food webs and spawning, and disrupted migration. As a result, extreme floods have been documented to reduce fish densities (Milner et al. 2013). However, some studies show that fish assemblages are resilient to the effects of floods at a basin scale and recover quickly (George et al. 2015). Potential positive effects include the creation of new habitats and nutrient redistribution (Peters et al. 2015).

4.5.1 Strategies to Manage Climate Change Impacts on FFAs

The Washington Silver Jackets is an interagency group formed in 2010 to plan for and manage flood risks. This group works to develop improved estimates of future flooding, develop resources for local planners, build capacity, coordinate on resiliency, improve public engagement, and coordinate floodplain management goals (Mauger and Kennard 2017). The University of Washington Climate Impacts Group has collaborated with the Washington Silver Jackets to integrate climate change predictions and impacts into flood management planning efforts. This led to the development of the

report, *Integrating Climate Resilience in Flood Risk Management: a Work Plan for the Washington Silver Jackets Team,* which provides a framework for strategic management (Mauger and Kennard 2017). Some strategies to manage climate change impacts on FFAs include:

- Develop improved estimates of future flood impacts (Mauger and Kennard 2017).
- Develop resources for local planners (Mauger and Kennard 2017).
- Build capacity and coordination on resilient floodplain management (Mauger and Kennard 2017).
- Improve public engagement (Mauger and Kennard 2017).
- Coordinate floodplain goals and management (Mauger and Kennard 2017).
- Maintain and update Comprehensive Flood Hazard Management Plans (CFHMP) and Shoreline Master Programs (SMP) to support stormwater management, salmonid habitat, and streamflow planning (Ecology 2021a).
- Implement and enforce Walla Walla County and Washington State laws and policies regarding flood prevention during permitting and development.
- Encourage and incentivize floodplain restoration actions to reconnect streams and wetlands, and to protect or restore riparian corridors to maintain the microclimate.
- Utilize the FEMA Climate Resiliency approach to support flood hazard management planning and follow grant funding opportunities.
- Refine topographic floodplain analysis to identify potential changes in floodplain extents.

5. GEOLOGICALLY HAZARDOUS AREAS

5.1 Definitions

Geologically hazardous areas (GHAs) are defined by Washington State as "areas that, because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns" (WAC 365-190-030). The four main types of geologically hazardous areas are erosion hazard areas, landslide hazard areas, seismic hazard areas, and areas subject to other geologic events such as coal mine hazards and volcanic hazards (WAC 365-190-120).

5.2 Existing Conditions

Walla Walla County is in the southeastern part of the Walla Walla Plateau, a section of the Columbia Plateaus physiographic province. The northern Rocky Mountains border the Columbia Plateaus to the east and the Sierra Nevada-Cascade region to the west. Known for its diverse landforms across Oregon, Idaho, and Washington, the Columbia Plateaus cover approximately 100,000 square miles. (HDR 2008)

This region primarily consists of uniform basaltic lava flows that exhibit significant folding and faulting, resulting in elevations ranging from about 200 to 5,000 feet above mean sea level (MSL). Older

mountain ranges, such as the Blue Mountains and Wallowa Mountains, rise above the lava flows in certain areas. (HDR 2008)

The terrain of the Columbia Plateaus is predominantly harsh and arid, characterized by coulees, scablands, and other features that reflect the movement of glacial waters across the landscape, alongside isolated volcanic formations. Sedimentary deposits intermingle with the lava; in some areas, the loess is deep enough to create fertile land. The plateau includes regions within the Big Bend of the Columbia River in Washington (specifically, the Walla Walla Plateau), the Blue Mountains of eastern Oregon, the Snake River Plain of southern Idaho, and the Harney Desert in southern Oregon. (HDR 2008)

5.3 Key Protection Strategies

The primary goal of geologic hazard protection measures is to protect people and property. USGS has mapped volcanic hazards in Washington, laying the groundwork for risk management. The USGS operates an early-detection system for volcanic activity that exceeds background levels in cooperation with the Pacific Northwest Seismic Network. Volcanic eruptions typically have a more extended warning phase before eruption onset than the initiation of other natural disasters, such as flooding and earthquakes, with potential warnings of months to days. This warning system is a primary mechanism for protecting people living in hazardous areas.

Risk management also occurs at the planning and development stages. Risks can be minimized by limiting occupancy and development in geologic hazard areas. This risk of development in geologic hazard areas is evaluated with classification systems to inform site development restrictions and requirements. One method to manage risk is to protect buffers around geologically hazardous areas to restrict development in those areas. For development in erosion or landslide hazard areas, design and construction standards are necessary to prevent the development from reducing slope stability and ensure that development is resilient to potential hazards. Any such development in the hazard area or its buffer should be evaluated on-site by a licensed geotechnical engineer or engineering geologist. Methods used in site studies should adhere to best professional standards and include subsurface exploration and testing of soils at an appropriate frequency across the site, as necessary.

The SR-530 Landslide Commission identified additional protection strategies following the Oso mudslide that occurred in March 2014. Recommendations from the commission include integrating and funding Washington's emergency management system, supporting a statewide landslide hazard and risk mapping program, establishing a geologic hazards resilience institute, conducting landslide investigations, and advancing public awareness of geologic hazards. Integrating Washington's emergency management system would bring together "the Governor's office, the [state] Legislature, tribes, county and municipal government, first responders, transportation agencies, non-government support agencies, the private sector, and members of the public" (SR530 Landslide Commission 2014). To improve landslide hazard and risk mapping, collaboration among agencies and landowners is recommended, along with risk prioritization, utilization of lidar mapping, and GIS database tools.

Per the SR-530 Landslide Commission's 2014 findings, updates to critical area regulations are recommended to better identify and regulate land uses in geologic hazard areas. This may include requiring geologic risk assessments for subdivision permit application reviews, slope-density regulations, conservation easements, and grading ordinances. Slope-density calculation is a method for determining the number of allowable development units of subdivisions with geological hazards. Usually, the steeper the slope, the fewer units are permitted.

Seismic hazards can be managed by applying earthquake-resistant building standards to at-risk areas. The Washington State Building Code (WAC 51-50) provides guidance on the 2018 International Existing Building Code, with amendments specific to the State, including several related seismic standards.

5.4 Climate Change Effects

Geologically hazardous areas, particularly erosion and landslide-prone areas, are expected to be affected by climate change. Climate change models project warmer, drier summers and increased precipitation in other seasons, while maintaining roughly the same annual precipitation (Dalton, Mote, and Snover 2013). Extreme precipitation events modeled by the UW Climate Impacts Group are expected to intensify and become more frequent (Mauger, Morgan, and Won 2021). Increased rainfall intensity and frequency can lead to oversaturated soils and slope instability in hazard areas. Consequently, geologic hazard risks are anticipated to grow because rainfall intensity and duration are known indicators of landslide events (Chleborad 2006; DNR 2012). Additionally, the severity and frequency of wildfires are expected to increase, heightening susceptibility to erosion and landslide hazards (Mauger et al. 2015).

A changing climate is also expected to affect vegetation community composition and native plant mortality through shifts in plant hardiness zones and species ranges (Lenoir and Svenning 2015). Existing species assemblages, canopy types, and root systems may be disrupted and displaced by invasive species. Although plant provenance is not the only indicator of a plant's capability to stabilize slopes, opportunistic invasive plants often have shallow root systems and short lifespans that are less effective at anchoring soils than their native counterparts. Himalayan blackberry, for example, is a widespread invasive plant likely to displace native plants, has a shallow root system, and can cause soil erosion by preventing the establishment of native counterparts (Gaire et al. 2015). High levels of plant diversity also generally improve soil stability by combining multiple forms of root architecture (Ghestem et al. 2014).

5.4.1 Strategies to Manage Climate Change Impacts on Geologically Hazardous Areas

- Encourage or require climate-informed design for development and infrastructure in or near geological hazard areas (DNR 2020).
- Require appropriate surface water and groundwater management practices for development near bluffs.
- Encourage utilization of soft shore protection strategies.

- Identify and prioritize geologic hazards within the County, then update mapping using current practices such as LiDAR and GIS database tools.
- Keep in communication with the governor's office to ensure that Walla Walla County is included in statewide collaborative efforts to manage geologic hazard areas and update hazard mitigation plans.
- Manage vegetation for climate resilience and slope stability.
- Regularly update erosion and sediment control guidance.

6. FISH AND WILDLIFE HABITAT CONSERVATION AREAS

6.1 Definition

Washington State defines fish and wildlife habitat conservation areas (FWHCAs) in WAC 365-190-030(6) as follows:

(a) "Fish and wildlife habitat conservation areas" are areas that serve a critical role in sustaining needed habitats and species for the functional integrity of the ecosystem, and which, if altered, may reduce the likelihood that the species will persist over the long term. These areas may include, but are not limited to, rare or vulnerable ecological systems, communities, and habitat or habitat elements including seasonal ranges, breeding habitat, winter range, and movement corridors; and areas with high relative population density or species richness. Counties and cities may also designate locally important habitats and species.

(b) "Habitats of local importance" designated as fish and wildlife habitat conservation areas include those areas found to be locally important by counties and cities.

(c) "Fish and wildlife habitat conservation areas" does not include such artificial features or constructs as irrigation delivery systems, irrigation infrastructure, irrigation canals, or drainage ditches that lie within the boundaries of, and are maintained by, a port district or an irrigation district or company.

The following FWHCAs must be considered for classification and designation (WAC 365-190-130):

(a) Areas where endangered, threatened, and sensitive species have a primary association;
(b) Habitats and species of local importance, as determined locally;
(c) Commercial and recreational shellfish areas;
(d) Kelp and eelgrass beds; herring, smelt, and other forage fish spawning areas;
(e) Naturally occurring ponds under 20 acres and their submerged aquatic beds that provide fish or wildlife habitat;
(f) Waters of the state;
(g) Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity; and
(h) State natural area preserves, natural resource conservation areas, and state wildlife areas.

The Walla Walla County CAO defines FWHCAs as follows (WWMC 17A.04.020):

A. Fish and wildlife habitat conservation areas include:

1. Areas where state or federal designated endangered, threatened, and sensitive species have a primary association.

a. Federal designated endangered and threatened species are those fish, wildlife, and plant species identified by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service that are in danger of extinction or threatened to become endangered. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service should be consulted as necessary for current listing status.

b. State designated endangered, threatened, and sensitive species are those fish, wildlife and plant species native to the state of Washington identified by the state Department of Fish and Wildlife, that are in danger of extinction, threatened to become endangered, vulnerable, or declining and are likely to become endangered or threatened in a significant portion of their range within the state without cooperative management or removal of threats. State designated endangered, threatened, and sensitive species are periodically recorded in WAC 232-12-014 (state endangered species), and WAC 232-12-011 (state threatened and sensitive species). The state Department of Fish and Wildlife maintains the most current listing and should be consulted as necessary for current listing status.

2. State priority habitats and areas associated with state priority species. Priority habitats and species are considered priorities for conservation and management. Priority species require protective measures for their perpetuation due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance. Priority habitats are those habitat types or elements with unique or significant value to a diverse assemblage of species. A priority habitat may consist of a unique vegetation type or dominant plant species, a described successional stage, or a specific structural element. Priority habitats and species are identified by the state Department of Fish and Wildlife.

3. Habitats and species of local importance. Habitats and species of local importance are those identified by the County, including those that possess unusual or unique habitat warranting protection because of species diversity or habitat system health indicators. The following habitats and species of local importance, shown on Map CA-5B, have been designated: High Density of Wintering Birds of Prey Habitat, Raptor Ferruginous Hawk Habitat, and Neotropical Migrant Songbird Habitat.

4. Naturally occurring ponds under twenty (20) acres. Naturally occurring ponds are those ponds under twenty (20) acres and their submerged aquatic beds that provide fish or wildlife habitat, including those artificial ponds intentionally created from dry areas in order to

mitigate impacts to ponds. Naturally occurring ponds do not include ponds deliberately designed and created from dry sites, such as canals, detention facilities, wastewater treatment facilities, farm ponds, temporary construction ponds, and landscape amenities, unless such artificial ponds were intentionally created for mitigation.

5. *Waters of the state. Waters of the state includes lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, and all other surface waters and watercourses within the jurisdiction of the state of Washington, as classified in WAC 222-16-031.*

6. *Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity.*

7. *State natural area preserves and natural resources conservation areas. Natural area preserves and natural resource conservation areas are defined, established, and managed by the state Department of Natural Resources.*

8. *Streams shall be designated in accordance with the Washington State Department of Natural Resources (DNR) stream type as provided in WAC 222-16-030. Streams are further categorized according to Ecosystem Diagnosis and Treatment (EDT)/Walla Walla Subbasin Plan priority protection reaches.*

9. *Areas of rare plant species and high quality ecosystems that are identified by the Washington State Department of Natural Resources through the Natural Heritage Program.*

B. *All areas within the county meeting one or more of these criteria, regardless of any formal identification, are hereby designated critical areas and are subject to the provisions of this title.*

6.2 Existing Conditions

Wildlife habitat quality is relatively high in the upper reaches of the main rivers and tributaries, including the Walla Walla River, Touchet River, and Mill Creek, due to favorable vegetation conditions. The mountain and foothill forests in these areas benefit large mammals such as elk, mule deer, white-tailed deer, black bears, coyotes, mountain lions, and bobcats. Additionally, furbearers like beavers, river otters, minks, and raccoons are common. The upper drainages are home to various bird species, including ruffed grouse, woodpeckers, hummingbirds, and numerous songbirds. In contrast, highly cultivated agricultural lands and remnants of riparian strips and pockets influence habitat complexity and quality in the lowland valleys. These lowlands support white-tailed and mule deer populations, ring-necked pheasants, quail, mourning doves, raptors, songbirds, and small mammals. (Northwest Management, Inc. 2018)

The Walla Walla and Touchet rivers historically supported Chinook, coho, and chum salmon. The watershed is home to bull trout and steelhead, both listed as threatened under the Federal Endangered Species Act. A large expanse of riparian habitat exists in the 1,896-acre Wallula Habitat Management Unit, which has been managed by USACE since 2007. This unit, located at the mouth of the Walla Walla River, features a mix of cottonwood forests, various shrubs, wetlands, sagebrush, and agricultural lands

that support many species, including waterfowl, shorebirds, songbirds, raptors, upland game birds, mule deer, white-tailed deer, furbearers, and small mammals. The McNary National Wildlife Refuge, managed by the U.S. Fish and Wildlife Service (USFWS) near Burbank in western Walla Walla County, encompasses over 15,000 acres of habitat for migratory birds and developing fall Chinook salmon. The refuge is home to rare and endangered birds, including bald eagles, peregrine falcons, and thousands of nesting water birds. (Northwest Management, Inc. 2018)

The aquatic habitats in Walla Walla County support a variety of species. The main aquatic priority habitats on non-federal lands in the County are located along the Columbia and Snake Rivers and in the waterbodies of the Walla Walla basin, including the Walla Walla River and its major tributaries. The species range from federally listed to priority, focal, and species of interest identified in the Walla Walla Subbasin Plan. The Washington Department of Fish and Wildlife (WDFW) and the Washington State Department of Natural Resources' (DNR) Natural Heritage Program (NHP) compile and map fish and wildlife habitats throughout the state. Numerous studies focus on specific species and habitat types relevant to Walla Walla County. The Priority Habitat and Species (PHS) database provides the most comprehensive information on the presence and distribution of priority habitats and wildlife species, including site-specific data (Table 1).

Table 1. WDFW Designated PHS that Occur in Walla Walla County.

PHS Type	Species/Habitats	State Status	Federal Status
Habitats	Aspen Stands		
	Biodiversity Areas & Corridors		
	Eastside Steppe		
	Inland Dunes		
	Juniper Savannah		
	Riparian		
	Shrubsteppe		
	Freshwater Wetlands & Fresh Deepwater		
	Instream		
	Caves		
	Cliffs		
	Snags and Logs		
	Talus		
Fishes	Pacific Lamprey		
	White Sturgeon		
	Leopard Dace	Candidate	
	Umatilla Dace	Candidate	
	Mountain Sucker	Candidate	
	Bull Trout/ Dolly Varden	Candidate *	Threatened *
	Chinook Salmon		Threatened (Upper Columbia Spring run is Endangered)
	Coho Salmon		Threatened – Lower Columbia
	Kokanee		
	Rainbow Trout/ Steelhead/ Inland Redband Trout	Candidate **	Threatened **
	Sockeye Salmon		Threatened – Ozette Lake
			Endangered – Snake River
	Westslope Cutthroat Trout		
	Margined Sculpin	Sensitive	
Amphibians	Columbia Spotted Frog	Candidate	
	Rocky Mountain Tailed Frog	Candidate	
	Western Toad	Candidate	
Reptiles	Striped Whipsnake	Candidate	
	Sagebrush Lizard	Candidate	
Birds	American White Pelican	Sensitive	
	Western grebe	Candidate	

PHS Type	Species/Habitats	State Status	Federal Status
	E WA breeding concentrations of: Grebes, Cormorants		
	E WA breeding: Terns		
	Black-crowned Night-heron		
	Great Blue Heron		
	Cavity-nesting ducks: Wood Duck, Barrow's Goldeneye, Common Goldeneye, Bufflehead, Hooded Merganser		
	Tundra Swan		
	Waterfowl Concentrations		
	Ferruginous Hawk	Endangered	
	Golden Eagle	Candidate	
	Northern Goshawk	Candidate	
	Prairie Falcon		
	Dusky Grouse		
	Mountain Quail		
	Ring-necked Pheasant		
	Wild Turkey		
	Upland Sandpiper	Endangered	
	E WA breeding occurrences of: Phalaropes, Stilts and Avocets		
	Burrowing Owl	Candidate	
	Flammulated Owl	Candidate	
	Vaux's Swift		
	Black-backed Woodpecker	Candidate	
	Loggerhead Shrike	Candidate	
	Sage Thrasher	Candidate	
Mammals	Roosting Concentrations of: Big-brown Bat, Myotis bats, Pallid Bat		
	Townsend's Big-eared Bat	Candidate	
	Black-tailed Jackrabbit	Candidate	
	White-tailed Jackrabbit	Candidate	
	Washington Ground Squirrel	Candidate	Candidate
	Gray Wolf	Endangered	Endangered: only in Western two-thirds of Washington
	Marten		
	Bighorn Sheep		
	Northwest White-tailed Deer		

PHS Type	Species/Habitats	State Status	Federal Status
	Elk		
	Mule Deer		
	(formerly called Rocky Mountain Mule Deer)		
Invertebrates	Columbia Oregonian	Candidate	
	California Floater	Candidate	
	Monarch	Candidate	Candidate
	Western Bumble Bee	Candidate	Candidate
		* Bull Trout only	
		** Steelhead only	

Source: WDFW 2025[2]

6.3 Functions and Values

The functions of FWHCAs encompass the biological, chemical, and physical processes that impact wildlife. Since wildlife includes all species, from large megafauna to microorganisms, these functions represent a complex network of interacting ecological processes. At their core, FWHCAs provide suitable habitats for wildlife. This section examines the functions of FWHCAs most relevant to wildlife and habitat management, with particular focus on streams and riparian zones. Additionally, the functions of specific habitat areas are considered if they relate to societal values beyond wildlife.

The values associated with FWHCAs encompass a range of societal, economic, and ecological benefits derived from these lands and their wildlife inhabitants. These values include indirect benefits, such as non-consumptive uses like recreation, tourism, scientific research, option values (which account for future opportunities), and intrinsic existence values (Chardonnet et al. 2002). They also encompass direct values involving consumptive and productive uses, such as commercial harvesting, hunting, timber production, and firewood (Chardonnet et al. 2002). Together, these values reflect the diverse public interests and attitudes toward wildlife issues, which can evolve over time (Teel et al. 2010).

Streams, lakes, ponds, and surrounding riparian areas are essential habitats for various wildlife species. They play a vital role in surface and subsurface hydrology, exchanging nutrients and energy across the landscape. This section outlines the key functions and values associated with the ecosystems of streams, lakes, ponds, and riparian areas. It will also discuss land use activities that impact these ecosystems, including (1) land cover and the presence of impervious surfaces; (2) the recruitment of large woody debris to aquatic areas; (3) the effects of shade, temperature, and microclimates; and (4) stream migration and bank stability.

[2] *Priority Habitats and Species List | Washington Department of Fish & Wildlife-https://wdfw.wa.gov/species-habitats/at-risk/phs/list*

Other priority habitats in Walla Walla County include shrub-steppe. Shrub-steppe is defined by WDFW as, "a non-forested vegetation type consisting of one or more layers of perennial bunchgrasses and a conspicuous by discontinuous layer of shrubs." These areas are commonly comprised of sagebrush plant species, bunchgrasses like Idaho fescue, and may also include forbs, algae, mosses or lichens. Shrub-steppe habitat is associated with diverse topography, riparian areas, and canyons. This ecosystem supports a cryptobiotic crust, a fragile soil surface layer comprised of blue-green algae, bacteria, fungi, lichens or mosses. This soil crust holds moisture and reduces erosion. Sagebrush-obligate species, such as the greater sage-grouse, burrowing owl, sagebrush sparrow and sagebrush lizard rely on sagebrush for cover and food. Fragmentation and loss of shrub-steppe have resulted in a decline in shrub-steppe species (Azerrad 2020).

6.4 Key Protection Strategies

6.4.1 Water Type Classification

Aquatic areas in Washington are classified based on their flow volume, periodicity, size, and fish use/accessibility according to the water typing system and criteria in WAC 222-16-030. Using the criteria, aquatic areas are classified as one of four classes (Table 2): Type S (shoreline), Type F (fish habitat present), Type Np (non-fish habitat stream with perennial flow), and Type Ns (non-fish habitat stream with seasonal flow).

Table 2. Water type classification.

Type	Description
Type S= Shoreline	Streams and waterbodies designated "shorelines of the state" as defined in chapter 90.58.030 RCW.
Type F= Fish	Streams and waterbodies that are known to be used by fish or meet the physical criteria to be potentially used by fish. Fish streams may or may not have flowing water all year; they may be perennial or seasonal.
Type Np= Non-Fish	Streams with a flow year-round may have spatially intermittent dry reaches downstream of perennial flow. Type Np streams do not meet the physical criteria of a Type F stream. This also includes streams proven not to contain fish using methods described in the Forest Practices Board Manual Section 13.
Type Ns= Non-Fish Seasonal	Streams that do not have surface flow during at least some portion of the year, and do not meet the physical criteria of a Type F stream.

6.4.2 Riparian Management Zones in the Dryland Ecoregion

In 2020, the WDFW developed BAS guidance for protecting riparian areas (Rentz et al. 2020). The guidance emphasizes a shift in terminology and framework from "stream buffers" to "riparian management zones" (RMZs). While established stream buffers (based on water type), which are incorporated in many local CAOs, are based on the BAS and are intended to protect streams, they may

or may not provide full riparian function. To achieve full riparian function, the guidance recommends that RMZs be considered regulatory-critical areas and that the guidance be applied to all streams and rivers, regardless of size or type.

The RMZ is the area next to rivers and streams that has the potential to provide full riparian functions. It is established based from the edge of a channel migration zone or the ordinary high water mark (OWHM) if a channel migration zone is not present. WDFW recommends that the RMZ should be regulated as a FWHCA rather than a buffer from waterbodies (Rentz et al. 2020).

Walla Walla County is in the arid to semi-arid region of eastern Washington that supports predominantly non-forested habitats. In this dryland ecoregion, drought-tolerant plant communities like shrub-steppe are dominant outside of areas of development or agricultural use. In dryland ecoregions, WDFW recommends establishing RMZs based on the 200-year site potential tree height (see more information below) or the width of the riparian vegetation community. At a minimum, WDFW recommends a 100-foot-wide RMZ to support pollution removal functions (Rentz et al. 2020).

Site Potential Tree Height

To apply the site potential tree height framework (SPTH), the value derived from "…the average maximum height of the tallest dominant[3] trees (200 years or more) for a given site class" is used as the RMZ width. As depicted in Figure 1, and considered in this latest guidance, most riparian functions are achieved within one tree height from the edge of a stream. WDFW has 200-year SPTH data in the southeastern portion of Walla Walla County, near the Umatilla National Forest, where SPTH values range from 114 to 156 feet.

[3] Dominant trees are those which extend above the normal level of the forest canopy.

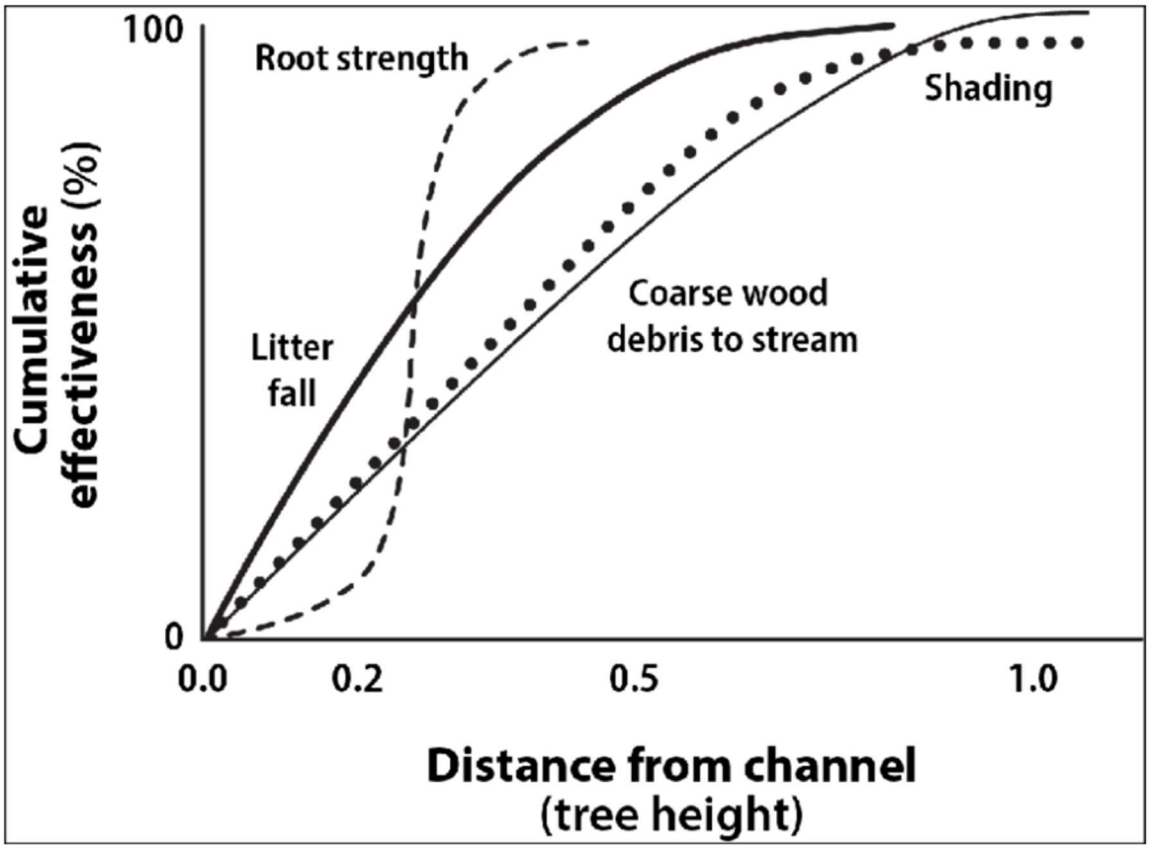


Figure 1. The "FEMAT Curves" is a conceptual model of the contributions of key riparian ecosystem functions that influence aquatic ecosystems by distance and cumulative effectiveness. Tree height refers to the average relative height of the site potential tree height (reproduced from FEMAT 1993).

Width of Riparian Vegetation

Where 200-year SPTH values are not available, which is the case for the dryland ecoregion across most of Walla Walla County, WDFW recommends that the extent of the riparian vegetation should be used instead or the minimum width to protect water quality, whichever is wider. Throughout Walla Walla County, riparian vegetation has often been modified through agricultural use.

In the absence of SPTH values and natural riparian vegetation, WDFW recommends a minimum 100-foot RMZ width based on pollution removal functions. Most of the RMZs in Walla Walla County are mapped in PHS on the Web at 100 feet wide.

Acknowledging that establishing functional RMZs using the recommended methods may not be practical in many developed areas, WDFW recommends effective watershed management, preservation, and protection, resulting in nearly complete restoration of riparian ecosystem habitat functions as is feasible within existing constraints.

6.4.3 Shrub-steppe Habitat

WDFW recommends that shrub-steppe is classified as a type of FWHCA in local critical area ordinances because it is a priority habitat. WDFW also publishes management recommendations for priority habitats (including shrub-steppe) that are often incorporated by reference in critical area regulations. Therefore, these WDFW management recommendations typically establish the standards by which local jurisdictions protect shrub-steppe habitat and other priority habitats. The current shrub-steppe management recommendations were originally published in 2011 with minor updates in 2020. WDFW is currently working on a revised draft of these management recommendations.

Local government user guides (WDFW 2023, 2025) recommend incorporating shrub-steppe into CAOs in the following ways:

- Designate Priority Habitats and Species as FWHCAs,
- Adopt and incorporate PHS maps by reference,
- Require detailed delineation and evaluations of shrub-steppe for projects that have the potential to disturb habitat, including use of associated WDFW management recommendations in reports.
- Allow for rapid screening-level site assessments and reporting to determine if detailed study and documentation is required.
- Land acquisition and conservation
- Manage shrub-steppe resources on a landscape scale, considering patch size, fragmentation and connectivity as important variables (Azerrad 2020).
- Utilize USGS has a GIS database for sage-grouse and shrub-steppe management (USGS 2001)

6.4.3.1 Landscape-scale Mapping

Protecting remaining shrub-steppe begins at the landscape scale. For example, understanding habitat patch size, location, distribution, and fragmentation/connectivity across a landscape will help to inform management decisions, including those that are part of the CAO update, and other long-range planning efforts.

WDFW's PHS on the Web is currently considered the best available mapping database for shrub-steppe habitat in Washington (WDFW 2025). The Washington Shrubsteppe Restoration and Resiliency Initiative Maps (WSRRI) is a secondary mapping source that can supplement the PHS mapping. These landscape-scale datasets are course and should be used in combination with other tools and information sources like high-resolution aerials and local knowledge/studies. For site-scale decisions, landscape-scale mapping should be verified in the field.

6.4.3.2 Site-scale Identification and Classification

In general, landscape-scale critical area mapping is intended to be used as a tool to determine where additional site review is necessary. WDFW created their shrub-steppe maps for this purpose (WDFW

2025). If WDFW's and/or WSRRI's landscape-scale shrub-steppe maps indicate shrub-steppe may be present at a site, field review to verify ground conditions is recommended.

Rapid Assessment

Per WDFW recommendations, field reviews for site-scale identification can be conducted rapidly with the purpose being to determine whether shrub-steppe habitat is present or absent within a site or assessment area boundary. If confirmed, a more extensive site visit to delineate and evaluate the shrub-steppe habitat (as outlined in Section 2.4.3) should be required to ensure compliance with local critical area regulations.

WDFW's management recommendations report and associated appendices are considered BAS for determining shrub-steppe location/boundaries and habitat quality. Updates to this document are currently in process. In general, shrub-steppe habitat is defined by shrublands consisting of one or more layers of perennial bunchgrasses. The shrub layer must be dominated by one of the following species to qualify as shrub-steppe:

- Big sagebrush (*Artemisia tridentata*), most common
- Antelope bitterbrush (*Purshia tridentata*)
- Threetip sagebrush (*Artemisia tripartite*)
- Scabland sagebrush (*Artemisia rigida*)
- Dwarf sagebrush (*Artemisia arbuscula*)

Shrub canopy cover is not currently used as a criterion to qualify shrub-steppe habitat. However, for general understanding, WDFW characterizes shrub canopy cover as typically between five and 30 percent, and as high as 60 percent. Similarly, Johnson and O'Neil (2001) describe the structure of shrub-steppe habitat as containing shrub cover of ten to 60 percent. Current guidance implies that if any of the previously listed shrubs are dominant in the shrub layer, then the area should be ranked or classified as one of four categories using an ecological integrity index, regardless of the amount of shrub cover or patch size.

Detailed Assessment

If the site-scale rapid assessment identifies shrub-steppe habitat within the project area, a more extensive site visit to delineate and evaluate the shrub-steppe habitat should be required. WDFW recommends requiring a Habitat Management Plan (HMP) or Critical Area Report to document assessment study methods and findings (Folkerts, Johnson and Michalak 2025). As of the date of this document, an Ecological Integrity Assessment protocol is used to map and rank shrub-steppe. The highest quality habitat patches should be prioritized for preservation. The most up-to-date shrub-steppe management recommendations from WDFW should be utilized for classifying habitat and determining mitigation requirements, if needed. All HMP's should be performed by a qualified professional.

6.4.3.3 Shrub-steppe Mitigation

Like mitigation for other types of critical areas, WDFW recommends the consistent application of mitigation sequencing for shrub-steppe in the following order of preference:

1. Avoid impact by not taking a certain action;
2. Minimize impacts by limiting the action;
3. Remedy the impact by restoring the affected area;
4. Reduce the impact over time by preservation or maintenance;
5. Compensate for the impact by replacing or substituting resources.

If direct impacts are unavoidable, compensatory mitigation may be accomplished through purchase of mitigation bank credits or restoration. WDFW recommends a ratio of two acres of protected shrub-steppe for every acre of lost habitat. Currently, this mitigation ratio does not vary based on the quality of habitat impacted based on WDFW management recommendations. Low quality habitat may qualify for reduced ratios while high quality habitat may require a higher ratio.

Shrub-steppe restoration can also be considered a mitigation option, although establishing this habitat type is known to be challenging.

6.4.3.4 Corridor Mapping

WDFW has identified several essential biodiversity areas and corridors that connect wildlife between core habitat areas through the development of the Washington Habitat Connectivity Plan (WAHCAP), and the Washington Wildlife Habitat Connectivity Working Group synthesized research to establish priority locations to connect habitats and create corridors. WAHCAP identified 12 Connected Landscapes of Statewide Significance (CLOSS) throughout Washington State and identified transportation barriers and mitigation strategies. The State and Tribal Recreation Impacts Initiative (STRII) characterized recreation impacts on wildlife corridors to inform management decisions. The WAHCAP mapping system is now publicly available.[4]

Additional tools used by specialists to identify wildlife corridors include TerrAdapt spatial tool[5] and the Least-Conflict Solar Siting collaboration through Washington State University.[6] Finally, the Washington Wildlife Habitat Connectivity Working Group has analyzed habitat connectivity statewide and has published various resources.[7]

---

[4] https://databasin.org/maps/f4ec2e8c532645a39d19abd418c6c7bf/active/
[5] https://terradapt.org/
[6] https://www.energy.wsu.edu/RenewableEnergy/LeastConflictSolarSiting.aspx
[7] Washington Wildlife Habitat Connectivity Working Group » Statewide Analysis

Walla Walla County can collaborate with WDFW and other groups to determine important habitat connectivity corridors and local priority habitats to ensure no net loss of FWHCAs.

6.5 Climate Change Effects

Climate change is predicted to have significant and irreversible impacts on fish, wildlife, and their habitats. Global climate change is anticipated to result in habitat loss and modification through changes in temperature, sea level rise, ocean acidification, extreme weather events, changes in precipitation, biological invasions, disruptions to food webs, and disease (Nagelkerken et al. 2023). The range of effects on fish and wildlife depends on species-specific interactions and may include range shifts, phenological shifts, changes to morphology and behavior, biodiversity loss, and extinction (Sattar et al. 2021). The cumulative impacts of these factors on wildlife are anticipated to result in a loss of biodiversity and an increase in extinction rates (Sattar et al. 2021).

Climate changes and seasonal precipitation patterns are projected to place additional stressors on FWHCAs. Some loss of riparian vegetation is anticipated due to the stresses of climate change, particularly warmer, drier summers. A reduction in riparian vegetation potentially triggers a cascading effect. A decrease in riparian vegetation would decrease shading, increase stream temperature, decrease detrital inputs, reduce available habitat structure, and reduce stream bank stability. Changes in seasonal hydrologic cycles may increase the frequency and magnitude of flashy runoff events, mobilize greater volumes of sediments and pollutants into streams, and reduce groundwater recharge that supports base stream flows in summer. Instream habitats are particularly negatively impacted by excess sediment discharge and deposition.

Hot, dry summers are projected to reduce stream flow volumes and increase instream temperatures. Extreme precipitation events, flooding, and erosion compound this stressor. All these stressors reduce instream habitat quality and stress salmonid populations.

6.5.1 Strategies to Manage Climate Change Impacts on FWHCAs

The following actions or policies have been developed for other local jurisdictions in coordination with the University of Washington Climate Impacts Group (CIG). They are potential strategies that Walla Walla County could use to reduce negative climate change impacts on FWHCAs.[8]

- Promote the retention of trees and forests and maintain tree replacement and reforestation requirements.
- Encourage and incentivize enhancement and restoration of native forest patches throughout the County, particularly where connectivity to one or more FWHCAs is identified. Both voluntary and required restoration planting should be paired with monitoring and maintenance that allows for dry-season irrigation and adaptive management.

[8] [8] https://www.redmond.gov/1708/Climate-Preparedness

- Consider assisted migration for seed selection of native plants from locations better adapted to future climate conditions.
- Manage stormwater infrastructure to avoid and minimize discharges of increased and/or untreated runoff to streams, offsetting the anticipated increase in intensive rainfall events. Promote the use of LIDs to manage stormwater effectively and minimize downstream impacts.
- Update and maintain regulations for habitats and species of local importance. This may include adding mapping resources to identify potential habitats and species requiring protection and management.
- Prioritize protection of streams and riparian corridors to reduce the stresses of climate change on native fish species and anadromous fish, such as chinook salmon.
- Identify and protect cold water refugia in waterbodies.
- Conduct vulnerability assessments and climate action plans.

7. REFERENCES

ASFPM. 2003. *No Adverse Impact: A Toolkit for Common Sense Floodplain Management*. Madison, WI: Association of State Floodplain Managers (ASFPM.

Asinas, E., C. Raymond, and A. Mehta. 2022. "Integrating Climate Resilience into Washington State Water System Planning." Seattle, WA: University of Washington Climate Impacts Group. https://doi.org/10.6069/.

Associates, Golder. 2007. "City of Walla Walla Extended Area Aquifer Storage and Recovery Groundwater Flow Model." August.

ASWM. 2015. "Wetlands and Climate Change: Considerations for Wetland Program Managers." Association of State Wetland Managers. https://www.nawm.org/pdf_lib/wetlands_and_climate_change_consideratons_for_wetland_program_managers_0715.pdf.

Aukema, J.E., N.G. Pricope, G.J. Husak, and D. Lopez-Carr. 2017. "Biodiversity Areas under Threat: Overlap of Climate Change and Population Pressures on the World's Biodiversity Priorities." *PLoS ONE* 12 (1): 0170615. https://doi.org/10.1371/journal.pone.0170615.

Azerrad, J.M., K.A. Divens, M.F. Livingston, M.S. Teske, H.L. Ferguson, and J.L. Davis. 2020. *Management recommendations for Washington's priority habitats: managing shrubsteppe in developing landscapes.* Guidance, Washington Department of Fish and Wildlife.

Baughman OW, Agneray AC, Forister ML, et al. Strong patterns of intraspecific variation and local adaptation in Great Basin plants revealed through a review of 75 years of experiments. *Ecol Evol*. 2019;9:6259–6275. **https://doi.org/10.1002/ece3.5200**

Brinson, M., and M.S.N.T.I.S.No Vicksburg. 1993. "A Hydrogeomorphic Classification for Wetlands." Technical Report WRP-DE-4,. Vicksburg, MS: U.S. Army Corps of Engineers Waterways Experiment Station.

Burkett, V., and J. Kusler. 2000. "Climate Change: Potential Impacts and Interactions in Wetlands of the United States." *JAWRA Journal of the American Water Resources Association* 36 (2): 313–20. https://doi.org/10.1111/j.1752-1688.2000.tb04270.x.

Burton, C.A., T.M. Hoefen, G.S. Plumlee, K.L. Baumberger, A.R. Backlin, and E. Gallegos. 2016. "Trace Elements in Stormflow, Ash, and Burned Soil Following the 2009 Station Fire in Southern California." *PLoS ONE* 11 (5): 0153372. https://doi.org/10.1371/journal.pone.0153372.

Chardonnet, P., B. Clers, J. Fischer, R. Gerhold, F. Jori, and F. Lamarque. 2002. "The value of wildlife." *OIE Revue Scientifique et Technique* 21 (1): 15–51. https://doi.org/10.20506/rst.21.1.1323.

Chleborad, A. 2006. "Modeling and Analysis of the 1949 Narrows Landslide, Tacoma, Washington." *Environmental & Engineering Geoscience* xxxi (3:305–27. https://doi.org/10.2113/gseegeosci.xxxi.3.305.

Dalton, M., P. Mote, and A. Snover. 2013. "Climate Change in the Northwest-Implications for Our Landscape." Washington DC: Island Press. https://cig.uw.edu/wp-content/uploads/sites/2/2020/12/daltonetal678.pdf.

DNR. 2012. "State Department of Natural Resources." Olympia, Washington. http://www.dnr.wa.gov/Publications/frc_na_apr11_natural_areas_map.pdf.

———. 2020. *Safeguarding Our Lands, Waters, and Communities: DNR's Plan for Climate Resilience*. Washington State Department of Natural Resources.

Ecology, Washington Department. 2021a. *Critical Aquifer Recharge Areas Guidance-Publication 05-10-028*. Washington Department of Ecology. From. https://apps.ecology.wa.gov/publications/SummaryPages/1406032.html.

———. 2021b. "Wetland Mitigation in Washington State Part 1 – Agency Policies and Guidance." *Version* 10 (21-06-003).

———. 2021c. Walla Walla 2050 Strategic Plan. Department of Ecology and Walla Walla Watershed Management Partnership. June 30, 2021. (21-12-011).

———. 2022. "DRAFT Wetland Guidance for Critical Areas Ordinance (CAO) Updates." *Western and Eastern Washington (Publication*, no. 22-06-005).

———. 2024. "Washington State Climate Resilience Strategy." *Publication*, no. 24-01–006. apps.ecology.wa.gov/publications/documents/2401006.pdf.

EPA. 2015. "Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence." https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=296414.

Gaire, R., C. Astley, M.K. Upadhyaya, D.R. Clements, and M. Bargen. 2015. "The Biology of Canadian Weeds. 154. Himalayan Blackberry." *Canadian Journal of Plant Science* 95 (3): 557–70.

Gallagher, J.B., K. Zhang, and C.H. Chuan. 2022. "A Re-Evaluation of Wetland Carbon Sink Mitigation Concepts and Measurements: A Diagenetic Solution." *Wetlands* 42 (3): 23.

George, S.D., B.P. Baldigo, A.J. Smith, and G.R. Robinson. 2015. "Effects of Extreme Floods on Trout Populations and Fish Communities in a Catskill Mountain River." *Freshwater Biology* 60 (12): 2511–22.

Ghestem, M., K. Cao, W. Ma, N. Rowe, R. Leclerc, and C. Gadenne. 2014. "A Framework for Identifying Plant Species to Be Used as 'Ecological Engineers' for Fixing Soil on Unstable Slopes." *PLoS ONE* 9 (8): 95876. https://doi.org/10.1371/journal.pone.0095876.

Granger, T., T. Hruby, A. McMillan, D. Peters, J. Rubey, D. Sheldon, and E. Stockdale. 2005. "Wetlands in Washington State-Ecology Publication #05-06-008." Washington State Department of Ecology. https://apps.ecology.wa.gov/publications/documents/0506008.pdf.

Halabisky, M. 2017. *Reconstructing the Past and Modeling the Future of Wetland Dynamics under Climate Change (Dissertation*. Seattle, WA: University of Washington.

Hattermann, F., V. Krysanova, and C. Hesse. 2008. "Modelling Wetland Processes in Regional Applications." *Hydrological Sciences Journal* 53 (5): 1001–12.

HDR, Inc. 2008. "Walla Walla County; Critical Areas Ordinance Best Available Science Review."

HDR, Inc. 2019. *Technical Memorandum-Final: To: Austin Melcher*. Washington State Department of Ecology, Water Resources Program.

Hruby, T. 2012. "Calculating Credit and Debits for Compensatory Mitigation in Wetlands of Western Washington, Final Report." *Publication*, no. 10-06–011.

———. 2014. "Washington State Wetland Rating System for Eastern Washington: 2014 Update." Olympia, WA: Washington Department of Ecology (Ecology.

Hruby, T., K. Harper, and S. Stanley. 2009. "Selecting Wetland Mitigation Sites Using a Watershed Approach." *Publication*, no. 09-06-032.

Hruby, T., and A. Yahnke. 2023. "Washington State Wetland Rating System for Western Washington: 2014 Update (Version 2." Washington Department of Ecology.

Hruby, Tom. 2013. "Update on Wetland Buffers: The State of the Science, Final Report." 13-06–011.

Kim, J.H., and R.B. Jackson. 2012. "A Global Analysis of Groundwater Recharge for Vegetation, Climate, and Soils." *Vadose Zone Journal* 11 (1).

Kramer, A.T., Crane, B., Downing, J., Hamrick, J.L., Havens, K., Highland, A., Jacobi, S.K., Kaye, T.N., Lonsdorf, E.V., Ramp Neale, J., Novy, A., Smouse, P.E., Tallamy, D.W., White, A. and Zeldin, J. (2019), Sourcing native plants to support ecosystem function in different planting contexts. Restor Ecol, 27: 470-476. https://doi.org/10.1111/rec.12931

Lyons, M., O. LeDee, and R. Boyles. 2022. "Effects of Climate Change on Fish and Wildlife Species in the United States." USGS. Open-File Report 2021-1104.

Mansilha, C., A. Melo, Z.E. Martins, I.M. Ferreira, A.M. Pereira, and J. Espinha Marques. 2020. "Wildfire Effects on Groundwater Quality from Springs Connected to Small Public Supply Systems in a Peri-Urban Forest Area." *Water* 12 (4): 1146.

Mauger, G., and H. Kennard. 2017a. *Integrating Climate Resilience in Flood Risk Management: A Work Plan for the Washington Silver Jackets. Report Prepared for FEMA*. Seattle, WA: Climate Impacts Group, University of Washington. From. https://doi.org/10.7915/CIG7MP4WZ.

———. 2017b. *Integrating Climate Resilience in Flood Risk Management: A Work Plan for the Washington Silver Jackets. Report Prepared for FEMA*. Seattle, WA: Climate Impacts Group, University of Washington. From. https://doi.org/10.7915/CIG7MP4WZ.

Mauger, G., H. Morgan, and J. Won. 2021. *Projected Changes in Extreme Precipitation Web Tool*. Seattle, WA: University of Washington, Climate Impacts Group. From. https://doi.org/10.6069/79CV-4233.

Mauger, G.S., J.H. Casola, H.A. Morgan, R.L. Strauch, B. Jones, B. Curry, and A.K. Snover. 2015. "State of Knowledge: Climate Change in Puget Sound." Seattle, WA: Climate Impacts Group, University of Washington. https://doi.org/10.7915/CIG93777D.

Mauger, G.S., and J.S. Won. 2019. *Expanding the Ensemble of Precipitation Projections for King County. Report Prepared for the King County Department of Natural Resources*. Seattle: Climate Impacts Group, University of Washington.

Milner, A.M., A.L. Robertson, M.J. McDermott, M.J. Klaar, and L.E. Brown. 2013. "Major flood disturbance alters river ecosystem evolution." *Nature Climate Change* 3 (2): 137–41.

Mote, P.W., Parson E.A., A.F. Hamlet, W.S. Keeton, D. Lettenmaier, N. Mantua, E.L. Miles, et al. 2003. "Preparing for Climatic Change: The Water, Salmon." *And Forests of the Pacific Northwest* 61:45–88.

Nagelkerken, I., B.J. Allan, D.J. Booth, J.M. Donelson, G.J. Edgar, T. Ravasi, and C. Mellin. 2023. "The Effects of Climate Change on the Ecology of Fishes." *PLOS Climate* 2 (8): 0000258.

Nahlik, A., and M. Fennessy. 2016. "Carbon Storage in US Wetlands." *Nature Communications* 7 (13835). https://doi.org/10.1038/ncomms13835.

Naiman, R.J., and H. Decamps. 1997. "The Ecology of Interfaces: Riparian Zones." *Annual Review of Ecology, Evolution and Systematics* 28 (November):621–58. https://doi.org/10.1146/annurev.ecolsys.28.1.621.

Northwest Management, Inc. n.d. "Walla Walla County Multi-Jurisdictional Hazard Mitigation Plan (HMP)." http://www.doh.wa.gov/ehp/dw/our_main_pages/data_download.htm.

Peters, D.L., D. Caissie, W.A. Monk, S.B. Rood, and A. St-Hilaire. 2015. "An Ecological Perspective on Floods in Canada." *Canadian Water Resources Journal / Revue Canadienne Des Resources Hydriques* 41 (1–2): 288–306. https://doi.org/10.1080/07011784.2015.1070694.

Petts, G., A. Gurnell, P.J. Edwards, and G.E. Petts. 2005. "Effects of Deposited Wood on Biocomplexity of River Corridors." *Frontiers in Ecology and the Environment. From*, September. https://doi.org/10.1890/1540-9295(2005)003.

Rentz, T., A. Windrope, K. Folkerts, and J. Azerrad. 2020. *Riparian Ecosystems, Volume 2: Management Recommendations*. Habitat Program, Washington Department of Fish and Wildlife. https://wdfw.wa.gov/sites/default/files/publications/01988/wdfw01988.pdf.

Rentz, T., Amy Windrope, Terra Rentz, Keith Folkerts, and Jeff Azerrad. 2020. *Riparian Ecosystems, Volume 2: Management Recommendations*. Olympia, Washington: Washington Department of Fish and Wildlife.

Salathe, E., A. Hamlet, C. Mass, S. Lee, M. Stumbaugh, and R. Steed. 2014. "Estimates of Twenty-First Century Flood Risk in the Pacific Northwest Based on Regional Climate Model Simulations." https://doi.org/10.1175/JHM-D-13-0137.1.

Sattar, Q., M.E. Maqbool, R. Ehsan, S. Akhtar, Q. Sattar, M.E. Maqbool, and S. Akhtar. 2021. "Review on Climate Change and Its Effect on Wildlife and Ecosystem." *Open Journal of Environmental Biology* 6 (1): 008–014.

Sheldon, D., P. Hruby, P. Johnson, K. Harper, A. McMillan, T. Granger, and E. Stockdale. 2005. *Wetlands in Washington State*. Vol. 1. Olympia, WA: Washington State Department of Ecology (Ecology.

Snover, A.C. 2019. "No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State." Seattle, WA: Climate Impacts Group, University of Washington. https://cig.uw.edu/resources/specialreports/no-time-to-waste/.

Teel, T.L., M. Manfredo, T.L. Teel, and M.J. Manfredo. 2010. "Understanding the Diversity of Public Interests in Wildlife Conservation." *Conservation Biology* 24 (1): 128–39. https://doi.org/10.1111/j.1523-1739.2009.01374.x.

USGS. 2001. *SAGEMAP*. 15 11. Accessed 2 28, 2026. https://www.usgs.gov/centers/forest-and-rangeland-ecosystem-science-center/science/sagemap.

Voisin, N., D. Rose, D. Broman, N. Sun, and I. Kraucunas. 2023. "Exploring Multiscale Earth System and Human-Earth System Dynamics in the Puget Sound Region," no. PNNL-33801, 1906804, 33801,. https://doi.org/10.2172/1906804.

WSDA (2025). Climate Resilience Plan for Washington Agriculture. D.L. Gelardi (Ed.). Washington State Department of Agriculture AGR2-2502-003 https://agr.wa.gov/Washington-Agriculture/Climate-Resilience-Plan-for-Washington-Agriculture

Xiao, T., P. Li, W. Fei, and J. Wang. 2024. "Effects of Vegetation Roots on the Structure and Hydraulic Properties of Soils: A Perspective Review." *Science of the Total Environment* 906:167524.

APPENDIX A. Ecology's Wetland Buffer Width Recommendations

Appendix D. Buffer Approaches for Eastern Washington

Option 1

Table 1. Wetland buffer width requirements, in feet, if Table 2 is implemented and a habitat corridor is provided

Category of wetland	Habitat Score 3-5 points (corridor not required)	Habitat Score 6-7 points	Habitat Score 8-9 points	Buffer width based on special characteristics
Category I & II: Based on rating of wetland functions (and not listed below)	75	110	150	NA
Category I & II: Forested	75	110	150	NA
Category I: Bogs, calcareous fens, and Wetlands of High Conservation Value	NA	NA	NA	190
Category I: Alkali	NA	NA	NA	150
Category II: Vernal pool	NA	NA	NA	150
Category III	60	110	150	NA
Category IV	40	40	40	NA

Impact minimization measures

Developments that produce the listed disturbances and are requesting a buffer reduction are required to address the disturbance through the use of applicable minimization measures.

This is not a complete list of measures, nor is every example measure required. Though not every measure is required, all effort should be made to implement as many measures as possible. Regulatory staff should determine, in coordination with the applicant, which measures are applicable and practicable.

Table 2. Impact minimization measures

Examples of disturbance	Activities and uses that cause disturbances	Examples of measures to minimize impacts
Lights	• Parking lots • Commercial/Industrial • Residential • Recreation (e.g., athletic fields) • Agricultural buildings	• Direct lights away from wetland • Only use lighting where necessary for public safety and keep lights off when not needed • Use motion-activated lights • Use full cut-off filters to cover light bulbs and direct light only where needed • Limit use of blue-white colored lights in favor of red-amber hues • Use lower-intensity LED lighting • Dim light to the lowest acceptable intensity
Noise	• Commercial • Industrial • Recreation (e.g., athletic fields, bleachers, etc.) • Residential • Agriculture	• Locate activity that generates noise away from wetland • Construct a fence to reduce noise impacts on adjacent wetland and buffer • Plant a strip of dense shrub vegetation adjacent to wetland buffer
Toxic runoff	• Parking lots • Roads • Commercial/industrial • Residential areas • Application of pesticides • Landscaping • Agriculture	• Route all new, untreated runoff away from wetland while ensuring wetland is not dewatered • Establish covenants limiting use of pesticides within 150 ft. of wetland • Apply integrated pest management (Note: These examples are not necessarily adequate for minimizing toxic runoff if threatened or endangered species are present at the site.)

Examples of disturbance	Activities and uses that cause disturbances	Examples of measures to minimize impacts
Stormwater runoff	• Parking lots • Roads • Residential areas • Commercial/industrial • Recreation • Landscaping/lawns • Other impermeable surfaces, compacted soil, etc.	• Retrofit stormwater detention and treatment for roads and existing adjacent development • Prevent channelized or sheet flow from lawns that directly enters the buffer • Infiltrate or treat, detain, and disperse new runoff from impervious surfaces and lawns
Pets and human disturbance	• Residential areas • Recreation	• Use privacy fencing • Plant dense native vegetation to delineate buffer edge and to discourage disturbance • Place wetland and its buffer in a separate tract • Place signs around the wetland buffer every 50-200 ft., and for subdivisions place signs at the back of each residential lot • When platting new subdivisions, locate greenbelts, stormwater facilities, or other lower-intensity land uses adjacent to wetland buffers
Dust	• Tilled fields • Roads	• Use best management practices to control dust

Table 3. Wetland buffer width requirements, in feet, for applicants not providing a habitat corridor or implementing measures in Table 2

Category of wetland	Habitat score 3-5 points	Habitat score 6-7 points	Habitat score 8-9 points	Buffer width based on special characteristics
Category I & II: Based on rating of wetland functions (and not listed below)	100	150	200	NA
Category I & II: Forested	100	150	200	NA
Category I: Bogs, calcareous fens, and Wetlands of High Conservation Value	NA	NA	NA	250
Category I: Alkali	NA	NA	NA	200
Category II: Vernal pool	NA	NA	NA	200
Category III	80	150	200	NA
Category IV	50	50	50	NA

Conditions for implementing Tables 1, 2, and 3

1. Wetlands that score 6 points or more for habitat function: the buffers in Table 1 can be used only if all of the following criteria are met:

a. A relatively undisturbed, vegetated corridor at least 100 feet wide is protected between the wetland and:

i. A legally protected, relatively undisturbed and vegetated area (e.g., Priority Habitats, compensatory mitigation sites, wildlife areas/refuges, national, county, and state parks where they have management plans with identified areas designated as Natural, Natural Forest, or Natural Area Preserve, or

ii. An area that is the site of a Watershed Project identified within, and fully consistent with, a Watershed Plan as defined by RCW 89-08-460, or

iii. An area where development is prohibited according to the provisions of the local shoreline master program, or

iV. An area with equivalent habitat quality that has conservation status in perpetuity, in consultation with WDFW.

b. The corridor is permanently protected for the entire distance between the wetland and the shoreline or legally protected area by a conservation easement, deed restriction, or other legal means.

c. Presence or absence of the shoreline or Priority Habitat must be confirmed by a qualified biologist or shoreline Administrator.

d. The measures in Table 2 are implemented, as applicable, to minimize the impacts of the adjacent land uses.

2. For wetlands that score 5 or fewer habitat points, only the measures in Table 2 are required for the use of the buffers in Table 1.

3. If an applicant does not apply the mitigation measures in Table 2 or is unable to provide a protected corridor, then the buffers in Table 3 shall be used.

4. The buffer widths in Tables 1 and 3 assume that the buffer is vegetated with a native plant community appropriate for the ecoregion. If the existing buffer is un-vegetated, sparsely vegetated, or vegetated with invasive species that do not perform needed functions, the buffer must either be planted to create the appropriate native plant community or be widened to ensure that the buffer provides adequate functions to protect the wetland.

Note: An expanded table with graduated buffer widths based on habitat score is also outlined in the July 2018 Appendix 8-D[77] of *Wetlands in Washington State, Volume 2*. This is an approach that assigns unique buffer widths to each habitat score in seven increments. It is a gradual increase in buffer width with each point. Compared to Option 1, this avoids a marked increase in buffer width resulting from an increase of one point in the habitat score.

Option 2

Table 1. Width of buffers, in feet, needed to protect wetlands from impacts of proposed land uses (used with Table 2)

Category of wetland	Land use with low impact*	Land use with moderate impact*	Land use with high impact*
I	125	190	250
II	100	150	200
III	75	110	150
IV	25	40	50

*See Table 2 below for types of land uses that can result in low, moderate, and high impacts to wetlands

Table 2. Levels of impacts from proposed land use types

[Local governments are encouraged to ensure the uses in this table match the uses specified in their development and land use regulations and are consistent with the principles in this example.]

Level of impact from proposed land use	Types of land use
High	• Commercial • Urban • Industrial • Institutional • Mixed-use developments • Residential (more than 1 unit/acre) • Roads: federal and state highways, including on-ramps and exits, state routes, and other roads associated with high-impact land uses • Railroads • Agriculture with high-intensity activities (dairies, nurseries, greenhouses, growing and harvesting crops requiring annual tilling, raising and maintaining animals, etc.)

[77] https://apps.ecology.wa.gov/publications/parts/0506008part4.pdf

Level of impact from proposed land use	Types of land use
	• Open/recreational space with high-intensity uses (golf courses, ball fields, etc.) • Solar farms (utility scale)
Moderate	• Residential (1 unit/acre or less) • Roads: Forest Service roads and roads associated with moderate-impact land uses • Open/recreational space with moderate-intensity uses (parks with paved trails or playgrounds, biking, jogging, etc.) • Agriculture with moderate-intensity uses (orchards, hay fields, light or rotational grazing, etc.) • Utility corridor or right-of-way used by one or more utilities and including access/maintenance • Wind farm
Low	• Natural resource lands (forestry/silviculture–cutting of trees only, not land clearing and removing stumps) • Open/recreational space with low-intensity uses (unpaved trails, hiking, birdwatching, etc.) • Utility corridor without a maintenance road and little or no vegetation management • Cell tower

Option 3

Table 1. Wetland buffer width requirements, in feet, based solely on wetland category

Category of wetland	Buffer width
I	250
II	200
III	150
IV	50

APPENDIX B. Ecology's Recommended Wetland Mitigation Ratios for Eastern Washington

Appendix E. Mitigation Ratio Tables

Compensation ratios for permanent impacts (western and eastern Washington)

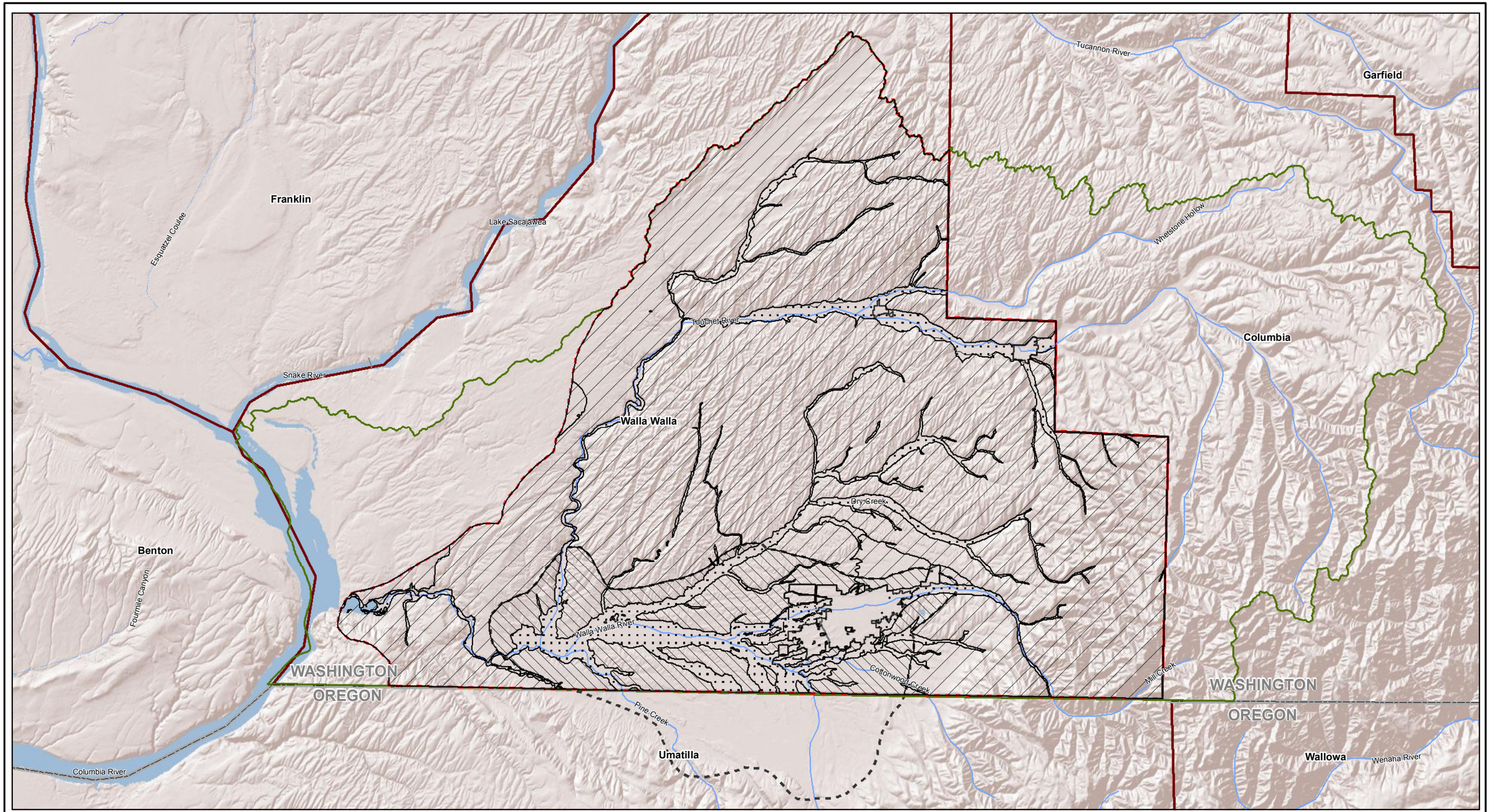
Table 1

Category of impacted wetland (based on score for function)	Re-establishment or creation	Rehabilitation	Preservation	Enhancement
Category I	4:1	8:1	16:1	16:1
Category II	3:1	6:1	12:1	12:1
Category III	2:1	4:1	8:1	8:1
Category IV	1.5:1	3:1	6:1	6:1

Notes:

- Ratios for rehabilitation, preservation, and enhancement may be reduced when combined with 1:1 replacement through re-establishment or creation. See Table 6B-2 in *Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance –Version 2* (Ecology et al., 2021 or as revised).
- All proposed preservation sites need to meet the preservation criteria listed in Chapter 070.3.E of Appendix A, Sample Wetland Regulations.
- The ratios provide in Table 1 are for permanent, direct impacts to wetlands. For recommended ratios for other types of impacts (e.g., long-term temporary, conversions), see Chapters 6B4.4 through 6B4.8 of *Wetland Mitigation in Washington State – Part 1: Agency Policies and Guidance –Version 2* (Ecology et al., 2021 or as revised).
- The category of impacted wetland is based on scores for functions. Compensation ratios in this table generally do not apply when impacts involve a wetland whose category is based on special characteristics. Compensation ratios for impacts to wetlands with special characteristics are provided in Table 2 below. Specific tables are provided for western and eastern Washington.

APPENDIX C. Critical Areas Maps



LEGEND

- Walla Walla River Catchment
- WRIA 32
- City Limits
- Shallow Gravel Aquifer Area Delineated by County
- States
- Counties

Aquifer Vulnerability

- Zone 1 (High Vulnerability)
- Zone II (Moderate Vulnerability)
- Zone III (Low Vulnerability)

0 5

Scale in Miles

Map Projection:
Washington State Plane South
NAD 1983 Feet
Source:
Walla Walla County,
Golder Associates Inc.

N

This figure was originally produced in color. Reproduction in black and white may result in a loss of information.

MAP **8**

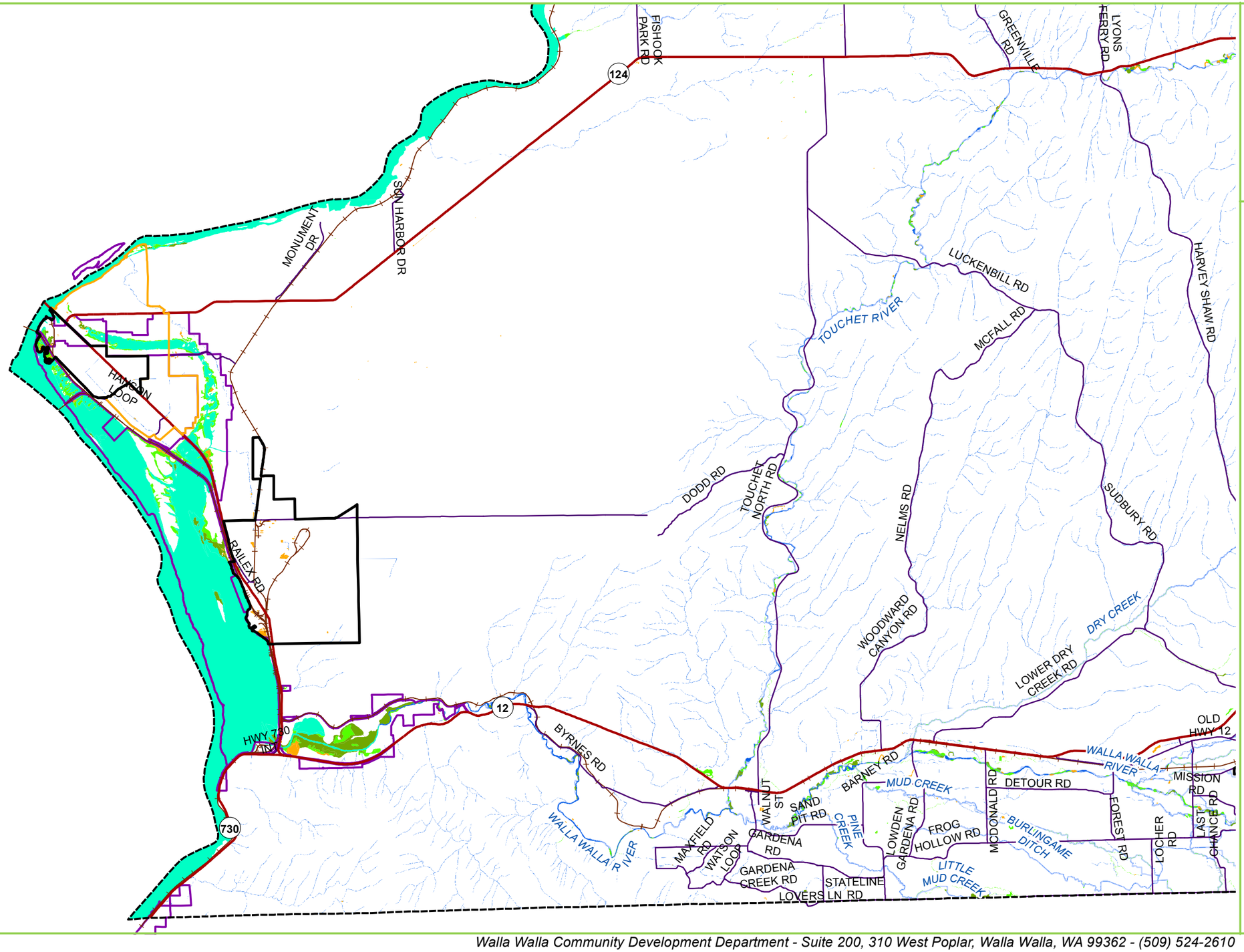
WALLA WALLA RIVER SHALLOW GRAVEL AQUIFER VULNERABILITY MAP (NOVEMBER 2012)

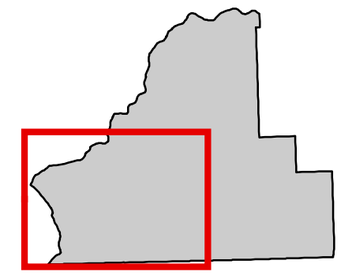
WALLA WALLA COUNTY CARA REVIEW/WA

11393087F13_AquiferVulnerabilityMap.mxd | 11/14/2012 | THAMMOND

Golder Associates

WETLANDS - Southwest County





BASE MAP LAYERS

- County Boundary
- Urban Growth Area
- Burbank Rural Activity Center
- State Highway
- Public Road
- Railroads
- Streams
- National Wildlife Refuge Boundary

NATIONAL WETLANDS INVENTORY

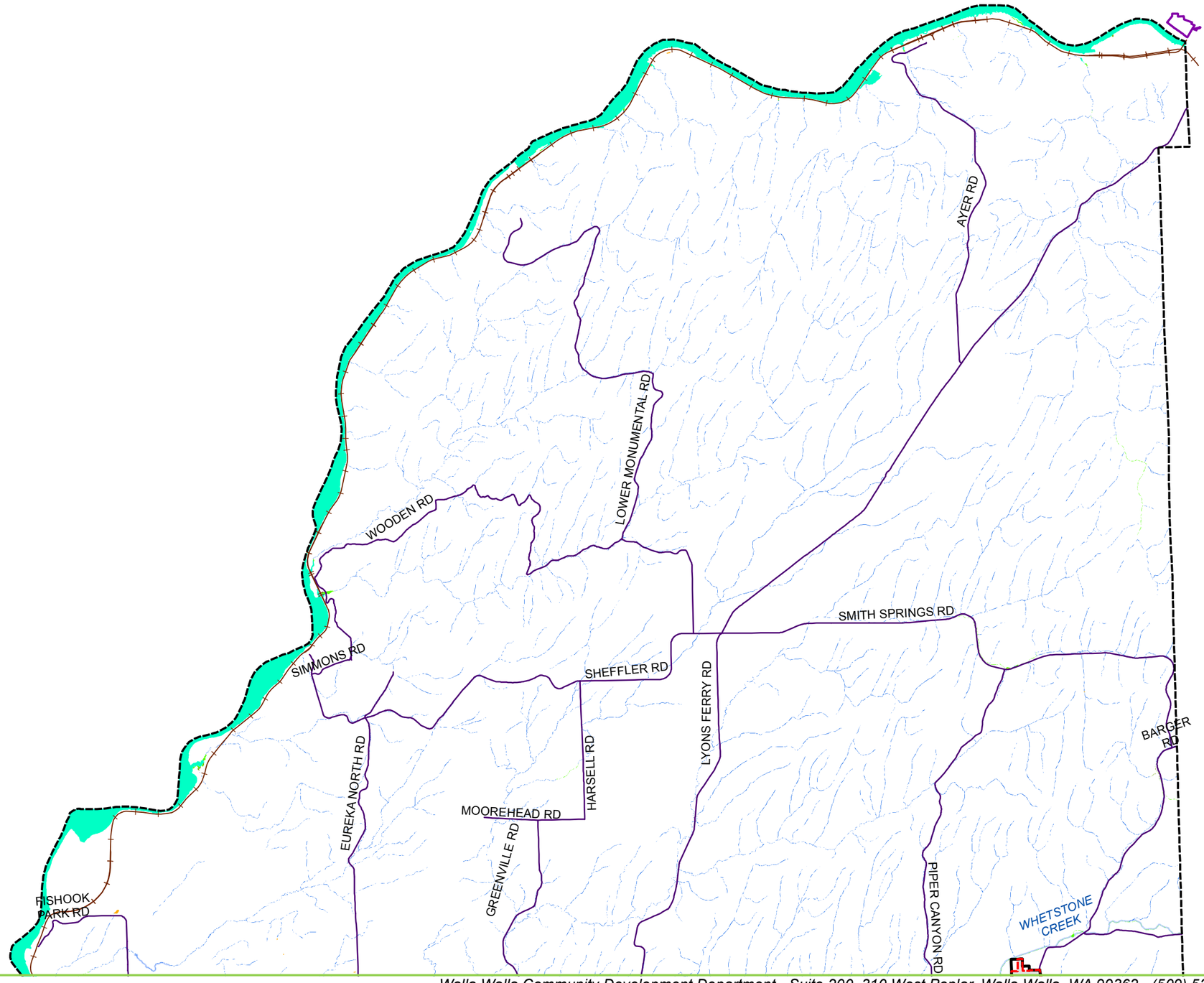
Wetland Type

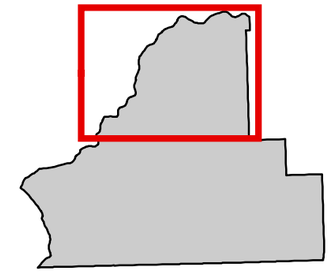
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Riverine

0 1.5 3 mi

COUNTY OF WALLA WALLA

WETLANDS - North County





BASE MAP LAYERS

- County Boundary
- City Limits
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- National Wildlife Refuge Boundary

NATIONAL WETLANDS INVENTORY

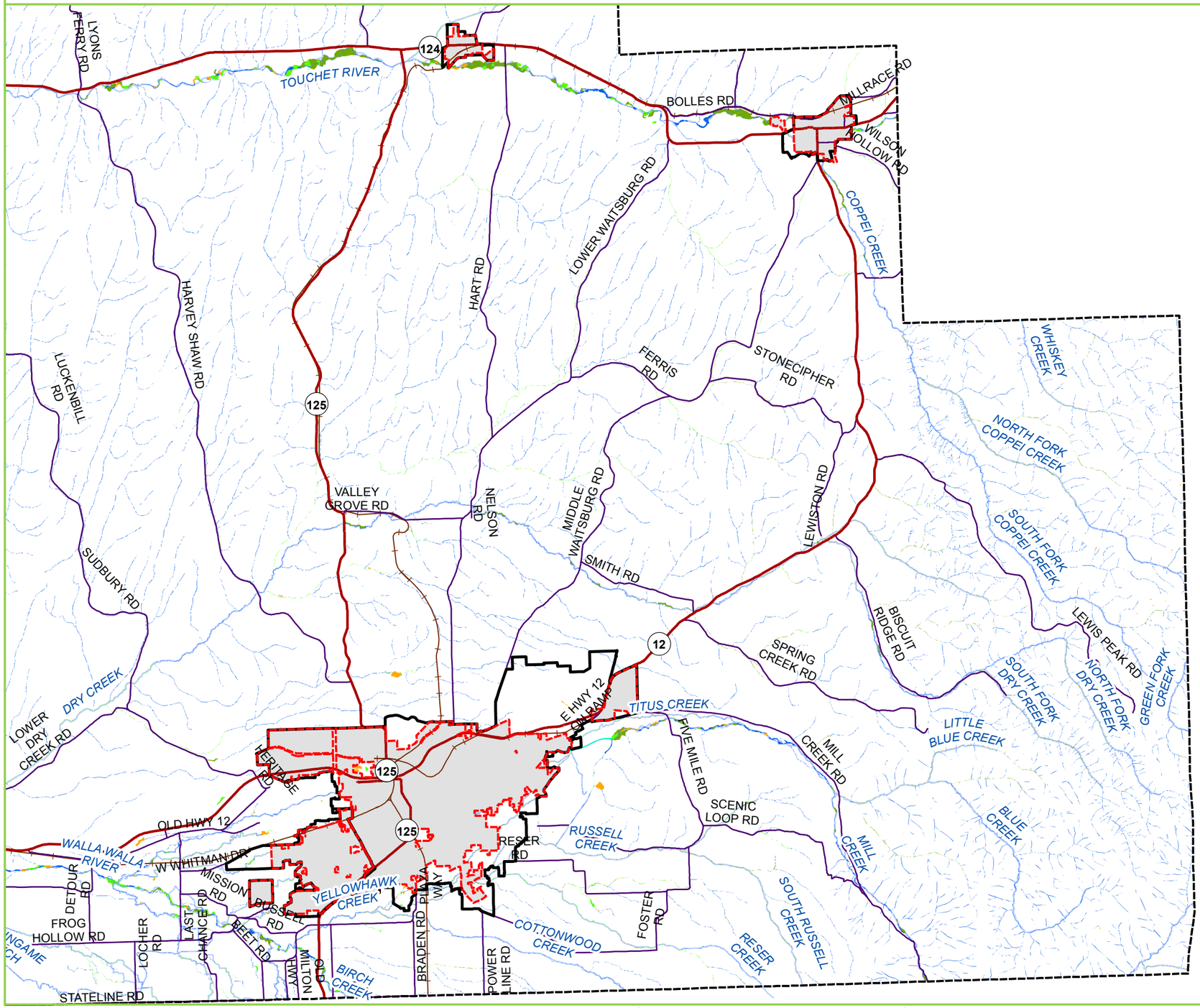
Wetland Type

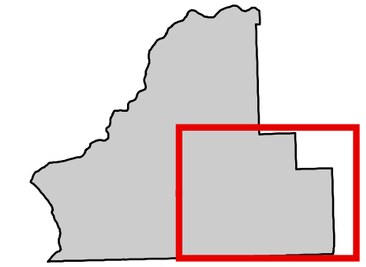
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Riverine

0 1 2 mi

COUNTY OF WALLA WALLA

WETLANDS - Southeast County





BASE MAP LAYERS

- County Boundary
- City Limits
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- National Wildlife Refuge Boundary

NATIONAL WETLANDS INVENTORY

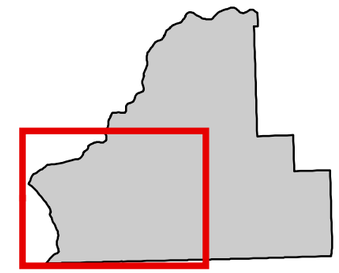
Wetland Type

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Riverine

0 1 2 mi

COUNTY OF WALLA WALLA

FREQUENTLY FLOODED AREAS - Southwest County



BASE MAP LAYERS

- County Boundary
- Urban Growth Area
- Burbank Rural Activity Center
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

FREQUENTLY FLOODED AREAS*

- Floodway

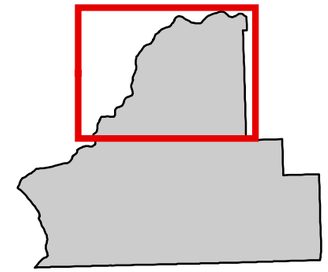
Flood Fringe Zone

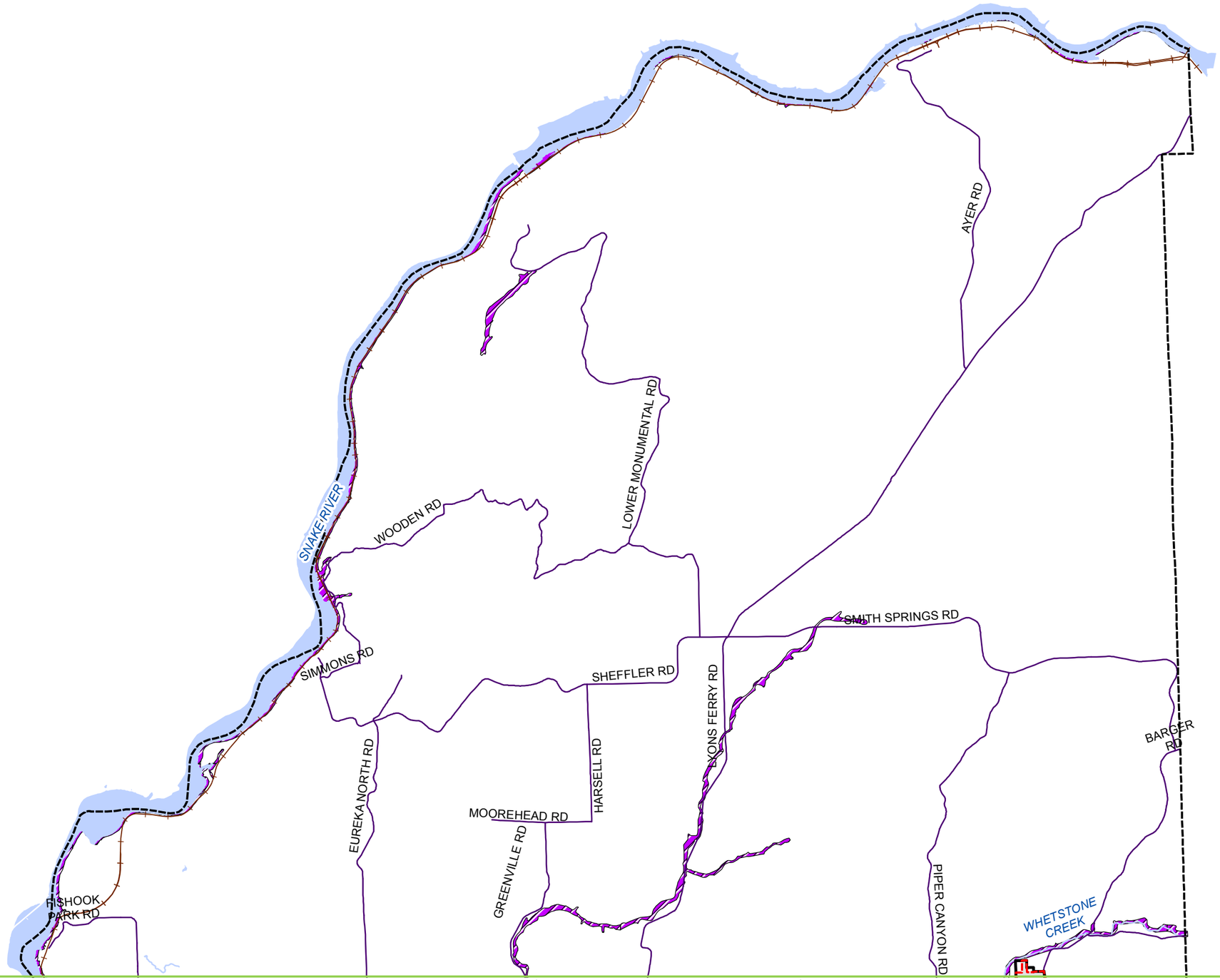
- A
- AE
- AO

* FEMA Q3 Flood Data, revised January 2002.

0 1.5 3 mi

FREQUENTLY FLOODED AREAS - North County





BASE MAP LAYERS

- County Boundary
- City Limits
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

FREQUENTLY FLOODED AREAS*

- Floodway

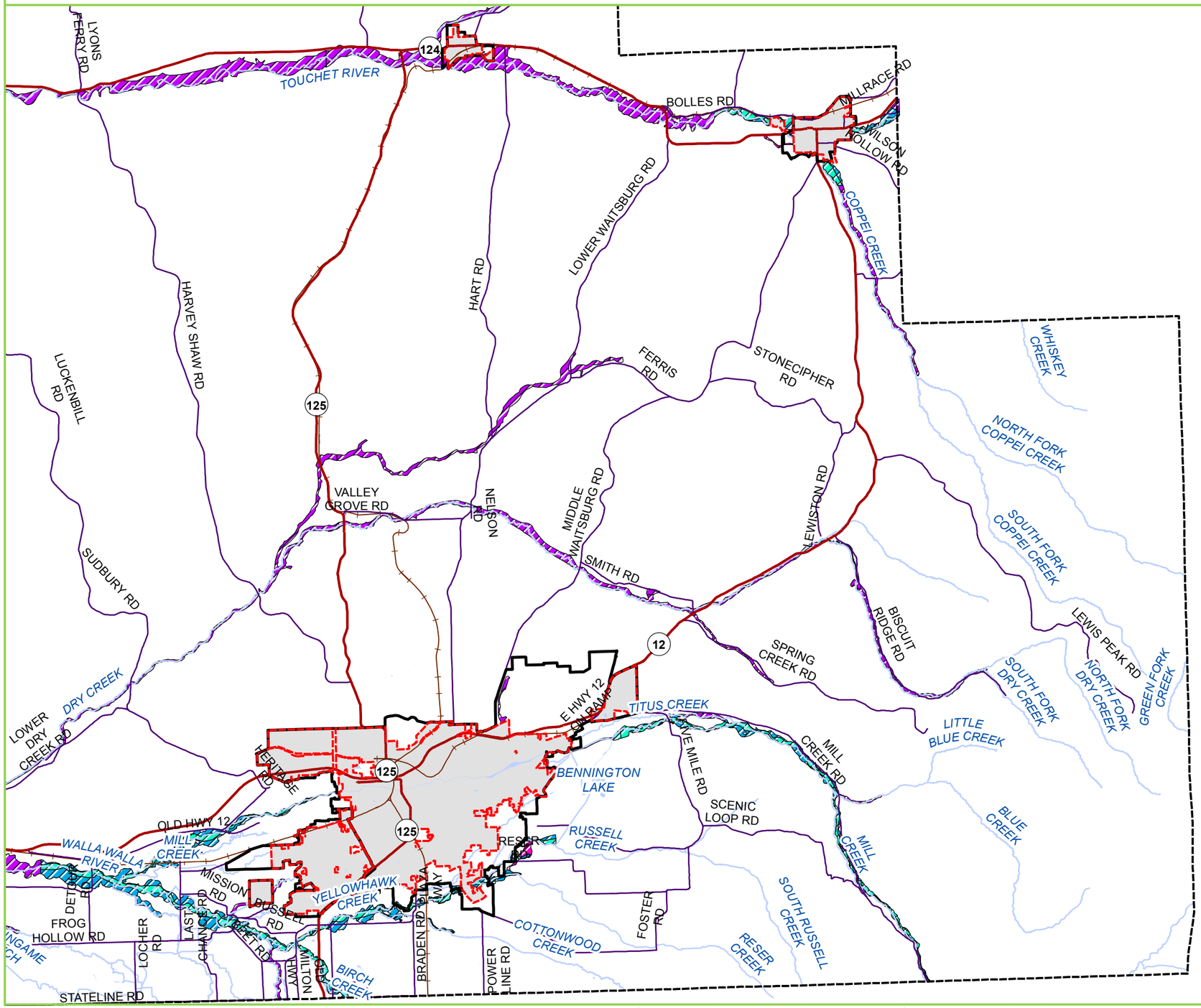
Flood Fringe Zone

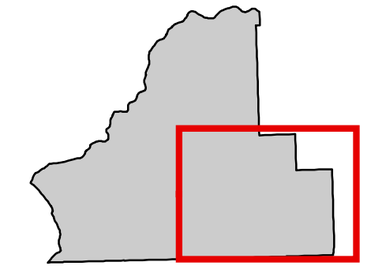
- A
- AE
- AO

* FEMA Q3 Flood Data, revised January 2002.

0 1 2 mi

FREQUENTLY FLOODED AREAS - Southeast County





BASE MAP LAYERS

- County Boundary
- City Limits
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

FREQUENTLY FLOODED AREAS*

- Floodway

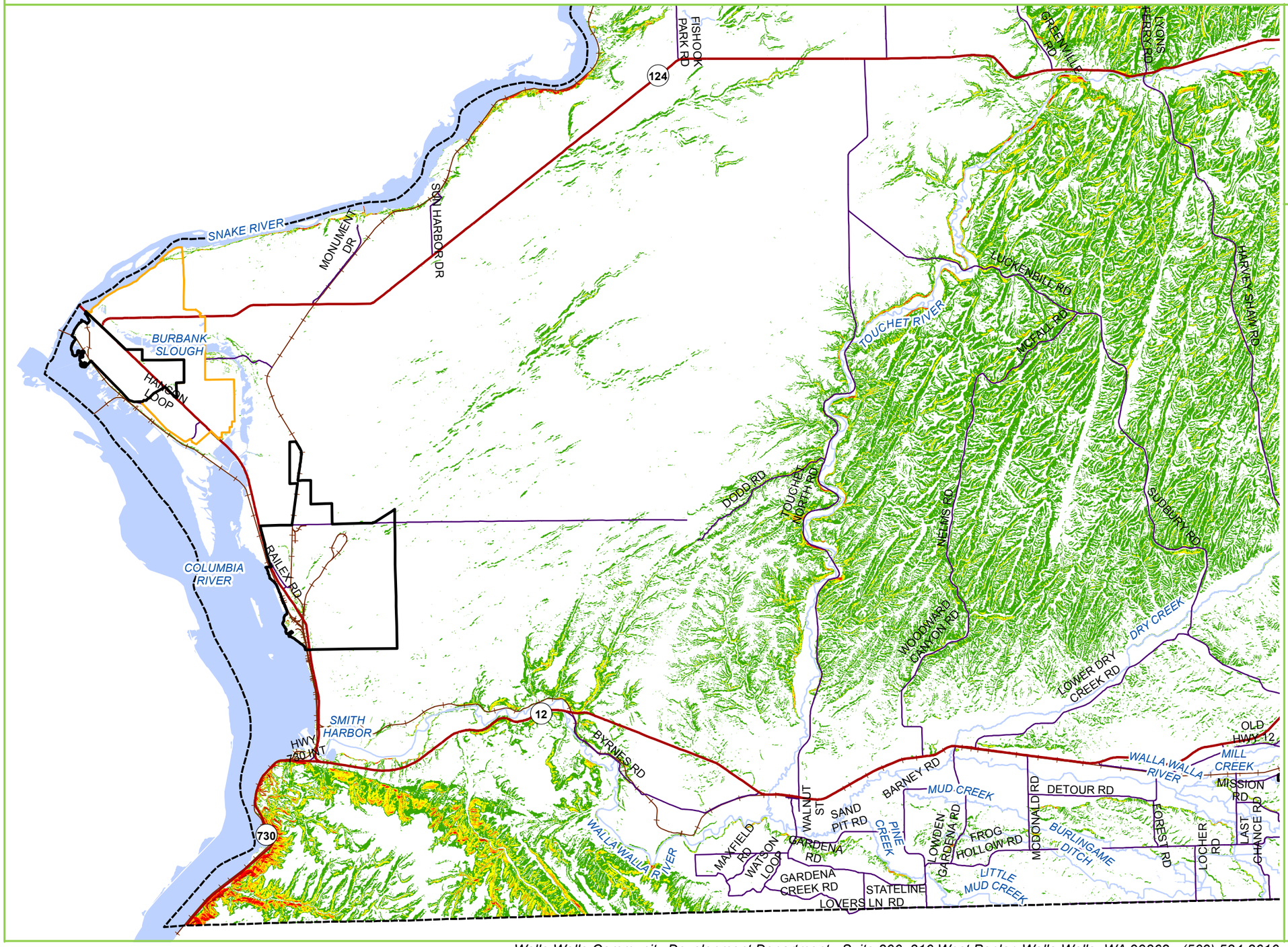
Flood Fringe Zone

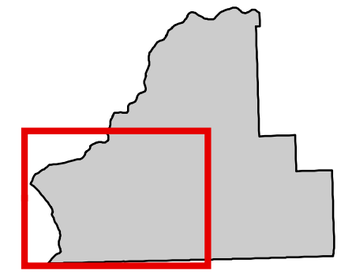
- A
- AE
- AO

* FEMA Q3 Flood Data, revised January 2002.

0 1 2 mi

GEOLOGICALLY HAZARDOUS AREAS - Steep Slopes - Southwest County





BASE MAP LAYERS

- County Boundary
- Urban Growth Area
- Burbank Rural Activity Center
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

STEEP SLOPES

- Landslide Hazard Areas[1]

Percent Slope[2]

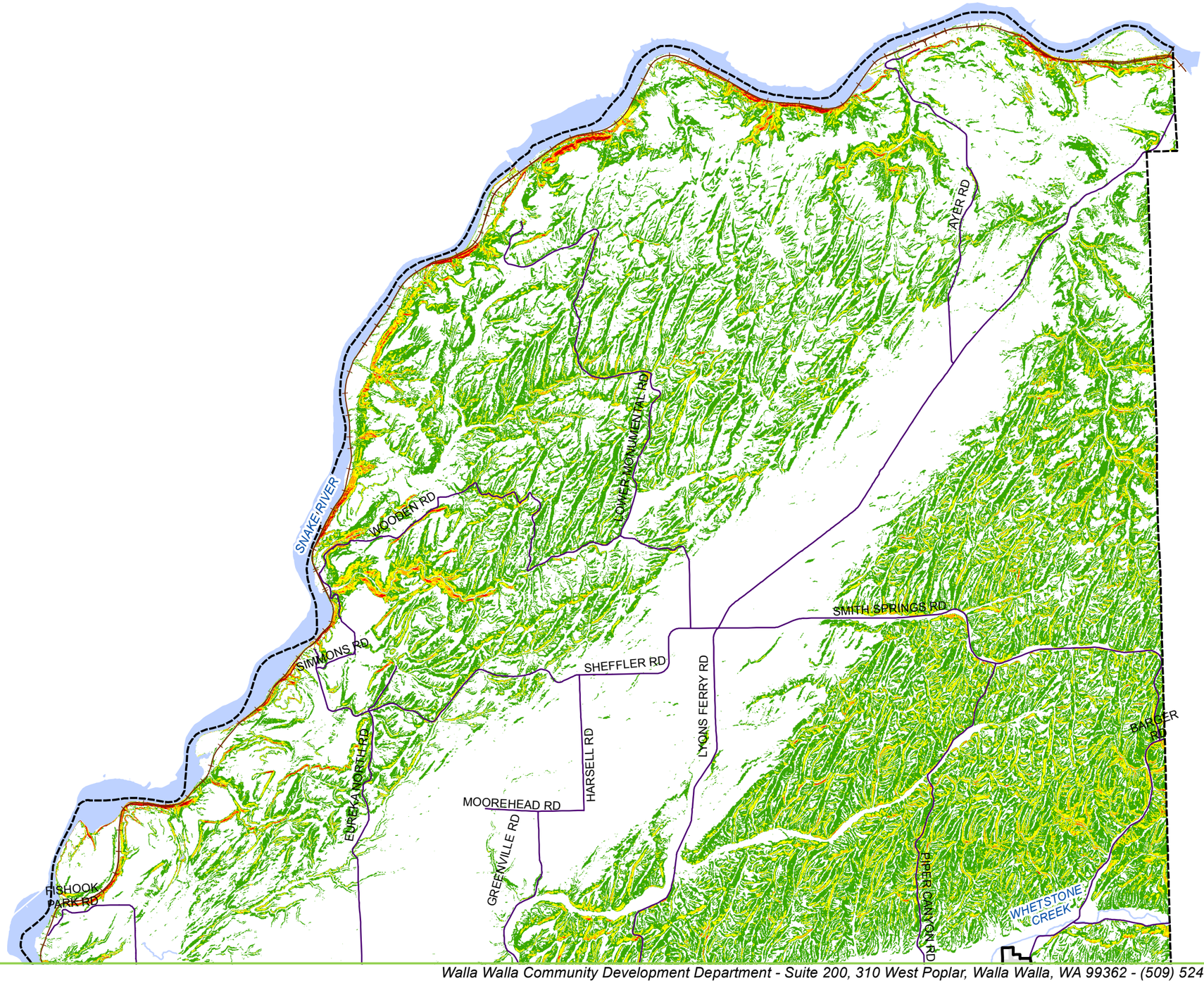
- 0<15
- 15<30
- 30<45
- 45<60
- 60<80
- >80

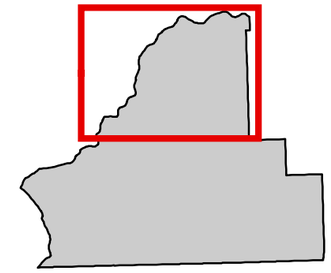
1. As designated and mapped by Walla Walla County.
2. Areas with slopes steeper than fifteen percent may be designated as erosion hazard areas or landslide hazard areas, depending on other site-specific factors, per Walla Walla County Code Chapter 18.08.

0 1.5 3 mi

COUNTY OF WALLA WALLA

GEOLOGICALLY HAZARDOUS AREAS - Steep Slopes - North County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

STEEP SLOPES

- Landslide Hazard Areas[1]

Percent Slope[2]

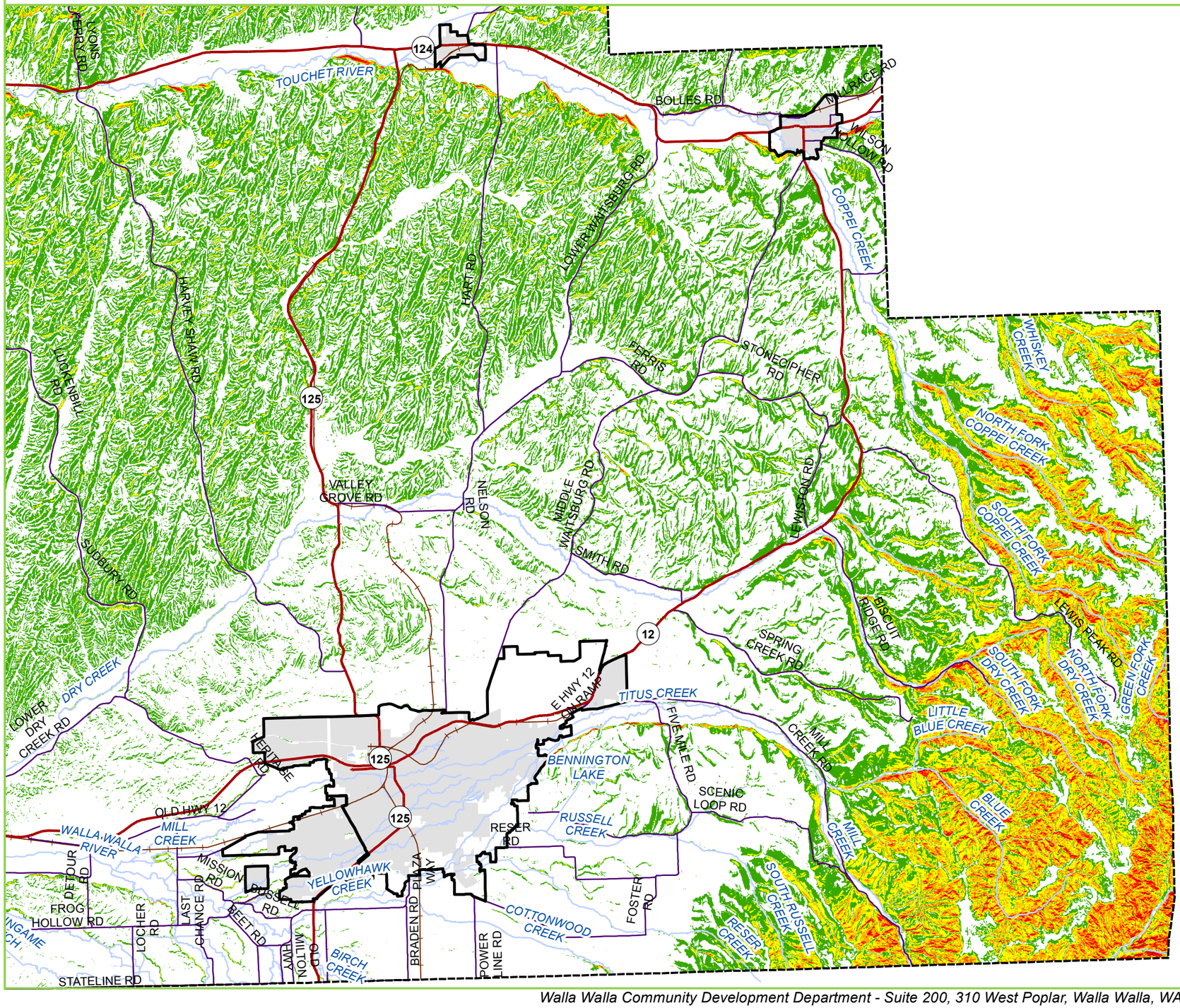
- 0<15
- 15<30
- 30<45
- 45<60
- 60<80
- >80

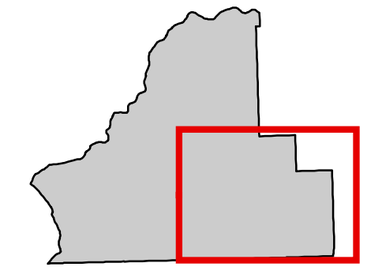
1. As designated and mapped by Walla Walla County.
2. Areas with slopes steeper than fifteen percent may be designated as erosion hazard areas or landslide hazard areas, depending on other site-specific factors, per Walla Walla County Code Chapter 18.08.

0 1 2 mi

COUNTY OF WALLA WALLA

GEOLOGICALLY HAZARDOUS AREAS - Steep Slopes - Southeast County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

STEEP SLOPES

- Landslide Hazard Areas[1]

Percent Slope[2]

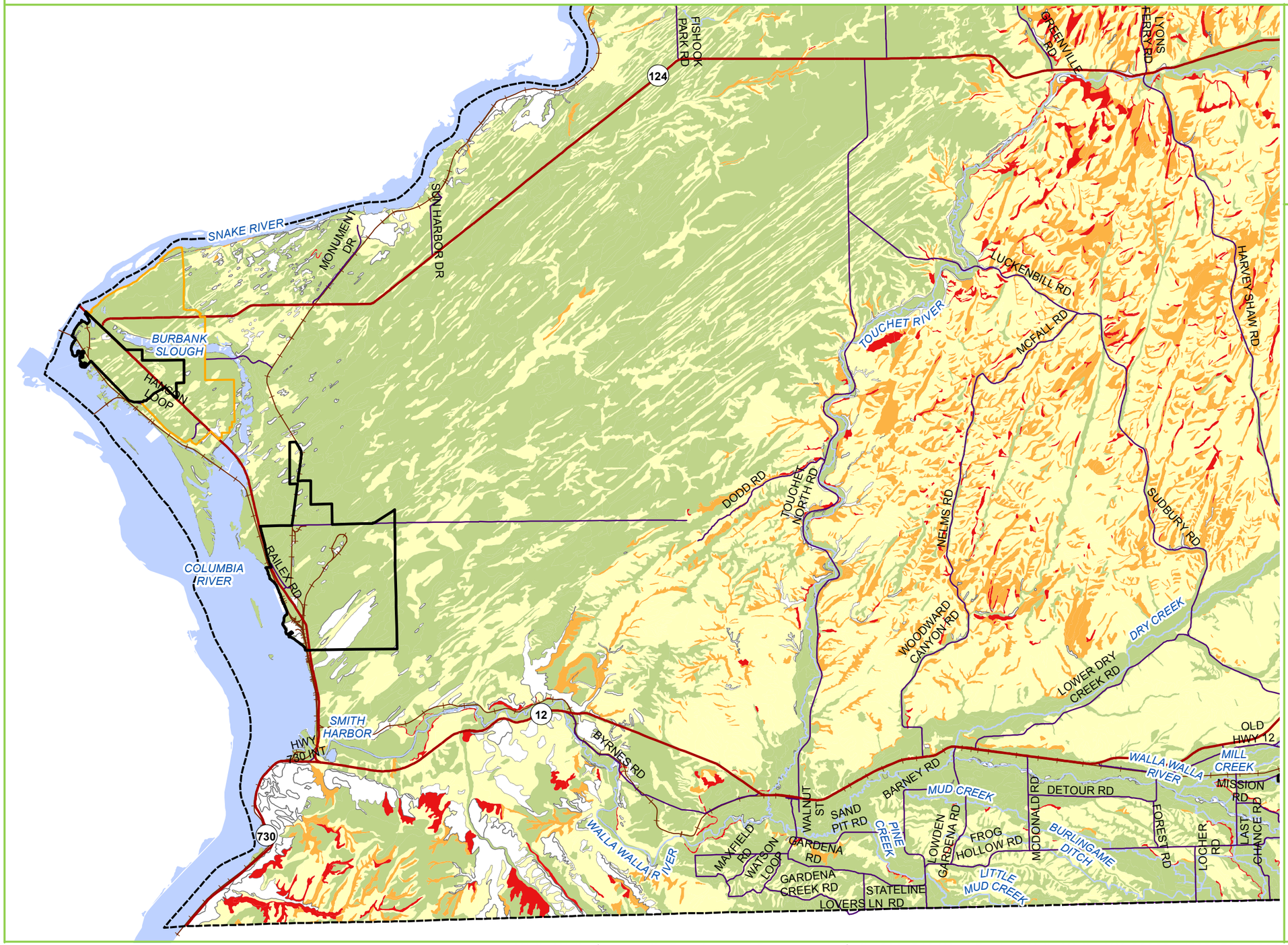
- 0<15
- 15<30
- 30<45
- 45<60
- 60<80
- >80

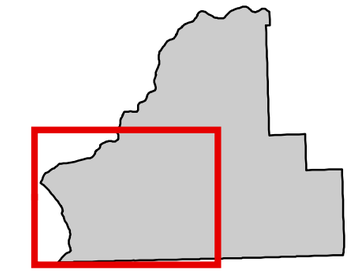
1. As designated and mapped by Walla Walla County.
2. Areas with slopes steeper than fifteen percent may be designated as erosion hazard areas or landslide hazard areas, depending on other site-specific factors, per Walla Walla County Code Chapter 18.08.

0 1 2 mi

COUNTY OF WALLA WALLA

EROSION HAZARD AREAS - Potential Soil Erosion Susceptibility - Southwest County





BASE MAP LAYERS

- County Boundary
- Urban Growth Area
- Burbank Rural Activity Center
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

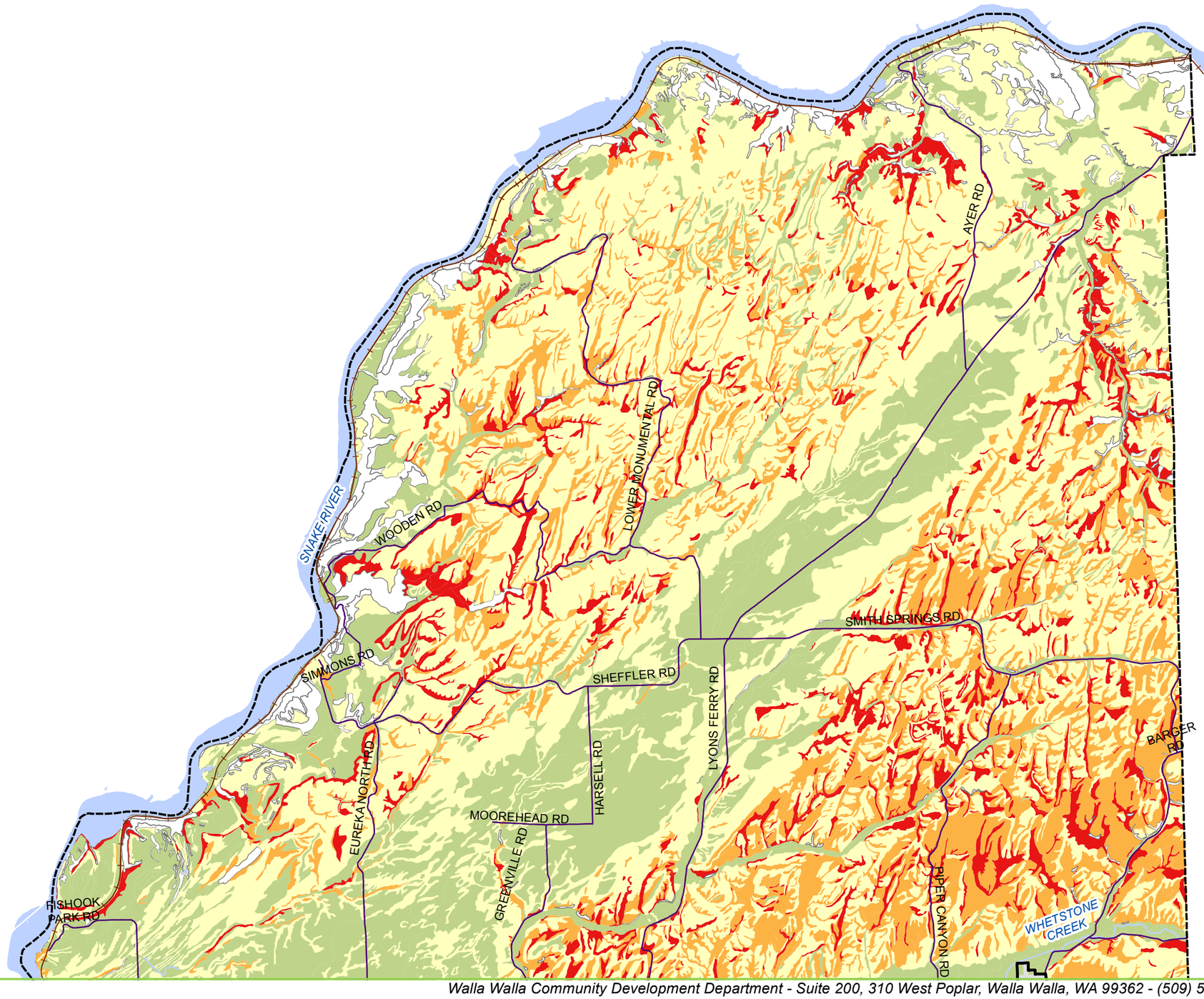
POTENTIAL SOIL EROSION SUSCEPTIBILITY[1]

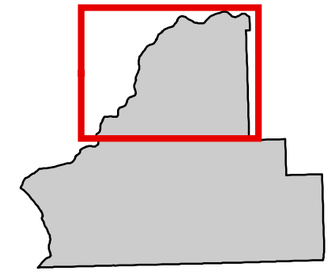
- Not rated
- Slight
- Moderate
- Severe[2]
- Very severe[2]

1. Defined as erosion hazard (off-road, off-trail), as mapped by the NRCS Web Soil Survey and based on slope and soil erosion factor K.
2. Designated as Geologically Hazardous Area under Walla Walla County Code Chapter 18.08.

0 1.5 3 mi

EROSION HAZARD AREAS - Potential Soil Erosion Susceptibility - North County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

POTENTIAL SOIL EROSION SUSCEPTIBILITY[1]

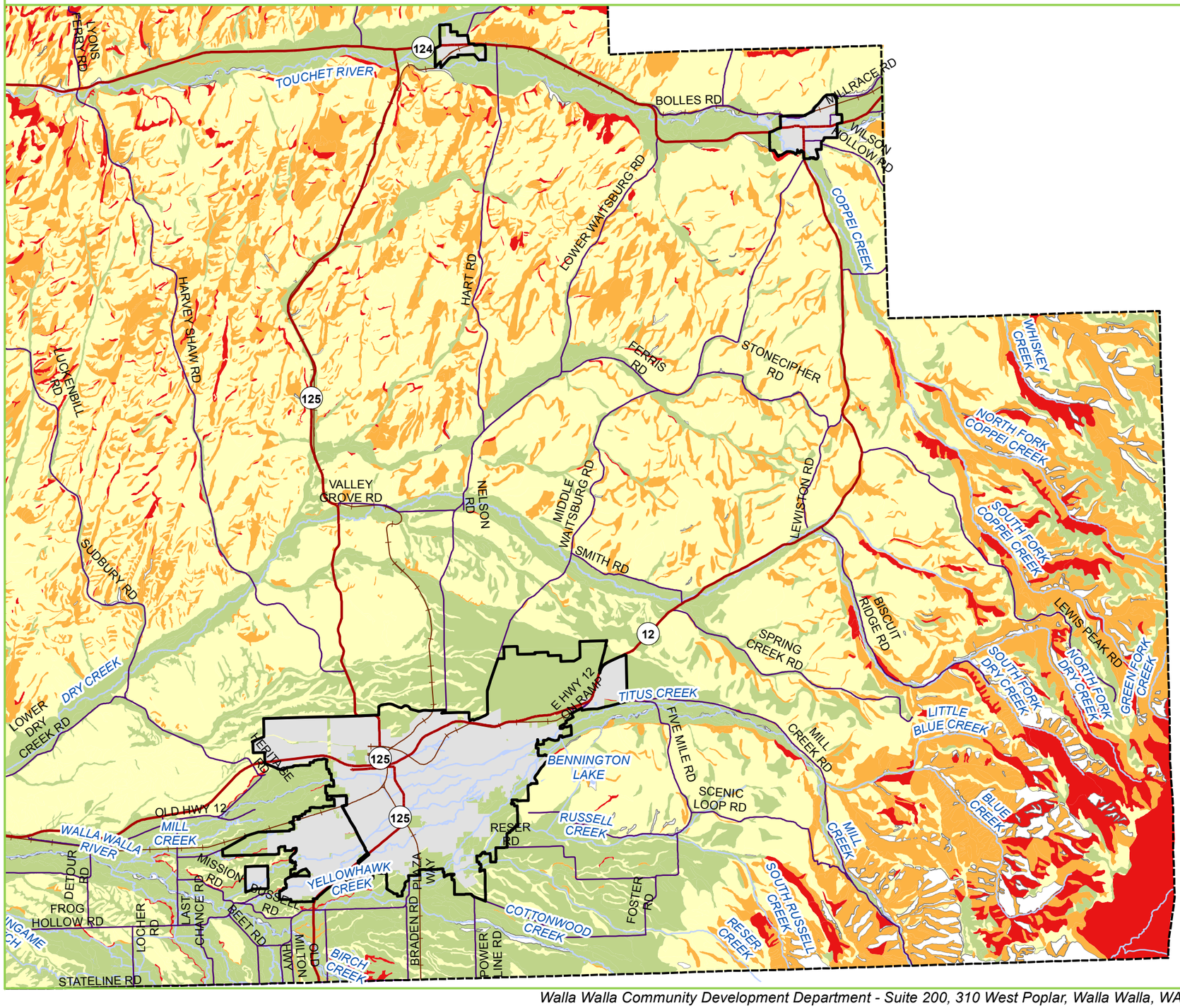
- Not rated
- Slight
- Moderate
- Severe[2]
- Very severe[2]

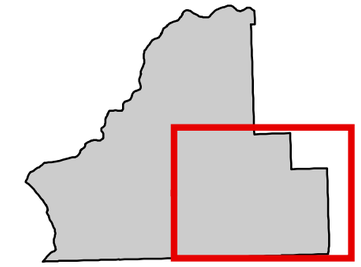
1. Defined as erosion hazard (off-road, off-trail), as mapped by the NRCS Web Soil Survey and based on slope and soil erosion factor K.
2. Designated as Geologically Hazardous Area under Walla Walla County Code Chapter 18.08.

0 1 2 mi

COUNTY OF WALLA WALLA

EROSION HAZARD AREAS - Potential Soil Erosion Susceptibility - Southeast County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

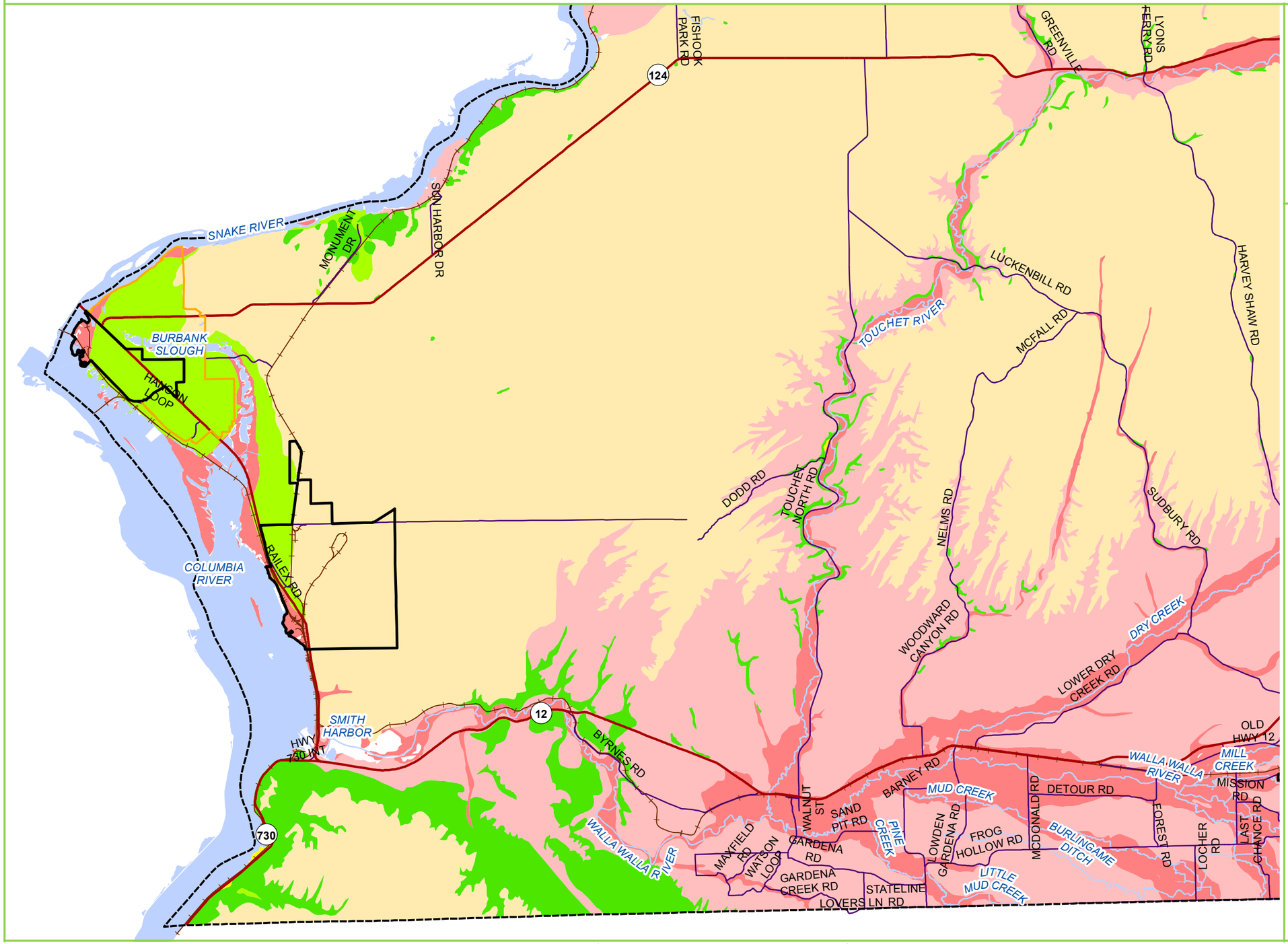
POTENTIAL SOIL EROSION SUSCEPTIBILITY[1]

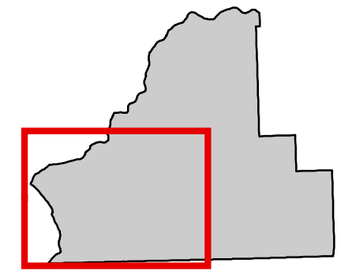
- Not rated
- Slight
- Moderate
- Severe[2]
- Very severe[2]

1. Defined as erosion hazard (off-road, off-trail), as mapped by the NRCS Web Soil Survey and based on slope and soil erosion factor K.
2. Designated as Geologically Hazardous Area under Walla Walla County Code Chapter 18.08.

0 1 2 mi

SEISMIC HAZARD AREAS - Potential Liquefaction Susceptibility - Southwest County





BASE MAP LAYERS

- County Boundary
- Urban Growth Area
- Burbank Rural Activity Center
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

POTENTIAL LIQUEFACTION SUSCEPTIBILITY

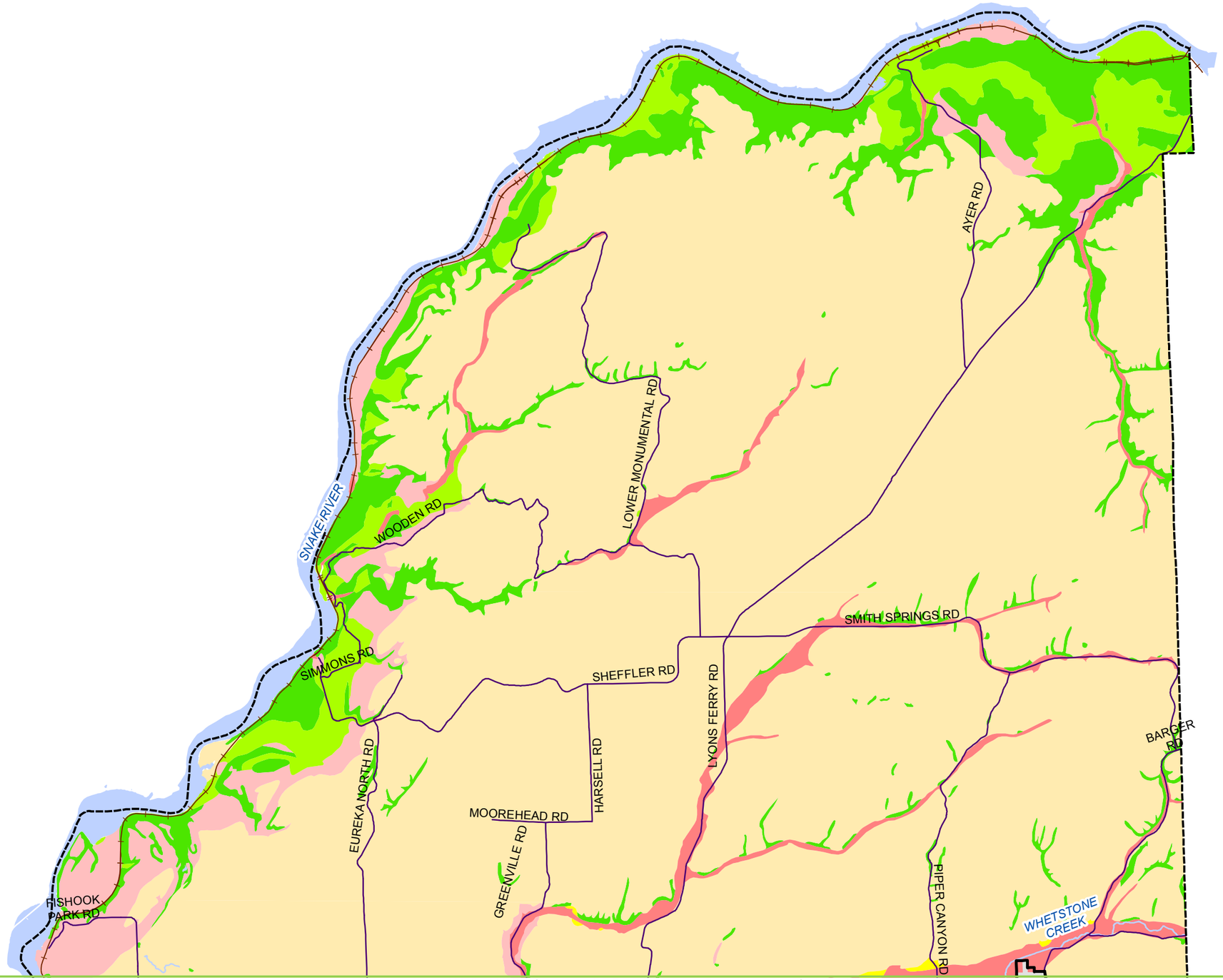
- High *
- Moderate to High *
- Low to Moderate
- Low
- Very Low to Low
- Very Low
- N/A (Bedrock)

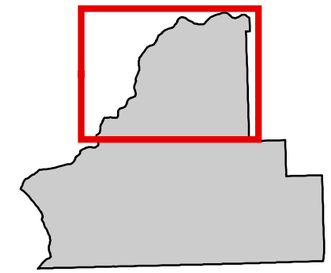
* Designated as Geologically Hazardous Area under Walla Walla County Code Chapter 18.08.

0 1.5 3 mi

COUNTY OF WALLA WALLA

SEISMIC HAZARD AREAS - Potential Liquefaction Susceptibility - North County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

POTENTIAL LIQUEFACTION SUSCEPTIBILITY

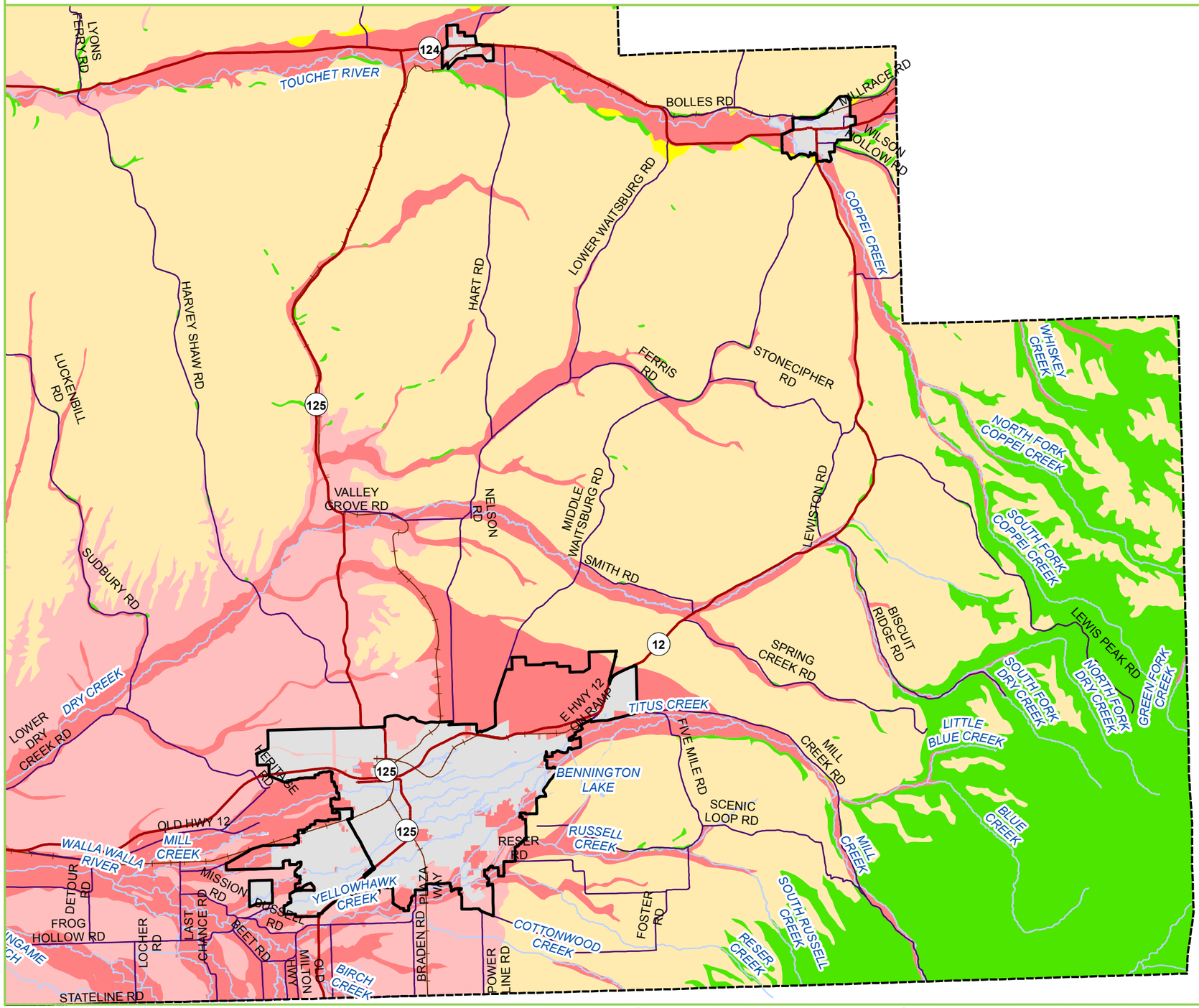
- High *
- Moderate to High *
- Low to Moderate
- Low
- Very Low to Low
- Very Low
- N/A (Bedrock)

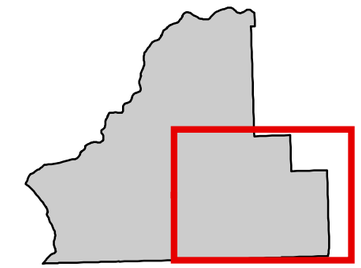
* Designated as Geologically Hazardous Area under Walla Walla County Code Chapter 18.08.

0 1 2 mi

COUNTY OF WALLA WALLA

SEISMIC HAZARD AREAS - Potential Liquefaction Susceptibility - Southeast County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

POTENTIAL LIQUEFACTION SUSCEPTIBILITY

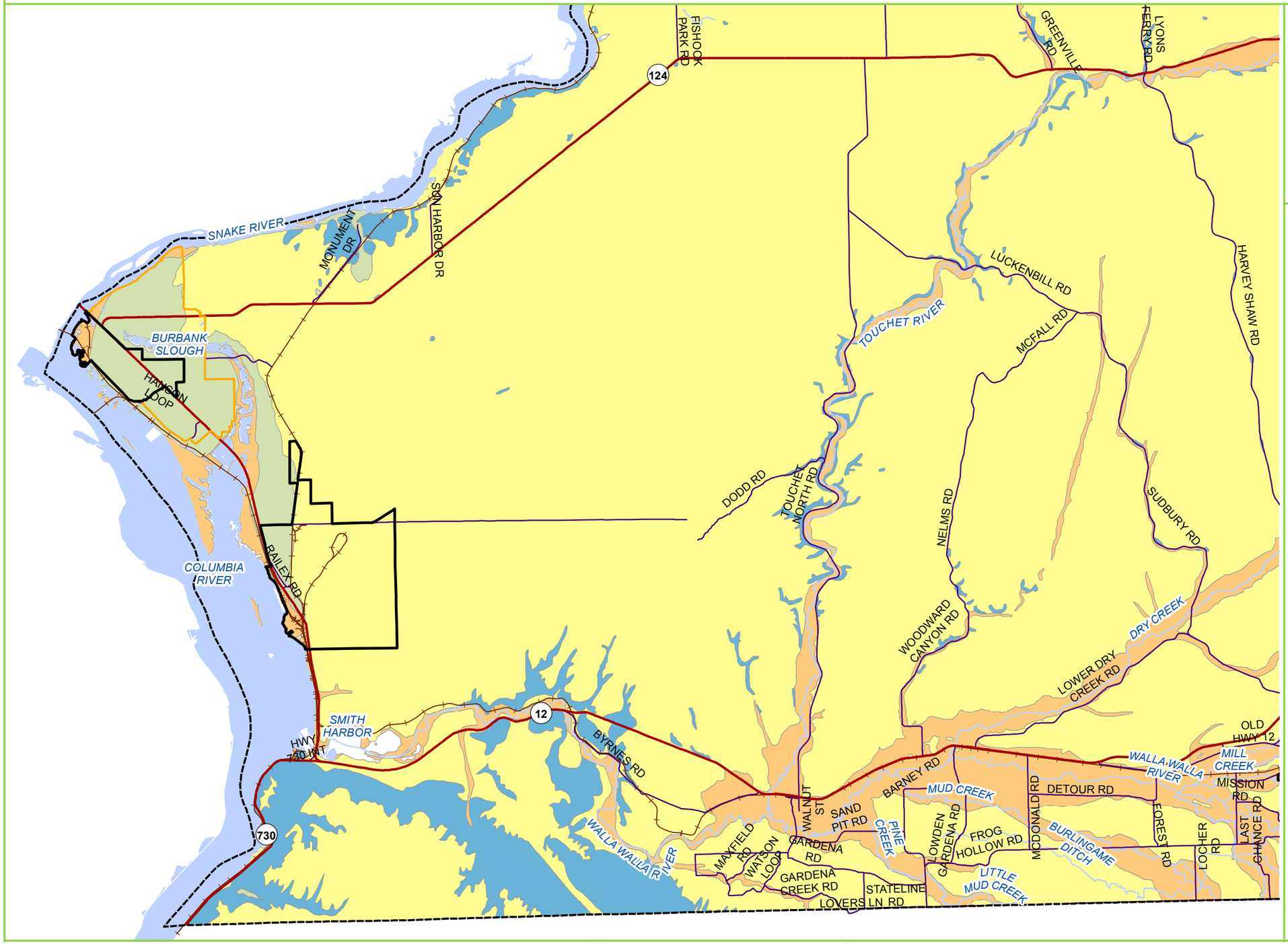
- High *
- Moderate to High *
- Low to Moderate
- Low
- Very Low to Low
- Very Low
- N/A (Bedrock)

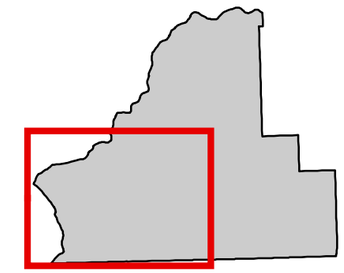
* Designated as Geologically Hazardous Area under Walla Walla County Code Chapter 18.08.

0 1 2 mi

COUNTY OF WALLA WALLA

SEISMIC HAZARD AREAS - Seismic Design Site Class - Southwest County





BASE MAP LAYERS

- County Boundary
- Urban Growth Area
- Burbank Rural Activity Center
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

SEISMIC DESIGN SITE CLASS

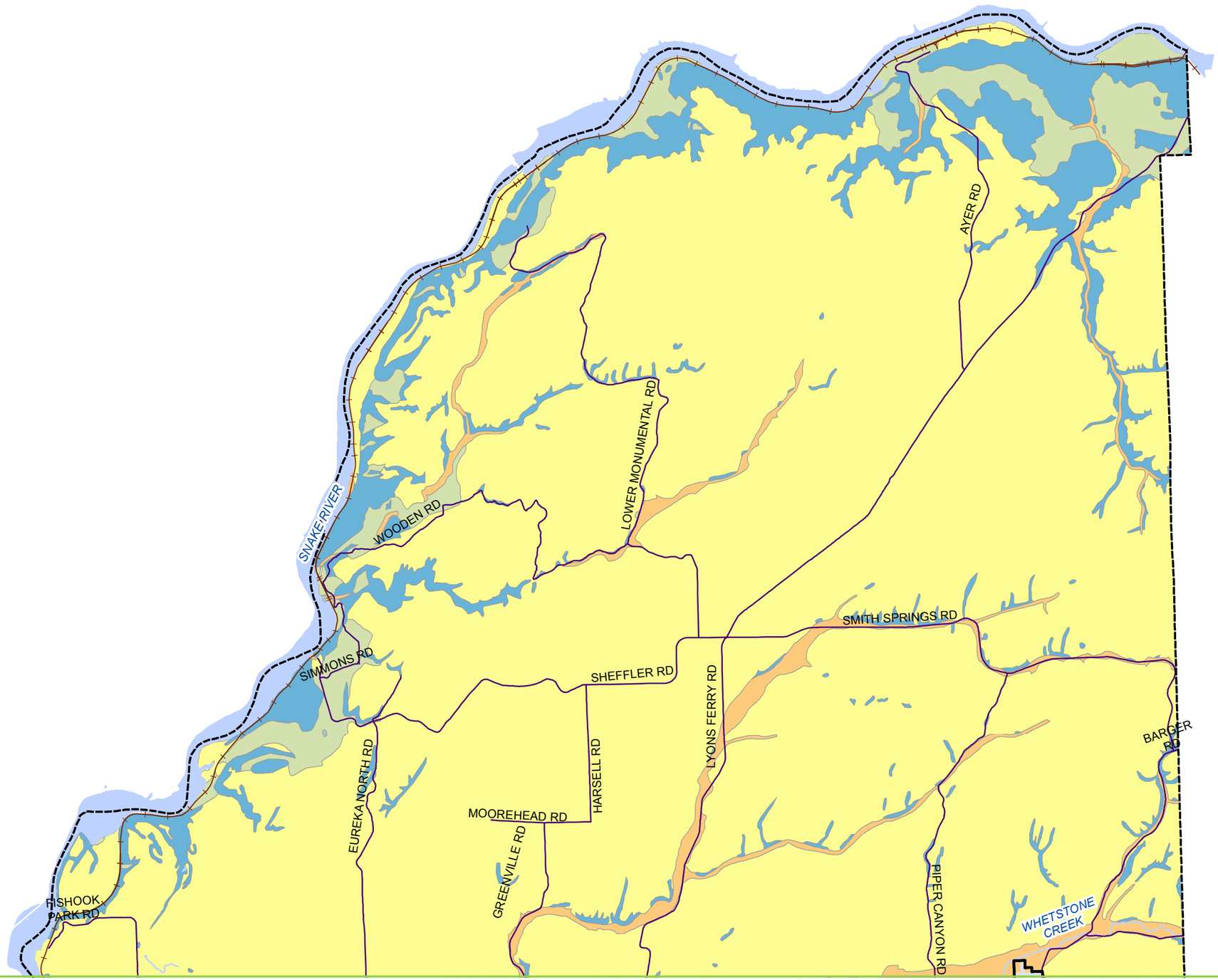
- Water
- B
- B-C
- C
- D
- D-E
- E

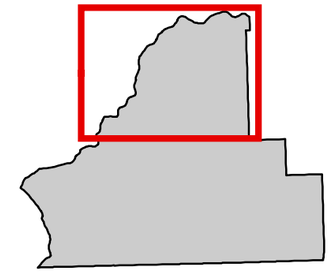
Increasing amplification of ground shaking

0 1.5 3 mi

COUNTY OF WALLA WALLA

SEISMIC HAZARD AREAS - Seismic Design Site Class - North County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

SEISMIC DESIGN SITE CLASS

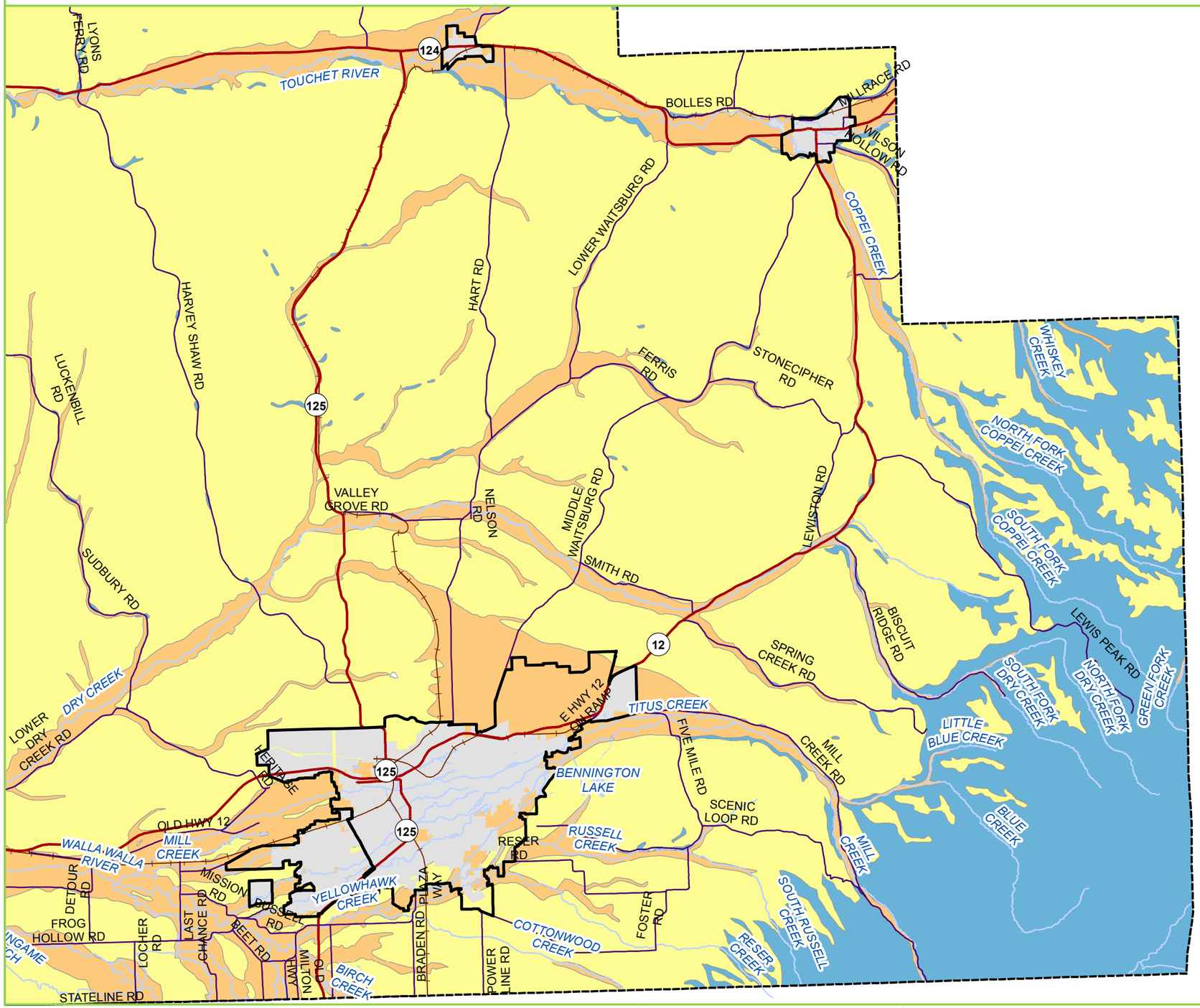
- Water
- B
- B-C
- C
- D
- D-E
- E

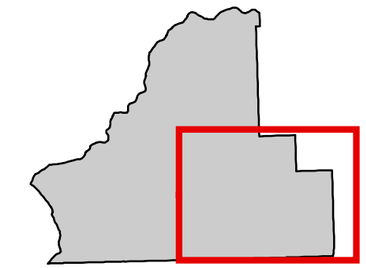
Increasing amplification of ground shaking

0 1 2 mi

COUNTY OF WALLA WALLA

SEISMIC HAZARD AREAS - Seismic Design Site Class - Southeast County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Streams
- Rivers/Water Bodies

SEISMIC DESIGN SITE CLASS

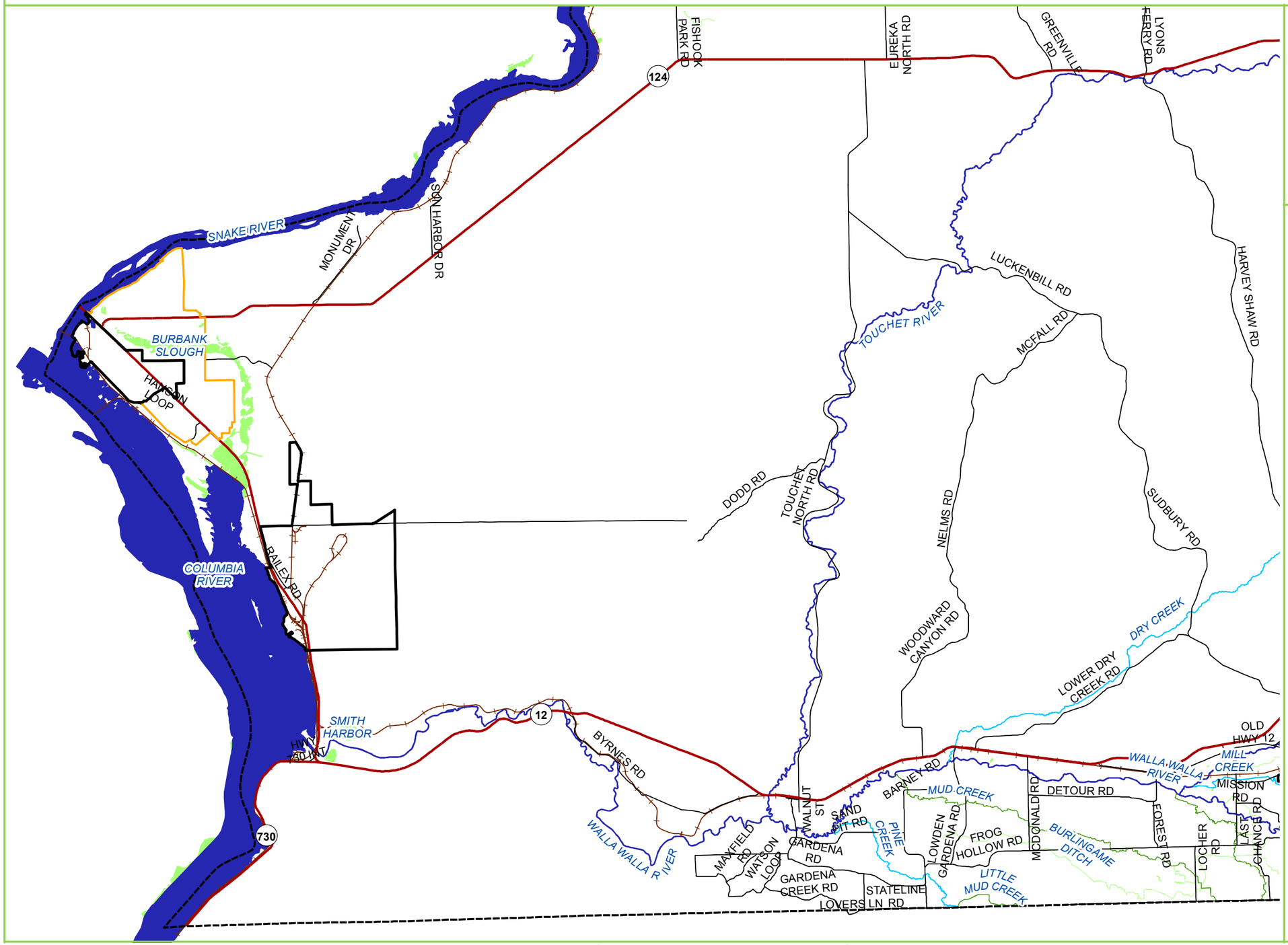
- Water
- B
- B-C
- C
- D
- D-E
- E

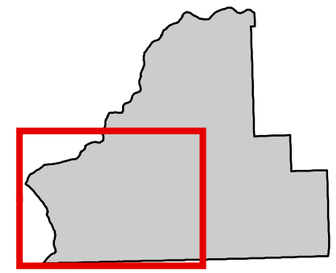
Increasing amplification of ground shaking

0 1 2 mi

COUNTY OF WALLA WALLA

FISH AND WILDLIFE HABITAT CONSERVATION AREAS - Waters of the State - Southwest County





BASE MAP LAYERS

- County Boundary
- Urban Growth Area
- Burbank Rural Activity Center
- State Highway
- Public Road
- Railroads

WATERCOURSES AND WATER BODIES

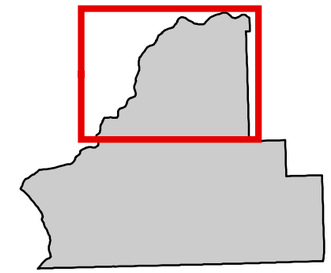
Minimum Riparian Buffer Width (feet)

- 100
- 75
- 50
- 35

0 1.5 3 mi

COUNTY OF WALLA WALLA

FISH AND WILDLIFE HABITAT CONSERVATION AREAS - Waters of the State - North County



BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads

WATERCOURSES AND WATER BODIES

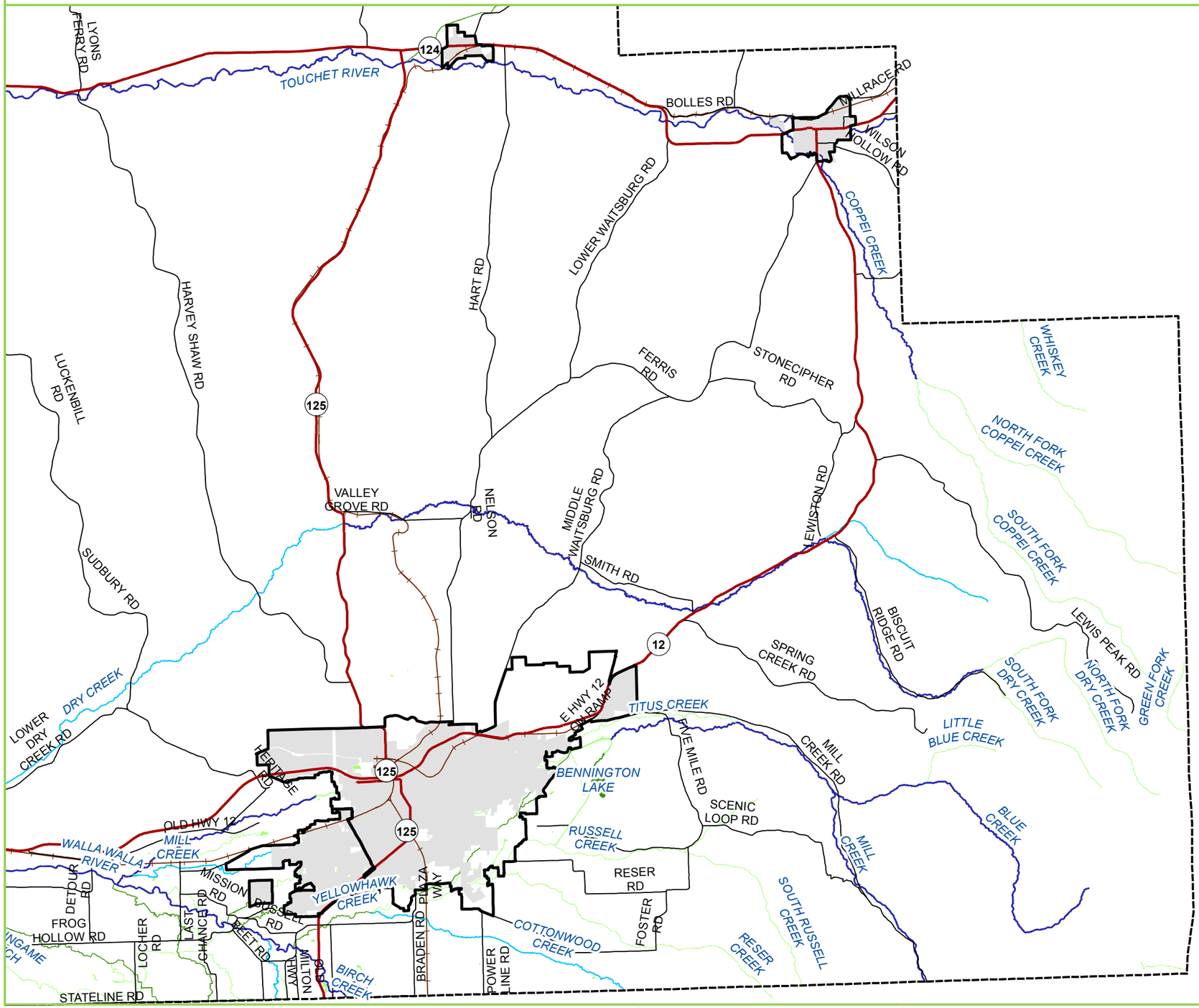
Minimum Riparian Buffer Width (feet)

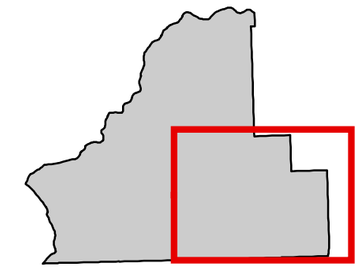
- 100
- 75
- 50
- 35

0 1 2 mi

COUNTY OF WALLA WALLA

FISH AND WILDLIFE HABITAT CONSERVATION AREAS - Waters of the State - Southeast County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads

WATERCOURSES AND WATER BODIES

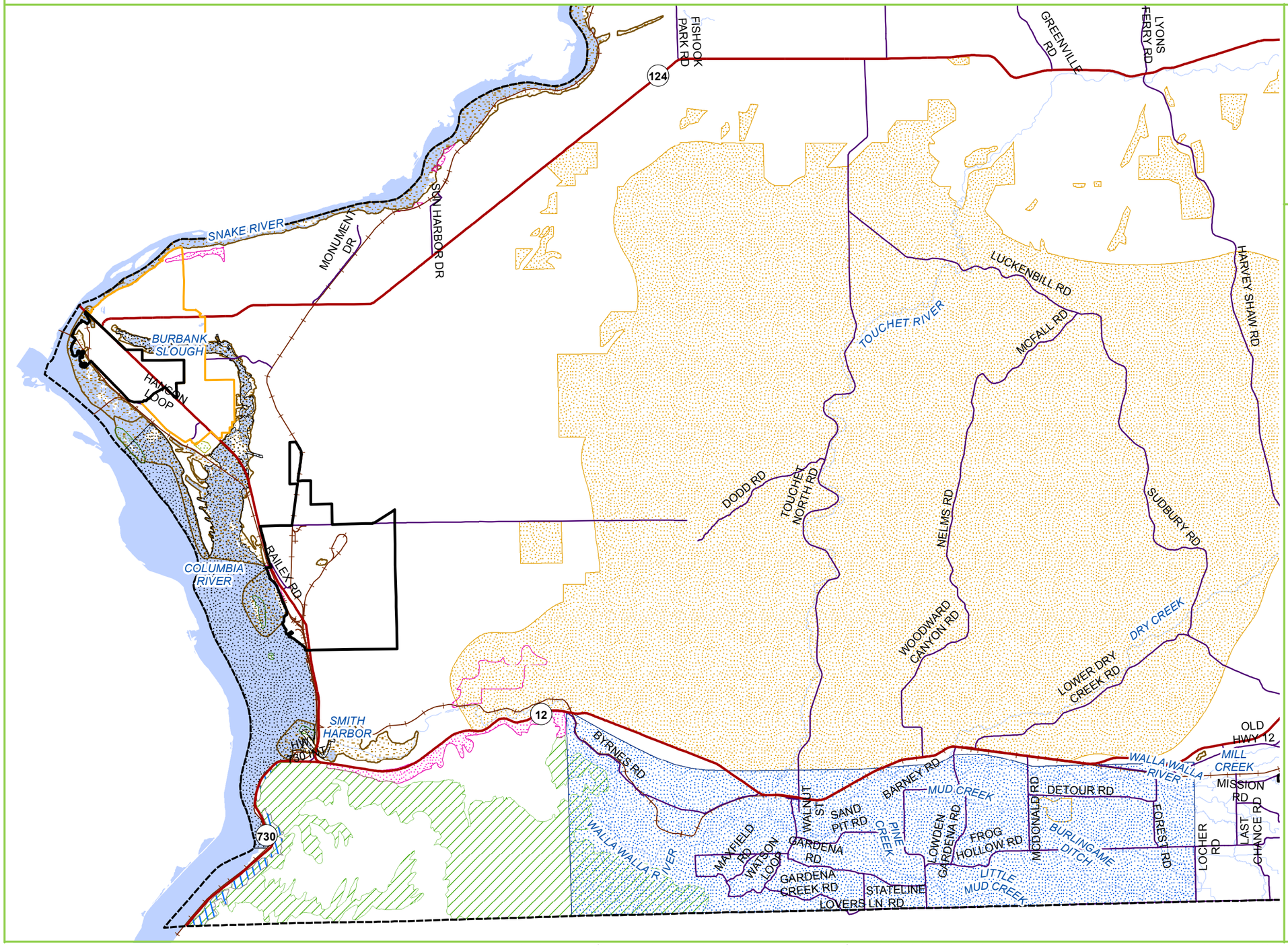
Minimum Riparian Buffer Width (feet)

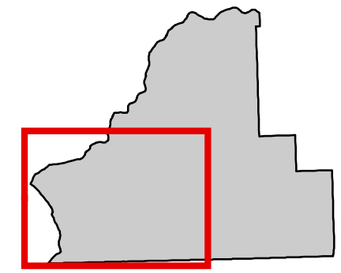
- 100
- 75
- 50
- 35

0 1 2 mi

COUNTY OF WALLA WALLA

FISH AND WILDLIFE HABITAT CONSERVATION AREAS - Priority Habitats and Species - Southwest County





BASE MAP LAYERS

- County Boundary
- Urban Growth Area
- Burbank Rural Activity Center
- State Highway
- Public Road
- Railroads
- Rivers/Water Bodies
- Streams

PRIORITY HABITATS AND SPECIES

Habitats of Local Importance

- High Density of Wintering Birds of Prey Habitat
- Neotropical Migrant Songbird Habitat
- Raptor Ferruginous Hawk Habitat

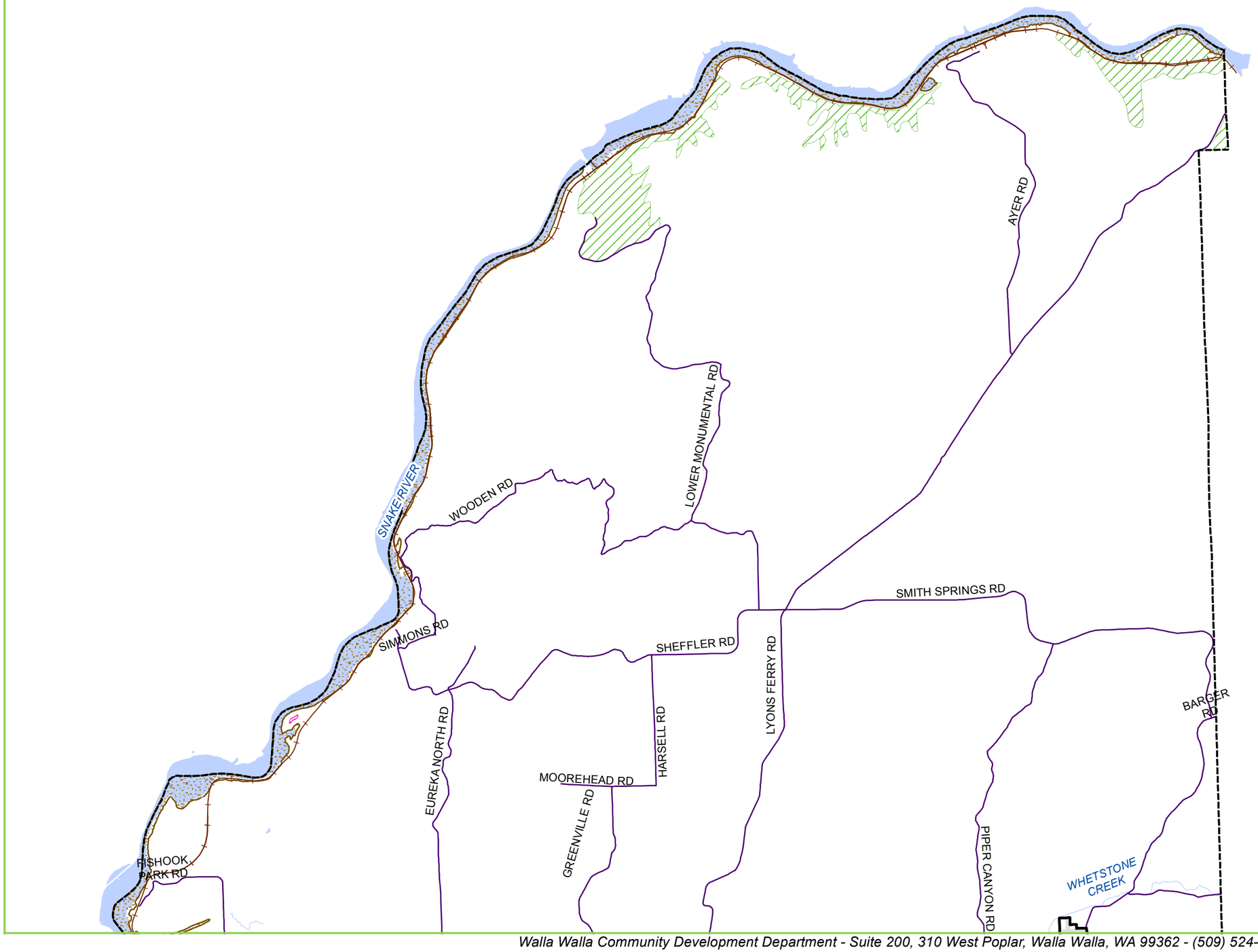
State Priority Habitats and Species (WDFW)

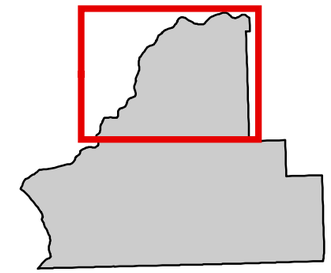
- American White Pelican
- Burrowing Owl
- Mule Deer
- Waterfowl Concentrations
- Cliffs/bluffs
- Shrub-steppe

0 1.5 3 mi

COUNTY OF WALLA WALLA

FISH AND WILDLIFE HABITAT CONSERVATION AREAS - Priority Habitats and Species - North County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Rivers/Water Bodies
- Streams

PRIORITY HABITATS AND SPECIES

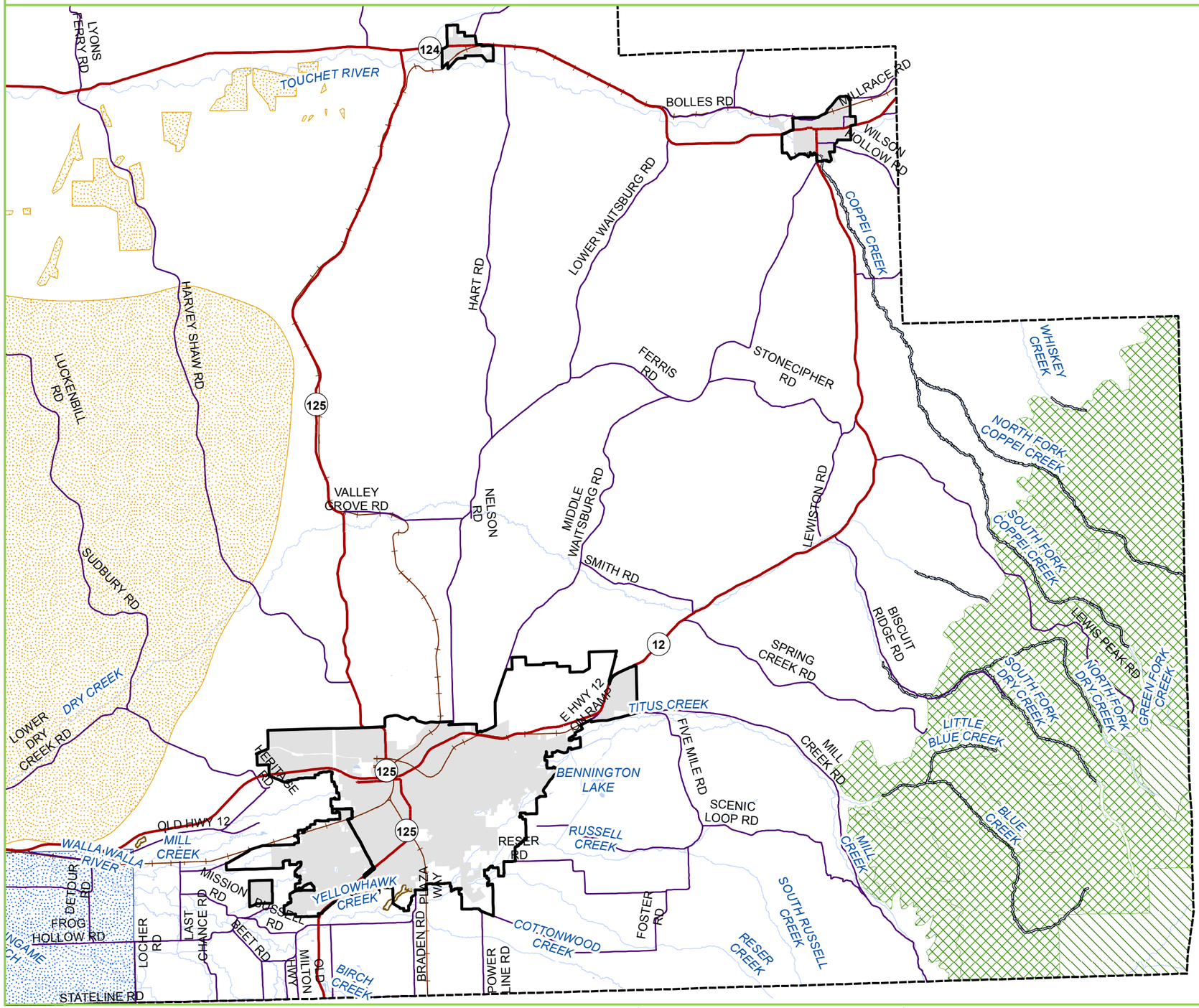
State Priority Habitats and Species (WDFW)

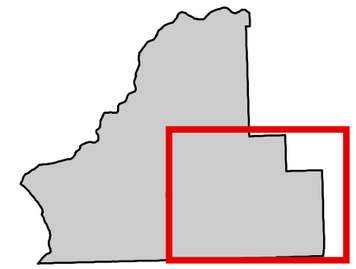
- Mule Deer
- Waterfowl Concentrations
- Shrub-steppe

0 1 2 mi

COUNTY OF WALLA WALLA

FISH AND WILDLIFE HABITAT CONSERVATION AREAS - Priority Habitats and Species - Southeast County





BASE MAP LAYERS

- County Boundary
- Incorporated Area
- Urban Growth Area
- State Highway
- Public Road
- Railroads
- Rivers/Water Bodies
- Streams

PRIORITY HABITATS AND SPECIES

Habitats of Local Importance

- High Density of Wintering Birds of Prey Habitat
- Neotropical Migrant Songbird Habitat
- Raptor Ferruginous Hawk Habitat

State Priority Habitats and Species (WDFW)

- Mule Deer
- Rocky Mountain Elk
- Waterfowl Concentrations

0 1 2 mi

COUNTY OF WALLA WALLA

FACET

Critical Areas Ordinance Update

Best Available Science Review Addendum

CITY OF WALLA WALLA

JUNE 26, 2026

Prepared for:

City of Walla Walla
15 N. Third Avenue
Walla Walla, WA 99362

Facet Number:
2507.0393.00

FACET

Spokane Office
601 W Main Ave, Suite 617
Spokane, WA 99201
509.606.3600

The information contained in this report is based on the application of technical guidelines currently accepted as the best available science. All discussions, conclusions, and recommendations reflect the best professional judgment of the author(s) and are based upon information available at the time the study was conducted. All work was completed within the constraints of budget, scope, and timing. The findings of this report are subject to verification and agreement by the appropriate local, state, and federal regulatory authorities. No other warranty, expressed or implied, is made.

Acronyms and Abbreviations

BAS	Best Available Science
BMP	Best Management Practices
CAO	Critical Areas Ordinance
CARA	Critical Aquifer Recharge Area
Commerce	Washington State Department of Commerce
CRB	Columbia River Basalt
CMZ	Channel Migration Zone
DNR	Washington State Department of Natural Resources
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FFA	Frequently Flooded Area
FIRM	Flood Insurance Rate Map
FWHCA	Fish and Wildlife Habitat Conservation Area
GIS	Geographic Information System
GMA	Growth Management Act
HUC	Hydrologic Unit Code
LID	Low Impact Development
OHWM	Ordinary High Water Mark
WWBWC	Walla Walla Basin Watershed Council
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries Service
PHS	Priority Habitats and Species
RCW	Revised Code of Washington
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code

Table of Contents

1. Introduction 1

1.1 Best Available Science 1

1.2 Climate Change 2

2. Critical Aquifer Recharge Areas 2

2.1 Definitions 2

2.2 Designation 2

2.3 CARA in the City of Walla Walla 3

2.3.1 Geology and Distribution 4

3. Wetlands 5

3.1 Definitions 5

3.2 Designation 6

3.3 Wetlands in the City of Walla Walla 6

3.3.1 Wetland Distribution 8

4. Frequently Flooded Areas 9

4.1 Definitions 9

4.2 Frequently Flooded Areas in the City of Walla Walla 9

4.2.1 Flood Hazard Mapping 10

5. Geologically Hazardous Areas 11

5.1 Definitions 11

5.2 Designation 11

5.3 Potential Geologic Hazards in the City of Walla Walla 13

6. Fish and Wildlife Habitat Conservation Areas 17

6.1 Definitions 17

6.2 Designation 19

6.3 FWHCA in the City of Walla Walla 21

6.3.1 Streams, ponds, lakes 21

6.3.2 Wildlife and Habitat 23

7. References 27

Tables

Table 1. Priority fish species distribution in the City of Walla Walla (HDR 2008). 24

Table 2. WDFW Designated Priority Habitats and Species that Occur in Walla Walla County 25

Figures

Figure 1. Critical Aquifer Recharge Areas mapped in City of Walla Walla (HDR 2008). 3
Figure 2. Designated wellhead protection areas. Reproduced from the Walla Walla Community Development Department, 2019. 4
Figure 3. Mapped wetlands in the City of Walla Walla and UGA (HDR 2008). 7
Figure 4. Wetlands mapped by Walla Walla County GIS database, retrieved April 8, 2026. 8
Figure 5. Mapped FFA in the City of Walla Walla and UGAs (HDR 2008). 10
Figure 6. Potential liquefaction areas in the City of Walla Walla (HDR 2008). 14
Figure 7. Steep slopes in the City of Walla Walla (HDR 2008). 15
Figure 8. Potential erosion hazard due to water in the City of Walla Walla (HDR 2008). 16
Figure 9. Potential erosion hazard due to wind in the City of Walla Walla (HDR 2008). 17
Figure 10. Mapped stream classifications in the City of Walla Walla (HDR 2008). 21
Figure 11. Existing riparian areas in the City of Walla Walla (HDR 2008). 22
Figure 12. City of Walla Walla recommended FWHCA buffers. 23

Appendices

APPENDIX A. ..... Walla Walla County CAO Update Best Available Science Review FINAL

1. INTRODUCTION

This review of the Best Available Science (BAS) was compiled to support the update of the City of Walla Walla's Critical Areas Ordinance (CAO). As mandated by the Washington State Growth Management Act (GMA), cities and counties must periodically update their comprehensive plans and development regulations. City of Walla Walla's Comprehensive Plan underwent a complete update in 2019. This document establishes the framework for planned updates to the CAO and serves as a basis for a gap analysis identifying which current critical-area regulations should be prioritized for consistency with BAS.

Walla Walla County is also going through the CAO update process. The County CAO work to-date includes a 2025 draft BAS review (Appendix A). That county-level BAS provides foundational scientific information that is also applicable within the City of Walla Walla. Accordingly, the purpose of this BAS review is not to replicate the County's work, but to supplement it by identifying and addressing local conditions specific to the City of Walla Walla and providing additional context to inform potential updates to City regulations.

Under the GMA, the City of Walla Walla must incorporate "best available science" (BAS) when developing policies and regulations to protect the functions and values of critical areas. Additionally, "special consideration" must be given to conservation or protection measures necessary to preserve or enhance anadromous fisheries. Anadromous fish spend parts of their life cycle in both freshwater and saltwater, entering freshwater from the ocean to spawn (WAC 365-195-900). Regulated critical areas include wetlands, areas critical for aquifer recharge used for potable water, fish and wildlife habitat conservation areas, frequently flooded areas, and geologically hazardous areas (RCW 36.70A.030(11)).

While this BAS review serves as a resource for critical area management, it is not designed to provide definitive answers for all policy and regulatory decisions. Policies and regulations should incorporate BAS and require decision-making processes grounded in societal values. Additionally, ecological systems are complex, and scientific knowledge continually evolves with new research and technology. Despite these advancements, there are limits to what is currently understood, and specific topics may remain ambiguous. Where scientific uncertainty exists in the literature about a particular subject, this review presents a range of current findings and recommendations. According to WAC 365-195-920, decision-makers may adopt a precautionary or no-risk approach when scientific information is incomplete.

1.1 Best Available Science

Best Available Science (BAS) refers to the most current and credible information developed through a valid scientific process as specified in WAC 365-195-900 through WAC 365-195-925. Characteristics of a valid scientific process include peer review, standardized methods, logical conclusions and reasonable inferences, quantitative analysis, proper context, and relevant references. Familiar sources of scientific

information encompass research, monitoring, inventory, modeling, assessment, and synthesis (WAC 365-195-905). BAS literature reviews synthesize the current scientific knowledge, and only resources meeting these criteria are included as references for this BAS.

The City of Walla Walla' most recent CAO in the City of Walla Walla Municipal Code (WWMC) Chapter 21.04 - Critical Areas.

1.2 Climate Change

As of July 2023, following the passage of Washington House Bill 1181, "Climate Change in Local Comprehensive Planning," the GMA requires jurisdictions to incorporate and evaluate the effects of climate change in long-range planning. Climate change is anticipated to have a profound influence on natural systems. Addressing anticipated climate change impacts on critical areas enables decision-makers to incorporate climate resilience into policies and regulations.

The Walla Walla County BAS Review includes a detailed discussion of climate change trends and management strategies for each critical area type. See Appendix B for further details.

2. CRITICAL AQUIFER RECHARGE AREAS

2.1 Definitions

Critical aquifer recharge areas (CARAs) are defined in WAC 365-190-030(3) as follows:

> *Critical aquifer recharge areas are areas with a critical recharging effect on aquifers used for potable water, including areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water, or is susceptible to reduced recharge.*

The City of Walla Walla CAO defines CARAs as follows (WWMC 21.04.020):

> *means areas designated by WAC 365-190-080(2) that are determined to have a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030(2).*

2.2 Designation

The City of Walla Walla CAO designates CARAs as follows (WWMC 21.04.200):

> *Critical aquifer recharge areas (CARA) are those areas with a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030(2). CARA have prevailing geologic conditions associated with infiltration rates that create a high potential for contamination of ground water resources or contribute significantly to the replenishment of ground water. CARA in the city of Walla Walla are designated as follows: sufficient to minimize the hazard.*

A. Wellhead Protection Areas. Wellhead protection areas may be defined by the boundaries of the ten-year time of ground water travel or boundaries established using alternate criteria approved by the Washington State Department of Health in those settings where ground water time of travel is not a reasonable delineation criterion, in accordance with WAC 246-290-135.

B. The ten-year time of travel as defined in the wellhead protection plans submitted by communities and water providers to the Department of Health as of 2007. The city of Walla Walla maintains these groundwater capture zones. The CARA delineated by the ten-year capture zones are defined in Critical Area Map 1. Table 1 lists the communities and water providers in the city of Walla Walla that have designated wellhead protection areas. Table 1 also lists the total area encompassed by the ten-year time of travel.

2.3 CARA in the City of Walla Walla

City mapped gravel aquifers cover nearly the entirety of the incorporated city and its urban growth area (UGA) (Figure 1). Additionally, Walla Walla County has delineated the boundaries of wellhead protection areas, a type of CARA (Figure 2).

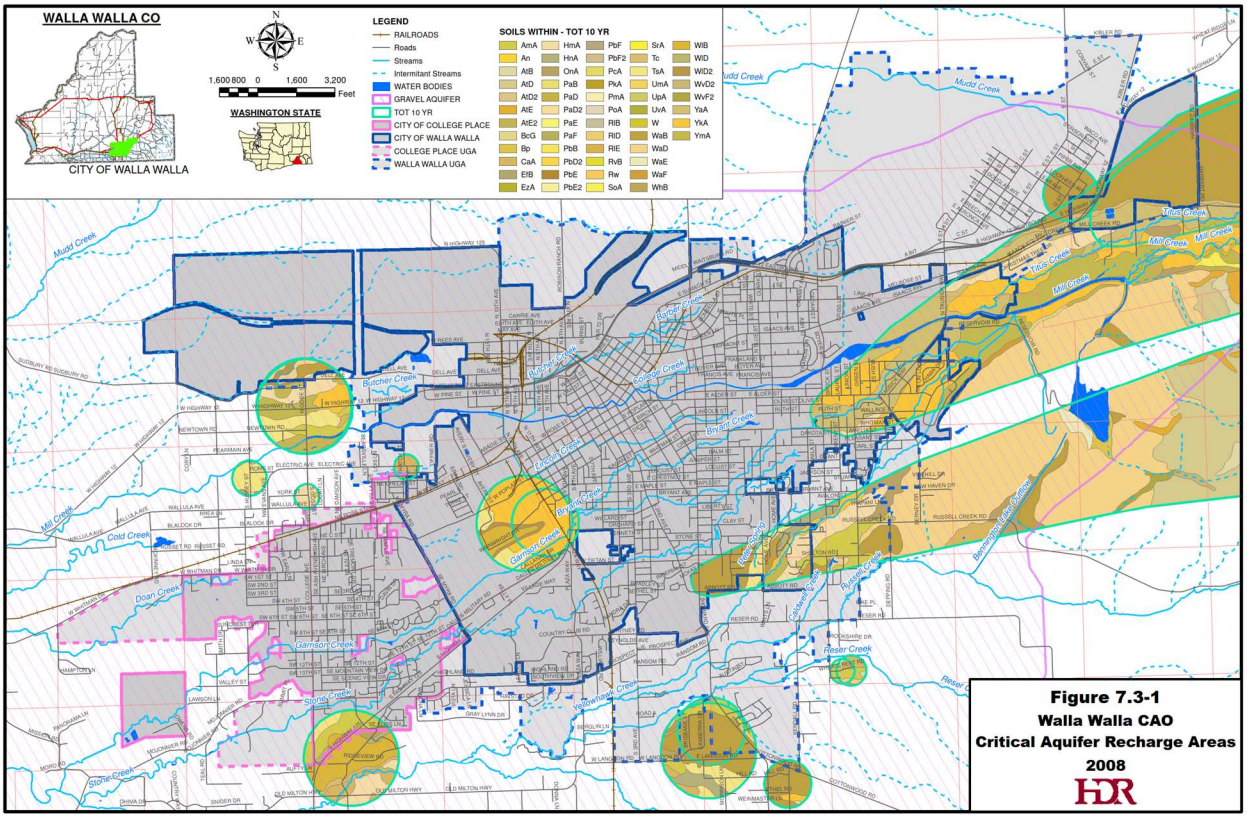


Figure 1. Critical Aquifer Recharge Areas mapped in City of Walla Walla (HDR 2008).

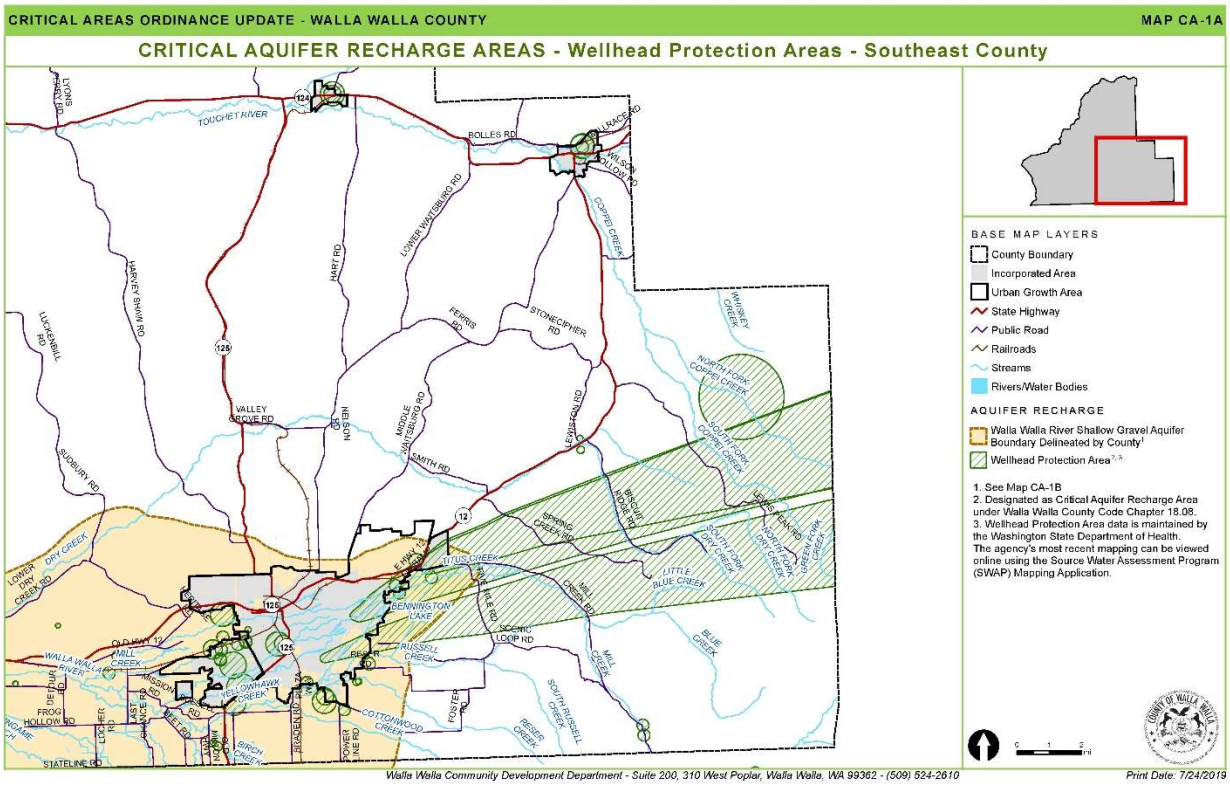


Figure 2. Designated wellhead protection areas. Reproduced from the Walla Walla Community Development Department, 2019.

2.3.1 Geology and Distribution

The Walla Walla Basin contains two principal aquifers: (1) The shallow gravel aquifer, which is made up of unconsolidated sediments located above a clay layer that encompasses the entire city and adjacent areas, and (2) the underlying basalt aquifer spans all of Walla Walla County and the Walla Walla River basin, including the City of Walla Walla. The entire gravel aquifer covers approximately 190 square miles, with about a third of that area in Oregon. In contrast, the basalt aquifer system in the Walla Walla River basin encompasses roughly 2,500 square miles, including the portion located in Oregon (HDR 2008).

The gravel aquifer typically occurs under unconfined or water-table conditions, though there are a few exceptions. This shallow aquifer has moderate to high permeability, meaning it can transmit water effectively. The highest permeabilities are found in the sands and gravels near stream and river channels. The gravel aquifer is also hydraulically connected to the streams, canals, and ditches above it. Water moves into and out of the gravel aquifer through various mechanisms, including rainfall, snowmelt, rivers, streams, ditches, and irrigation, allowing it to infiltrate and percolate through the ground (HDR 2008).

The Columbia River Basalt (CRB) formation beneath the City of Walla Walla consists of three major formations separated by sedimentary interbeds that generally impede water movement but can act as aquifers. These formations are combined and referred to as the "basalt aquifer." This aquifer comprises interconnected layers of basalt flows, typically ranging from 5 to 150 feet thick, with only 5 to 10 percent of the thickness contributing to water transmission. The basalt aquifer has high permeability, with groundwater flow following low-lying areas where most groundwater storage occurs. The depth to water-bearing zones varies widely, and groundwater is generally confined. The basalt aquifer discharges primarily into streams, maintaining summer flows in Mill Creek and the Walla Walla River, and contributes to the Columbia and Snake Rivers. Generally, recharge occurs from the Blue Mountains and the Walla Walla River Basin (HDR 2008).

The hydraulic connection between the gravel and basalt aquifers is not fully understood. Some evidence suggests upward and downward flow through the clay layers, but modeling estimates indicate a predominance of upward movement from basalt to gravel. This connection may be less direct than previously thought, suggesting that changes in basalt pumping may have less impact on gravel aquifer levels and flow patterns (Golder Associates 2011).

3. WETLANDS

3.1 Definitions

Washington State defines wetlands in WAC 365-190-030(24) as follows:

> *"Wetland" or "wetlands" means areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. However, wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate conversion of wetlands, if permitted by the City or city.*

The City of Walla Walla CAO definition of wetlands is substantively similar but includes a requirement for the use of the federal delineation manual (WWMC 21.04.020):

> *means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or*

those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas to mitigate the conversion of wetlands. For identifying and delineating a wetland, local government shall use the approved federal delineation manual and regional supplement, as amended.

3.2 Designation

The City of Walla Walla CAO designates wetlands as follows (WWMC 21.04.300):

Wetlands are those areas designated in accordance with the approved federal wetland delineation manual and applicable regional supplements, as amended, that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted for life in saturated soil conditions. All areas within the city of Walla Walla meeting the wetland designation criteria in the approved federal wetland delineation manual and applicable regional supplements, as amended, regardless of any formal identification, are hereby designated critical areas and are subject to the provisions of this title.

3.3 Wetlands in the City of Walla Walla

Known wetland locations in the City are shown in the 2008 Critical Areas Maps and Walla Walla County GIS database (Figures 3 and 4).

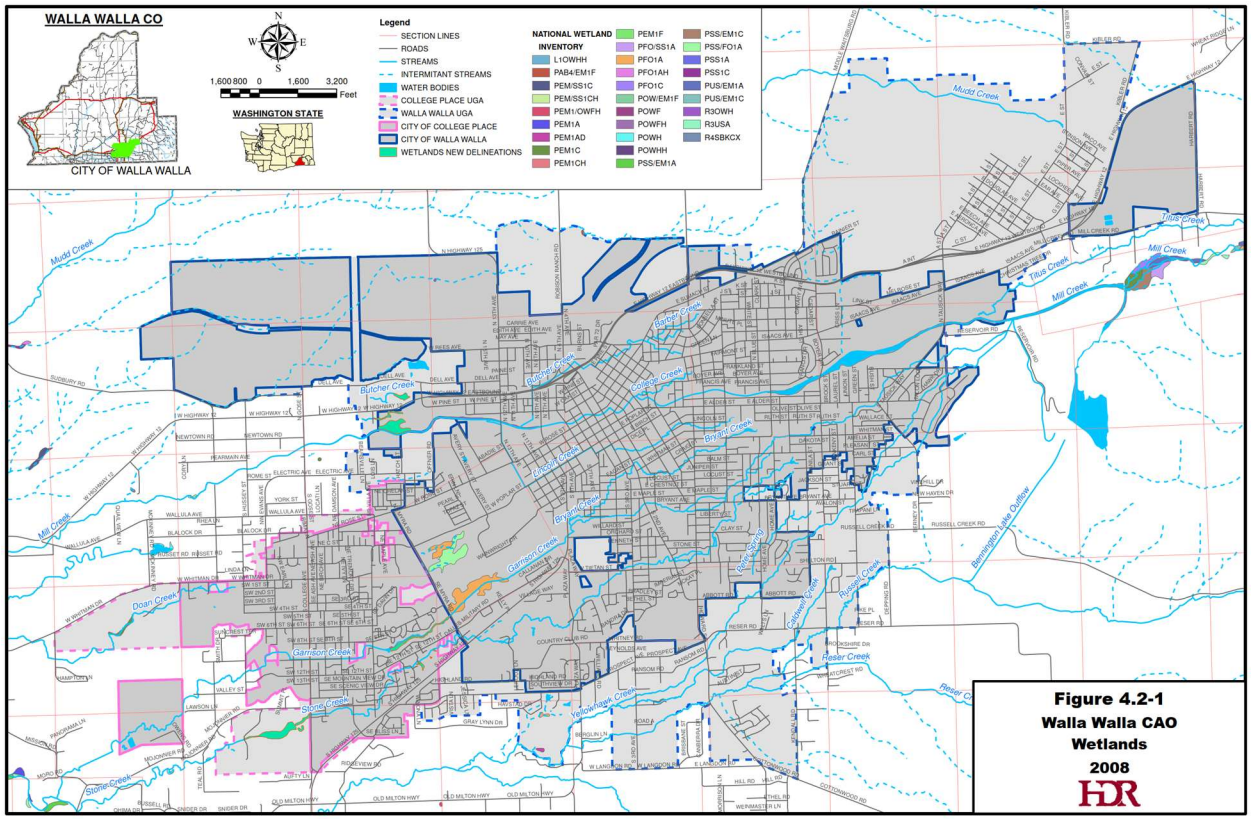


Figure 3. Mapped wetlands in the City of Walla Walla and UGA (HDR 2008).

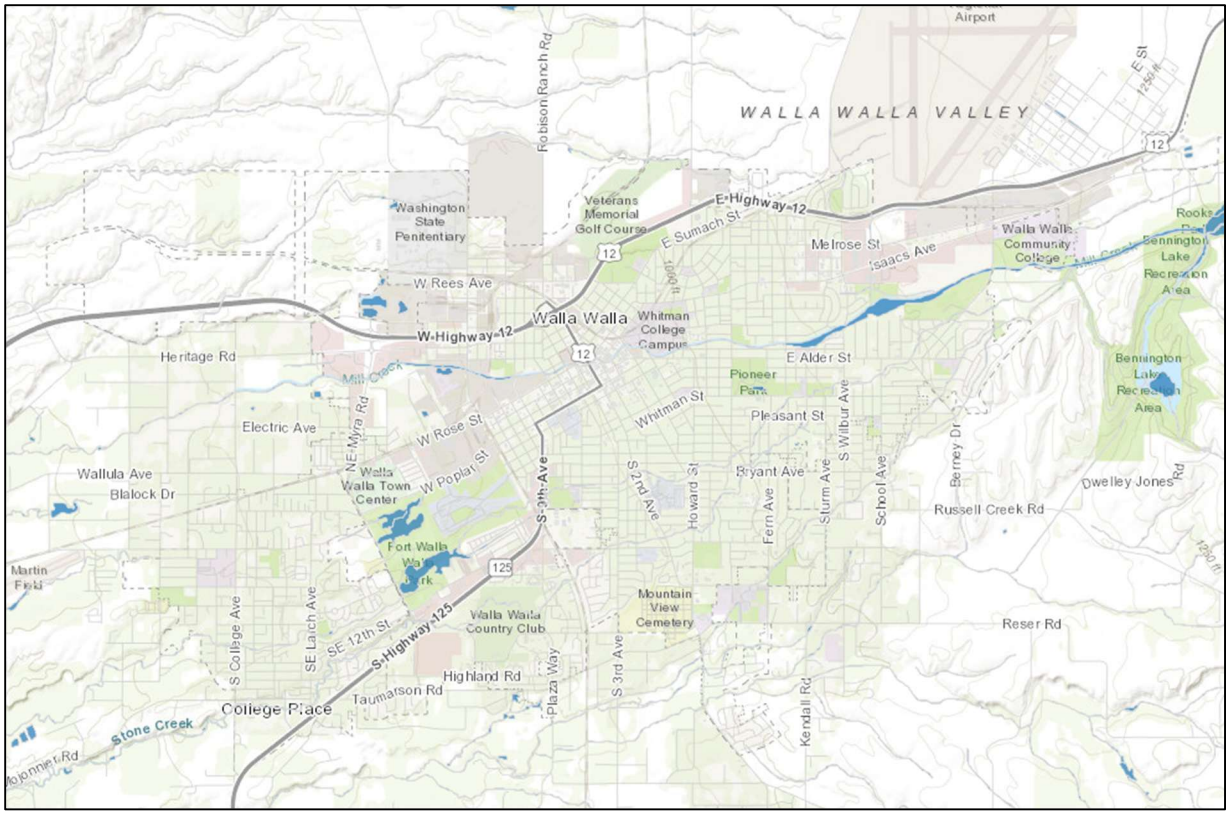


Figure 4. Wetlands mapped by Walla Walla County GIS database, retrieved April 8, 2026.

3.3.1 Wetland Distribution

City of Walla Walla is situated within the rain shadow of the Cascade Mountains, resulting in a semi-arid climate. Wetlands, predominantly riparian wetlands, occur in areas along perennial drainageways due to water availability. While isolated wetlands are less common in the City of Walla Walla, they play essential roles as habitat. Agricultural activities, such as surface water diversion for irrigation, influence the distribution and types of wetlands. Return flows from agriculture can create wetland conditions in drains or low areas.

Wetlands provide essential benefits to humans and wildlife. Woody vegetation stabilizes streambanks during floods, regulates water temperatures, and supports diverse habitats, including associated wetlands. The riparian wetlands along major drainage corridors, such as the Mill Creek, Yellowhawk Creek, Garrison Creek and Stone Creek, provide habitat and support aquatic life. These rivers and their riparian zones also function as important wildlife corridors.

4. FREQUENTLY FLOODED AREAS

4.1 Definitions

Frequently flooded areas (FFAs) are defined in WAC 365-190-030(8) as follows:

> *Frequently flooded areas are lands in the flood plain subject to at least a one percent or greater chance of flooding in any given year, or within areas subject to flooding due to high groundwater. These areas include, but are not limited to, streams, rivers, lakes, coastal areas, wetlands, and areas where high groundwater forms ponds on the ground surface.*

The City of Walla Walla regulates flood hazard areas in WWMC Chapter 21.10 – Floodplain Management and does not have a definition of frequently flooded areas. Instead it is referenced as a *special flood hazard area*, defined as follows (WWMC 21.10.070):

> *The areas of special flood hazard, as may be annexed to the city of Walla Walla, identified by the Federal Insurance Administration in a scientific and engineering report entitled, "The Flood Insurance Study for the Unincorporated Areas in Walla Walla County," dated January 18, 2002, or as amended, with accompanying flood insurance rate maps (FIRM) is adopted by reference and declared to be a part of this chapter. The flood insurance study and FIRM are on file at the development services department.*

4.2 Frequently Flooded Areas in the City of Walla Walla

No frequently flooded areas (FFA) are mapped within city limits. Mill Creek through the city center is mapped as a flood control channel. Mapped 100-year floodplains and floodways are within the UGA south of the city, along Reser Creek, Russell Creek and Yellowhawk Creek. A 100-year floodplain is also mapped in the northeastern UGA between Mudd Creek and Mill Creek (Figure 5).

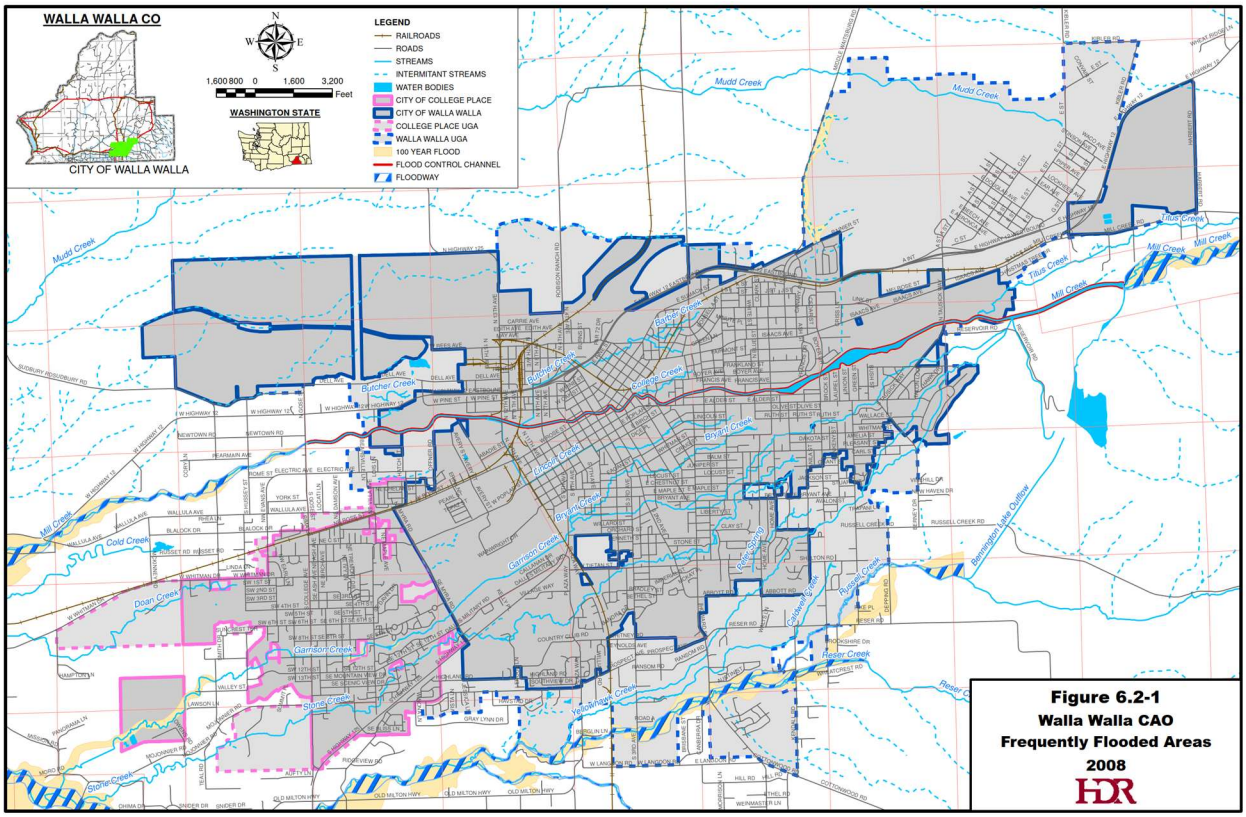


Figure 5. Mapped FFA in the City of Walla Walla and UGAs (HDR 2008).

4.2.1 Flood Hazard Mapping

In 2024, the City of Walla Walla, in collaboration with local officials and the cities of College Place, Prescott, Waitsburg, and Walla Walla County, updated the 2010 County of Walla Walla Multi-Jurisdictional Hazard Mitigation Plan. The Mill Creek Flood Control Zone District and Walla Walla Public Schools were also involved in this update, alongside various local, state, and federal agencies. FEMA approved the finalized plan in October 2018. The current Flood Insurance Rate Maps (FIRMs), effective December 1, 1983, serve as the basis for identifying flood-prone areas and regulating development in the City's floodplains. While three individual panels were updated on January 18, 2002, FEMA is modernizing all FIRMs through its Map Modernization program. However, it does not currently have plans to update the City of Walla Walla's Flood Insurance Study and FIRMs. As a result, the existing FIRMs will likely remain the City's primary resource for the next several years. In the early 1980s, the City of Walla Walla and the City of Waitsburg received FIRMs and Flood Boundary and Floodway Maps (FBFMs). College Place and Prescott received mapping efforts in 2001 and 2002, respectively, while Walla Walla was never mapped. These tools help identify flood risks and define river channels and adjacent areas needed to manage floodwaters effectively.

5. GEOLOGICALLY HAZARDOUS AREAS

5.1 Definitions

Geologically hazardous areas (GHAs) are defined by Washington State as "areas that, because of their susceptibility to erosion, sliding, earthquake, or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns" (WAC 365-190-030). The four main types of geologically hazardous areas are erosion hazard areas, landslide hazard areas, seismic hazard areas, and areas subject to other geologic events such as coal mine hazards and volcanic hazards (WAC 365-190-120).

Walla Walla's definition is substantively similar, as follows (WWMC 21.04.020): "areas that may not be suited to development consistent with public health, safety or environmental standards because of their susceptibility to erosion, sliding, earthquake, or other geological events as designated by WAC 365-190-030(9). Types of geologically hazardous areas include: erosion, landslide, seismic, mine, and volcanic hazards."

5.2 Designation

The City of Walla Walla designates potential geologic hazard areas per WWC 21.04.500:

A. Geologically hazardous areas include areas susceptible to erosion, sliding, earthquake, or other geological events. The following regulations, in combination with the performance standards for development, will guide development in these critical areas. The purpose of these regulations is to maintain the natural integrity of hazardous areas and their buffers in order to protect adjacent lands from the impacts of landslides, mudslides, subsidence, excessive erosion and seismic events, and to safeguard the public from these threats to life or property. Geologically hazardous areas are designated as those areas that are susceptible to one or more of the following types of hazards:

1. *Erosion hazard;*
2. *Landslide hazard;*
3. *Seismic hazard;*
4. *Other geological events including mass wasting, debris flows, rock falls, and differential settlement.*

B. Erosion Hazard Areas. Erosion hazard areas are those areas of the city of Walla Walla which:

1. *Contain soils or soil complexes identified by the U.S. Department of Agriculture's Natural Resource Conservation Service or the soil survey for the city of Walla Walla as having moderate to severe, severe or very severe erosion hazard potential; or*
2. *Are impacted by shore land and/or stream bank erosion; or*
3. *Areas with a slope greater than fifteen percent.*

C. *Landslide Hazard Areas. Landslide hazard areas are those areas susceptible to landslides because of any combination of bedrock, soil, slope (gradient), slope aspect, structure, hydrology, or other physical factors. Potential landslide hazard areas exhibit one or more of the following characteristics:*

1. *Sensitive Sloped Areas. Slopes exceeding thirty-five percent with a vertical relief of ten or more feet except areas composed of competent rock and properly engineered slopes designed and approved by a geotechnical engineer licensed in the state of Washington and experienced with the site;*
2. *Areas mapped by the Washington State Department of Natural Resources (slope stability mapping) as unstable ("U"), unstable old slides ("UOS"), or unstable recent slides ("URS");*
3. *Areas designated by the U.S. Department of Agriculture's Natural Resource Conservation Service as having severe limitations for building site development;*
4. *Areas that have shown evidence of historic failure or instability, including but not limited to back-rotated benches on slopes; areas with structures that exhibit structural damage such as settling and racking of building foundations; and areas that have toppling, leaning, or bowed trees caused by ground surface movement;*
5. *Slopes greater than fifteen percent that have a relatively permeable geologic unit overlying a relatively impermeable unit and having springs or groundwater seepage;*
6. *Areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action;*
7. *Areas located in a canyon or active alluvial fan, presently or potentially subject to inundation by debris flows or catastrophic flooding; and*
8. *Areas designated as quaternary slumps, earthflows, mudflows, lahars, or landslides on maps published by the U.S. Geological Survey or Washington State Department of Natural Resources;*
9. *Areas that are at risk of mass wasting due to seismic forces; and*
10. *Slopes having gradients steeper than eighty percent subject to rock fall during seismic shaking.*

D. *Seismic Hazard Areas. Seismic hazard areas are those areas subject to severe risk of damage as a result of earthquake-induced ground shaking, slope failure, soil liquefaction or surface faulting including:*

1. Areas subject to surface faulting during a seismic event;
2. *Areas with underlying deposits indicative of a risk of liquefaction during a seismic event, including those areas mapped as moderate, moderate to high and high by the Washington State Department of Natural Resources;*
3. *Areas subject to slope failure during a seismic event;*
4. *Areas that are at risk of mass wasting due to seismic forces.*

Seismic hazards shall be as identified in Washington State Department of Natural Resources seismic hazard and liquefaction susceptibility maps for eastern Washington and other geologic resources.

E. Other Hazard Areas. Geologically hazardous areas shall also include areas determined by the director those areas subject to severe risk of damage as a result of other geological events including mass wasting, debris flows, rock falls and differential settlement.

5.3 Potential Geologic Hazards in the City of Walla Walla

Potential geologic hazards mapped in the City of Walla Walla and surrounding UGA are liquefaction, steep slopes, erosion due to water, and erosion due to wind (Figures 6 through 9). Landslide hazard areas within the City are not mapped.

The majority of the city has moderate to high susceptibility to liquefaction. Liquefaction susceptibility in the northwest corner and portions of the southwest is low and moderate (Figure 6). Steep slopes are concentrated at the north and south ends of the City (Figure 7). Susceptibility to water erosion is mapped at the east and west ends of Mill Creek and west of downtown (Figure 8). High to moderate wind erosion susceptibility is mapped throughout the city and UGAs. There is no wind erosion data within the city core (Figure 9).

The City of Walla Walla is in the southeastern part of the Walla Walla Plateau, a section of the Columbia Plateaus physiographic province. The northern Rocky Mountains border the Columbia Plateaus to the east and the Sierra Nevada-Cascade region to the west. Known for its diverse landforms across Oregon, Idaho, and Washington, the Columbia Plateaus cover approximately 100,000 square miles (HDR 2008).

This region primarily consists of uniform basaltic lava flows that exhibit significant folding and faulting, resulting in elevations ranging from about 200 to 5,000 feet above mean sea level (MSL). Older mountain ranges, such as the Blue Mountains and Wallowa Mountains rise above the lava flows in certain areas (HDR 2008).

The terrain of the Columbia Plateaus is predominantly harsh and arid, characterized by coulees, scablands, and other features that reflect the movement of glacial waters across the landscape, alongside isolated volcanic formations. Sedimentary deposits intermingle with the lava; in some areas, the loess is deep enough to create fertile land.

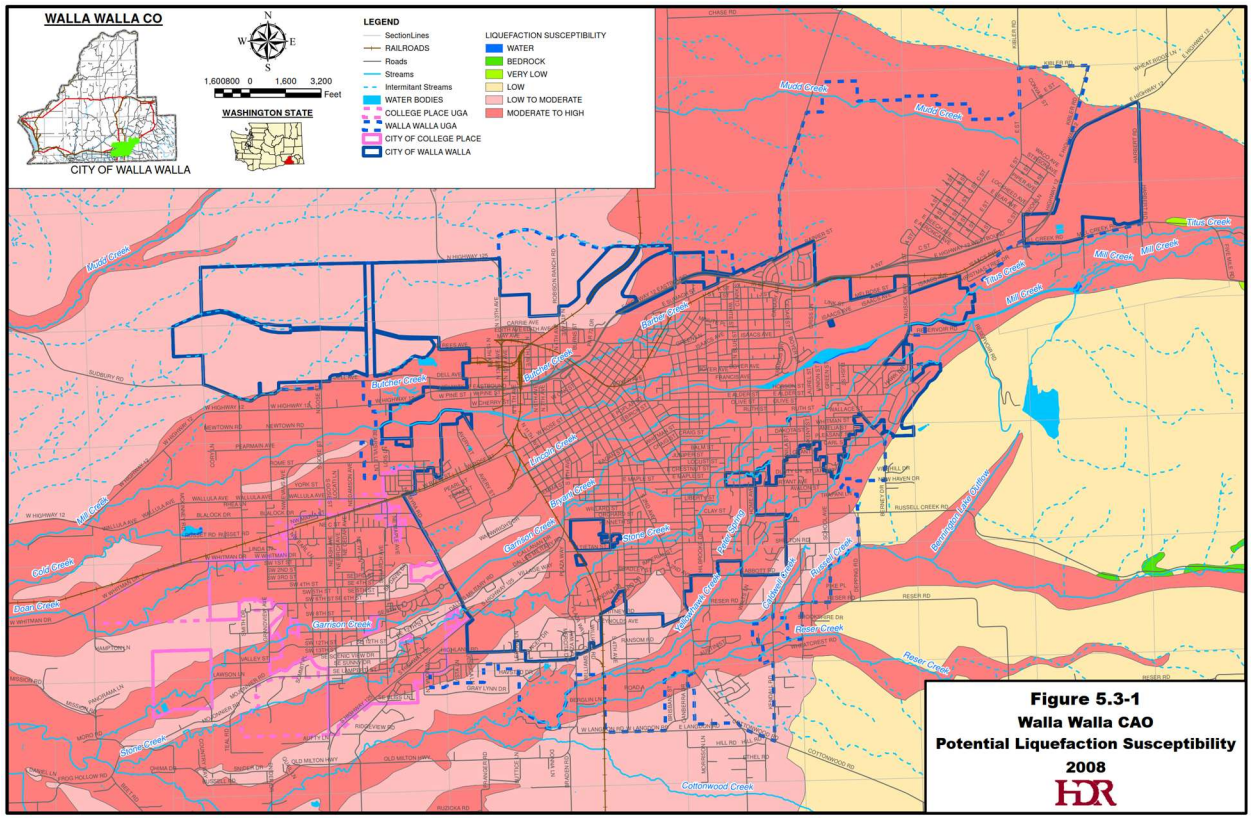


Figure 6. Potential liquefaction areas in the City of Walla Walla (HDR 2008).

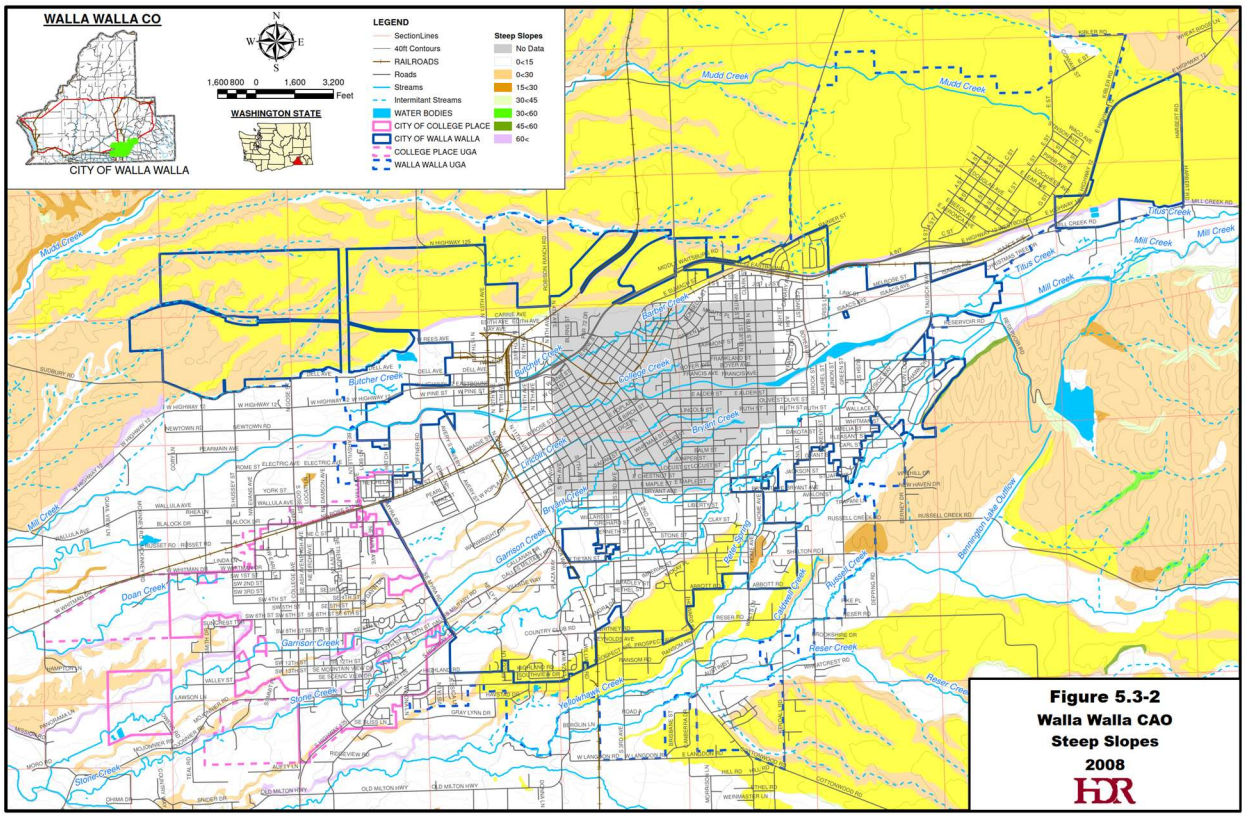


Figure 7. Steep slopes in the City of Walla Walla (HDR 2008).

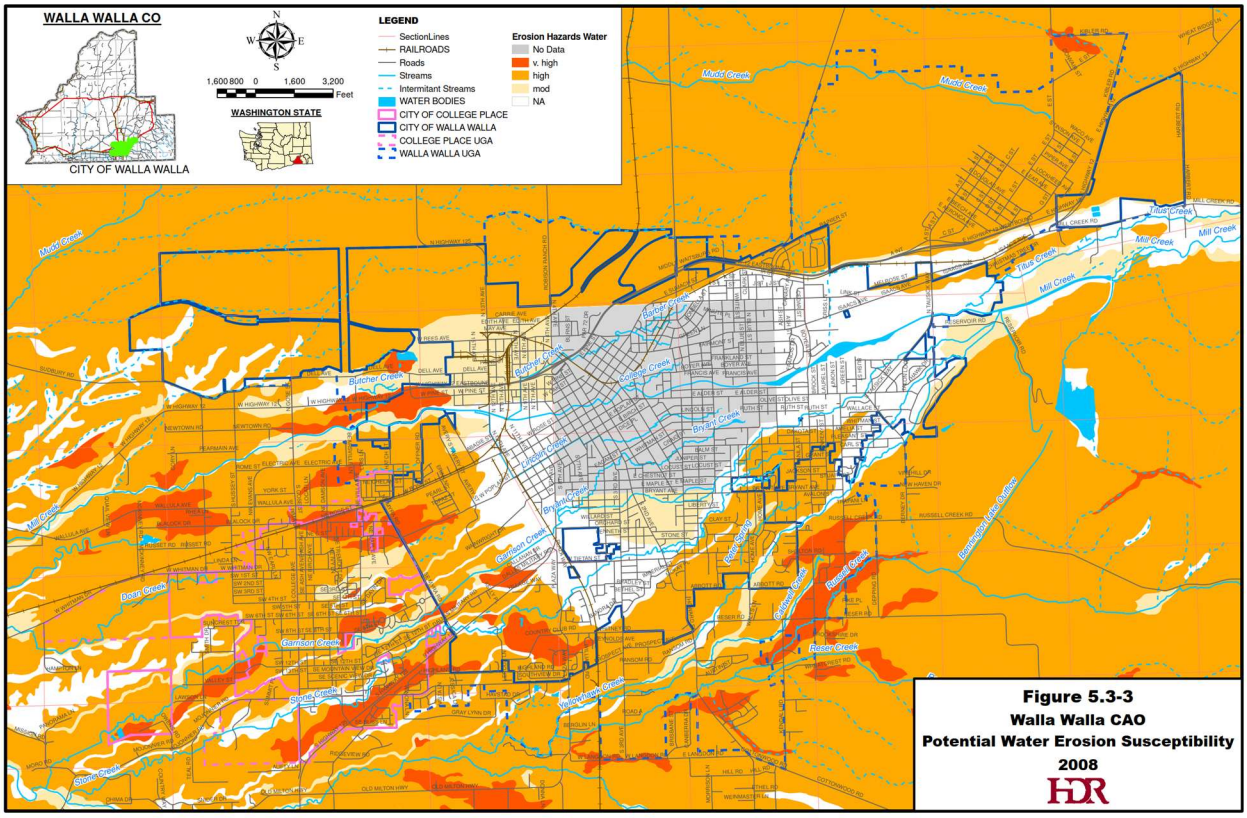


Figure 8. Potential erosion hazard due to water in the City of Walla Walla (HDR 2008).

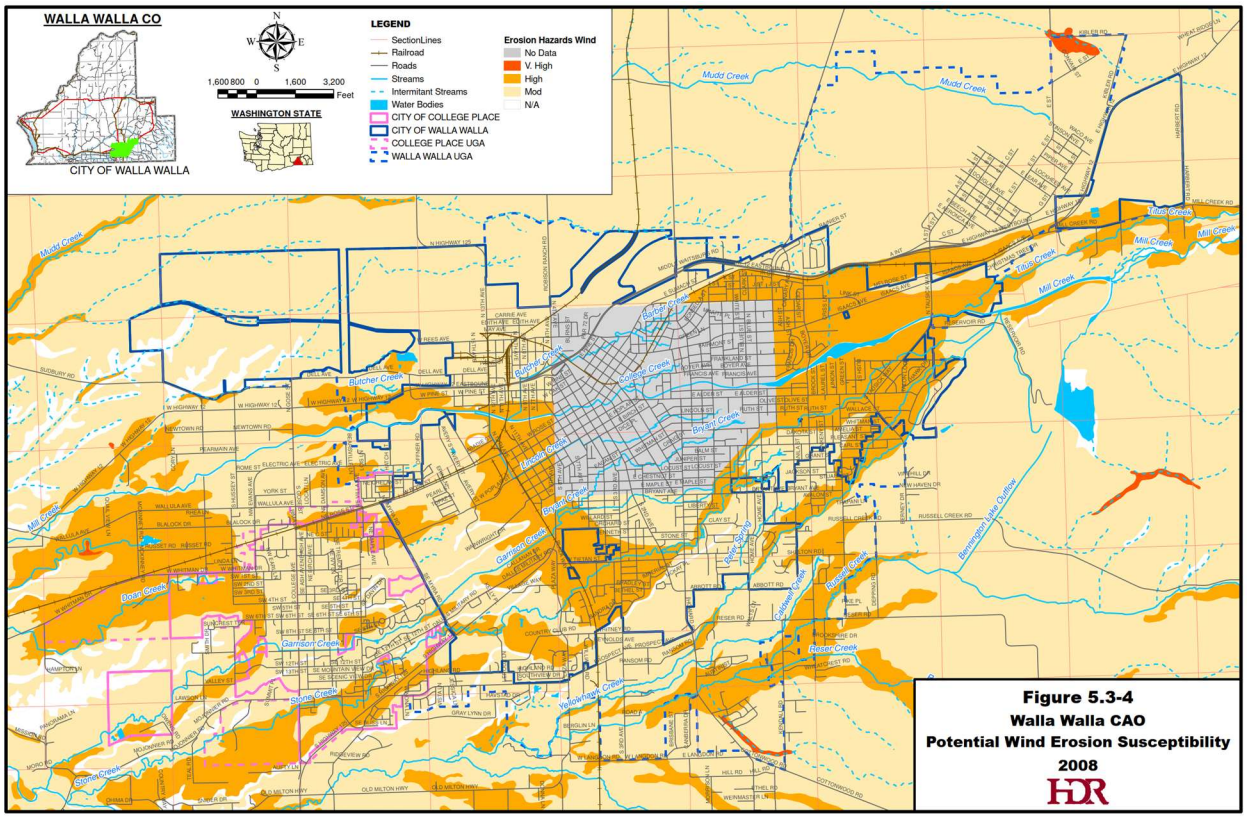


Figure 9. Potential erosion hazard due to wind in the City of Walla Walla (HDR 2008).

6. FISH AND WILDLIFE HABITAT CONSERVATION AREAS

6.1 Definitions

Washington State defines fish and wildlife habitat conservation areas (FWHCAs) in WAC 365-190-030(6) as follows:

(a) "Fish and wildlife habitat conservation areas" are areas that serve a critical role in sustaining needed habitats and species for the functional integrity of the ecosystem, and which, if altered, may reduce the likelihood that the species will persist over the long term. These areas may include, but are not limited to, rare or vulnerable ecological systems, communities, and habitat or habitat elements including seasonal ranges, breeding habitat, winter range, and movement corridors; and areas with high relative population density or species richness. Counties and cities may also designate locally important habitats and species.

(b) "Habitats of local importance" designated as fish and wildlife habitat conservation areas include those areas found to be locally important by counties and cities.

(c) "Fish and wildlife habitat conservation areas" does not include such artificial features or constructs as irrigation delivery systems, irrigation infrastructure, irrigation canals, or drainage ditches that lie within the boundaries of, and are maintained by, a port district or an irrigation district or company.

The following FWHCAs must be considered for classification and designation (WAC 365-190-130):

(a) Areas where endangered, threatened, and sensitive species have a primary association;
(b) Habitats and species of local importance, as determined locally;
(c) Commercial and recreational shellfish areas;
(d) Kelp and eelgrass beds; herring, smelt, and other forage fish spawning areas;
(e) Naturally occurring ponds under 20 acres and their submerged aquatic beds that provide fish or wildlife habitat;
(f) Waters of the state;
(g) Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity; and
(h) State natural area preserves, natural resource conservation areas, and state wildlife areas.

The City of Walla Walla CAO defines FWHCAs as follows (WWMC 21.04.020):

means areas that serve a critical role in sustaining needed habitats and species for the functional integrity of the ecosystem, and which, if altered, may reduce the likelihood that the species will persist over the long term. These areas may include, but are not limited to, rare or vulnerable ecological systems, communities, and habitat or habitat elements including seasonal ranges, breeding habitat, winter range, and movement corridors; and areas with high relative population density or species richness. "Fish and wildlife habitat conservation areas" does not include such artificial features or constructs as irrigation delivery systems, irrigation infrastructure, irrigation canals, or drainage ditches that lie within the boundaries of, and are maintained by, a port district or an irrigation district or company (WAC 365-190-030(6)). These areas are guided by the state's priority habitats and species list and include the following:

1. Areas with which state or federally designated endangered, threatened, and sensitive species have a primary association;

2. Habitats of local importance, including but not limited to areas designated as priority habitat by the Department of Fish and Wildlife, areas that provide important habitat for neotropical migratory songbirds, areas that provide important habitat for wintering birds of prey, and areas that provide unique habitats within the city;

3. Naturally occurring ponds under twenty acres and their submerged aquatic beds that provide fish or wildlife habitat, including those artificial ponds intentionally created from dry areas in order to mitigate impacts to ponds;

4. Waters of the state, including lakes, rivers, ponds, streams, inland waters, underground waters, salt waters and all other surface waters and watercourses within the jurisdiction of the state of Washington;

5. Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity;

6. State natural area preserves and natural resource conservation areas; and

7. Land essential for preserving connections between habitat blocks and open spaces.

6.2 Designation

The City of Walla Walla CAO designates FWHCAs as follows (WWMC 21.04.600):

A. Fish and wildlife habitat conservation areas include:

1. Areas where state or federally-designated endangered, threatened, and sensitive species have a primary association.

a. Federal designated endangered and threatened species are those fish, wildlife, and plant species identified by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service that are in danger of extinction or threatened to become endangered. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service should be consulted as necessary for current listing status.

b. State designated endangered, threatened, and sensitive species are those fish, wildlife and plant species native to the state of Washington identified by the state Department of Fish and Wildlife, that are in danger of extinction, threatened to become endangered, vulnerable, or declining and are likely to become endangered or threatened in a significant portion of their range within the state without cooperative management or removal of threats. State designated endangered, threatened, and sensitive species are periodically recorded in WAC 232-12-014 (state endangered species), and WAC 232-12-011 (state threatened and sensitive species). The state Department of Fish and Wildlife maintains the most current listing and should be consulted as necessary for current listing status.

2. State priority habitats and areas associated with state priority species. Priority habitats and species are considered priorities for conservation and management. Priority species require protective measures for their perpetuation due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance. Priority habitats are those habitat types or elements with unique or significant value to a diverse assemblage of species. A priority habitat may consist of a unique vegetation type or dominant plant species, a described successional stage, or a specific structural element. Priority habitats and species are identified by the state Department of Fish and Wildlife.

3. Habitats and species of local importance. Habitats and species of local importance are those identified by the City , including those that possess unusual or unique habitat warranting protection because of species diversity or habitat system health indicators. The following

habitats and species of local importance, shown on Map CA-5B, have been designated: High Density of Wintering Birds of Prey Habitat, Raptor Ferruginous Hawk Habitat, and Neotropical Migrant Songbird Habitat.

4. *Naturally occurring ponds under twenty (20) acres. Naturally occurring ponds are those ponds under twenty (20) acres and their submerged aquatic beds that provide fish or wildlife habitat, including those artificial ponds intentionally created from dry areas in order to mitigate impacts to ponds. Naturally occurring ponds do not include ponds deliberately designed and created from dry sites, such as canals, detention facilities, wastewater treatment facilities, farm ponds, temporary construction ponds, and landscape amenities, unless such artificial ponds were intentionally created for mitigation.*

5. *Waters of the state. Waters of the state includes lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, and all other surface waters and watercourses within the jurisdiction of the state of Washington, as classified in WAC 222-16-031.*

6. *Lakes, ponds, streams, and rivers planted with game fish by a governmental or tribal entity.*

7. *State Natural Area Preserves and Natural Resource Conservation Areas. Natural area preserves and natural resource conservation areas are defined, established, and managed by the state Department of Natural Resources.*

8. *Land essential for preserving eco-connectivity between habitat blocks and open spaces.*

9. *Areas of rare plant species and high quality ecosystems that are identified by the Washington State Department of Natural Resources through the Natural Heritage Program. Streams shall be designated in accordance with the Washington State Department of Natural Resources (DNR) stream type as provided in WAC 222-16-030. Streams are further categorized according to ecosystem diagnosis and treatment (EDT)/Walla Walla Subbasin Plan priority protection reaches.*

10. *Areas of rare plant species and high quality ecosystems that are identified by the Washington State Department of Natural Resources through the Natural Heritage Program.*

B. *All areas within the City meeting one or more of these criteria, regardless of any formal identification, are hereby designated critical areas and are subject to the provisions of this title.*

C. *The following is identified as an area of local importance: hawk habitat identified on Critical Area Map 6.*

D. *Shoreline Jurisdiction. The city's shoreline jurisdiction encompasses the Mill Creek water body plus its associated shorelands, which, in accordance with state law, includes lands within two hundred feet of the ordinary high water mark (OHWM) of Mill Creek, as well as floodways, floodplain areas within two hundred feet of a mapped floodway, and associated wetlands. Mill*

Creek and other fish and wildlife habitat conservation areas occurring within shoreline jurisdiction are subject to the provision of the critical areas regulations in the City of Walla Walla Shoreline Master Program, Appendix A, instead of the provisions of this title.

6.3 FWHCA in the City of Walla Walla

6.3.1 Streams, ponds, lakes

The City of Walla Walla contains 15 named streams and several tributaries labeled as intermittent (Figure 10). The city contains a few small ponds that appear to be managed landscape amenities. No lakes are present.

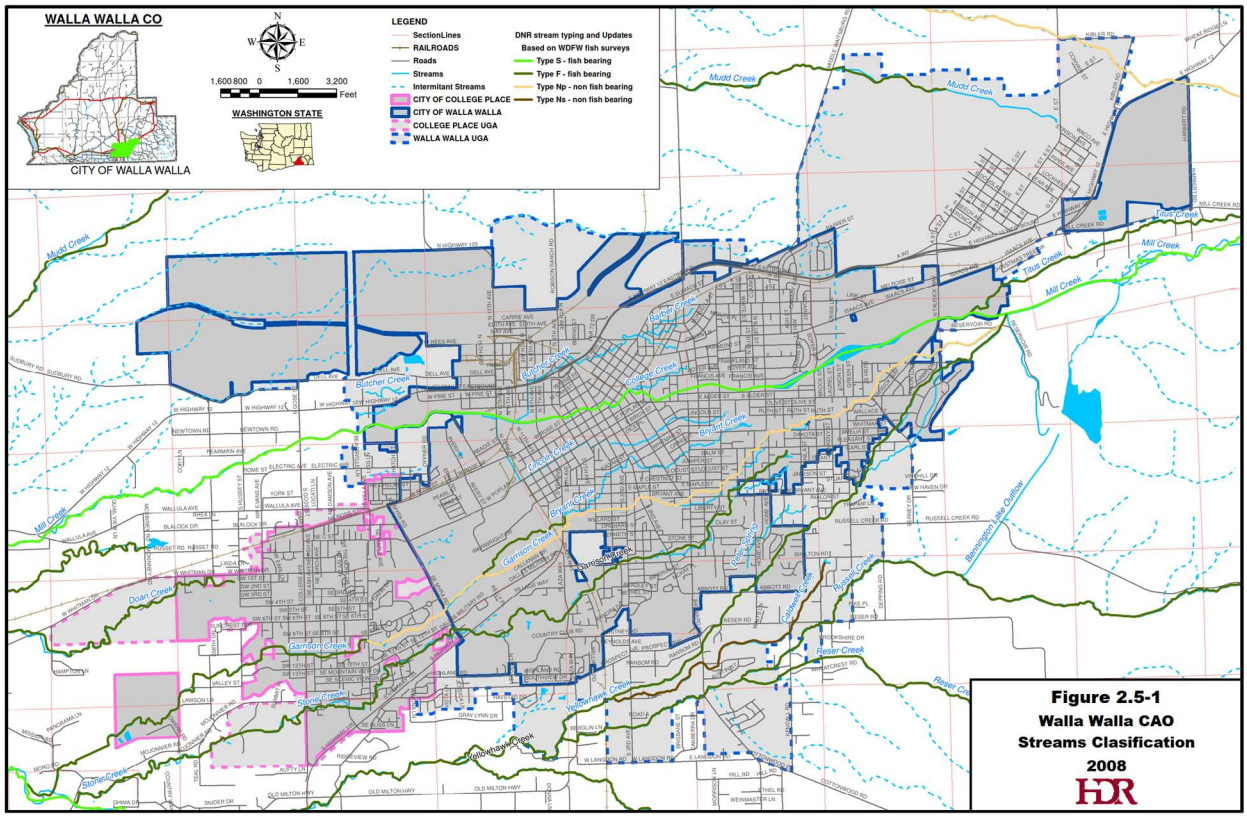


Figure 10. Mapped stream classifications in the City of Walla Walla (HDR 2008).

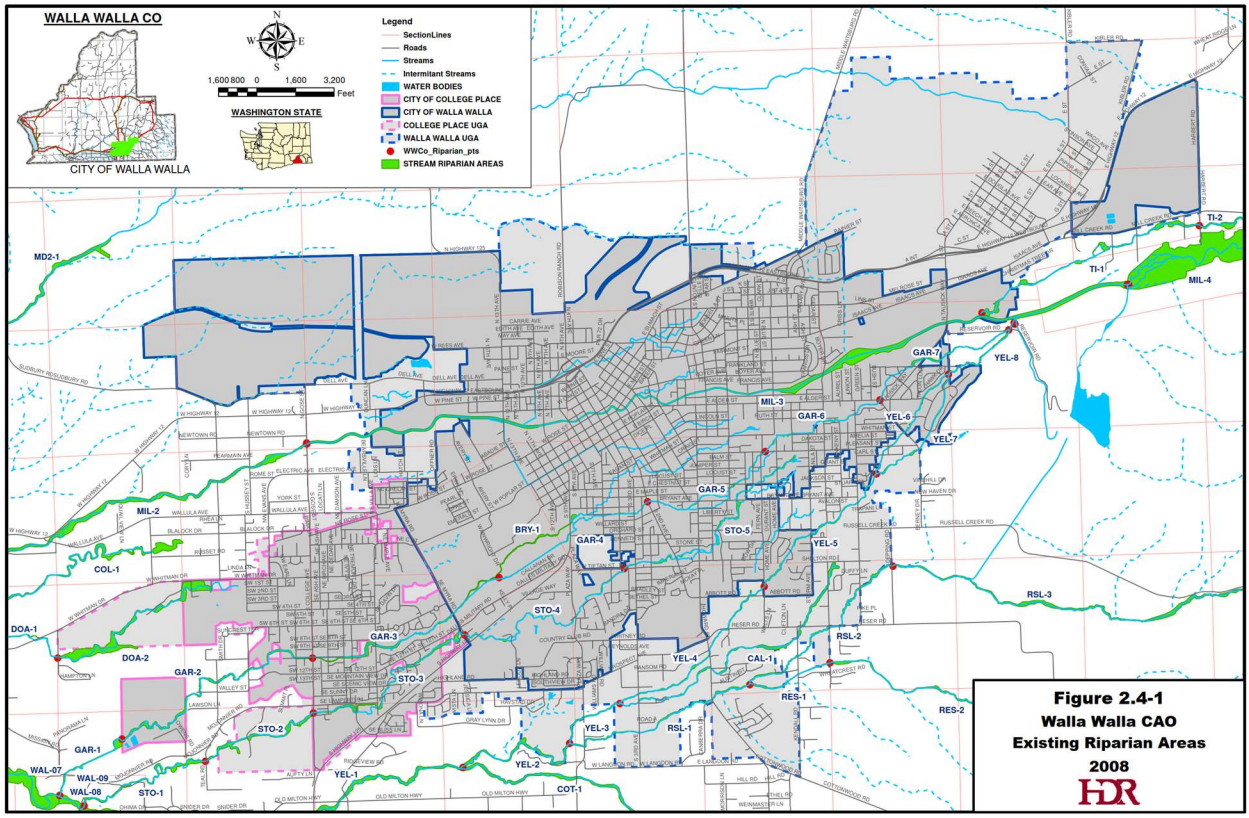


Figure 11. Existing riparian areas in the City of Walla Walla (HDR 2008).

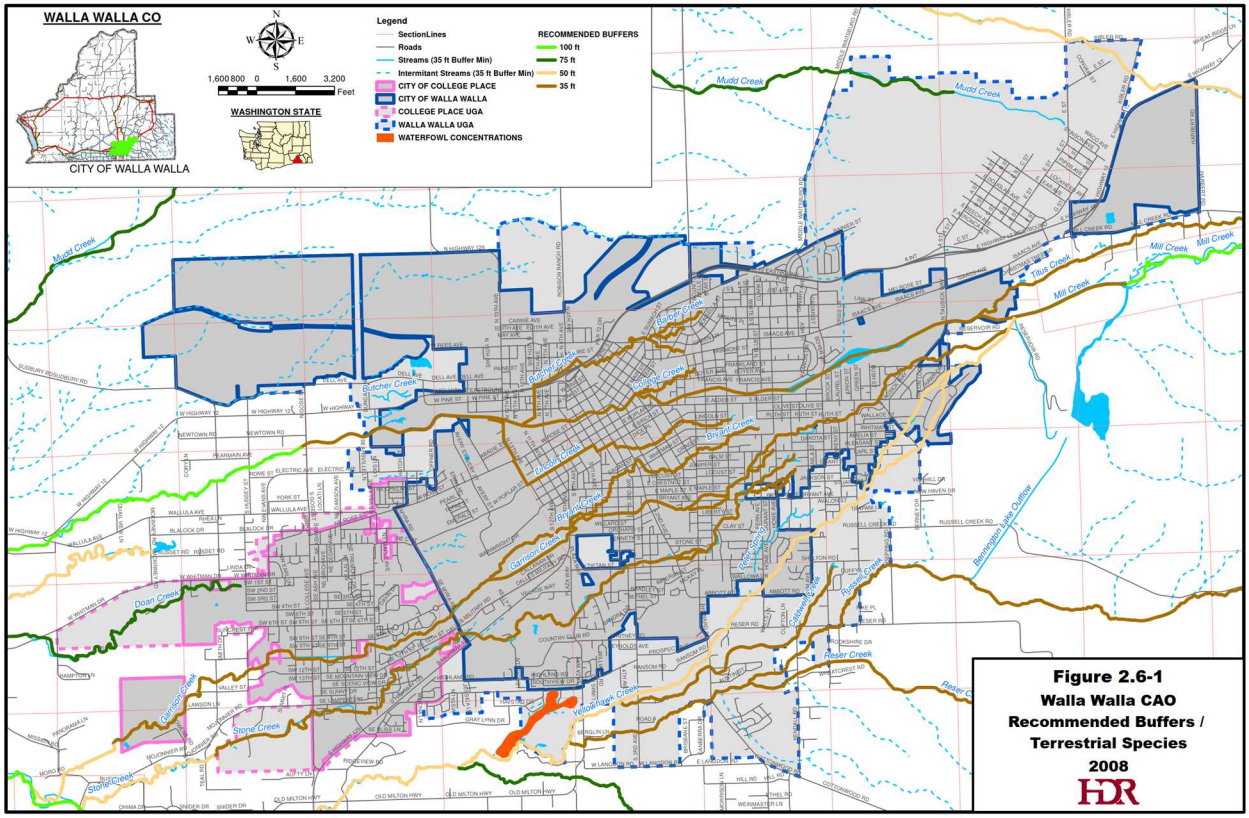


Figure 12. City of Walla Walla recommended FWHCA buffers.

6.3.2 Wildlife and Habitat

Wildlife habitat in the upper reaches of the main rivers and tributaries is generally high quality, including Mill Creek, which contain native vegetation communities. Mountain and foothill forests in these areas support a diversity of large mammals such as elk, mule deer, white-tailed deer, black bears, coyotes, mountain lions, and bobcats, as well as small mammals such as beavers, river otters, minks, and raccoons. The upper drainages also provide habitat for a wide range of bird species, including ruffed grouse, woodpeckers, hummingbirds, and numerous songbirds.

In contrast, habitat complexity and quality in the lowland valleys, including much of the city and surrounding lands, are shaped by intensive agriculture and fragmented riparian vegetation. These lowland areas continue to support white-tailed and mule deer, ring-necked pheasants, quail, mourning doves, raptors, songbirds, and small mammals (Northwest Management, Inc. 2018). Nearby regional habitats include the Blue Mountains to the east, the Columbia River to the west, with a mosaic of shrub steppe in patches amongst the farmlands and urban areas.

The rivers of the City of Walla Walla flow to the Walla Walla and Touchet Rivers which historically supported Chinook, Coho, and chum salmon. Priority fish species mapped within the City of Walla

Walla are summarized in Table 1 below. The City of Walla Walla is home to bull trout and steelhead, both listed as threatened under the Federal Endangered Species Act.

Table 1. Priority fish species distribution in the City of Walla Walla (HDR 2008).

Priority fish species	Notes	Stream
Bull trout	Migration	College Creek
		Garrison Creek
		Mill Creek
		Yellowhawk Creek
Steelhead (summer)	Rearing	Garrison Creek
		Mill Creek
		Yellowhawk Creek
	Presumed presence	Caldwell Creek
		Garrison Creek
		Russell Creek
		Stone Creek
Chinook salmon (spring)	Primary migration	Yellowhawk Creek

A large expanse of riparian habitat exists in the 1,896-acre Wallula Habitat Management Unit, which has been managed by USACE since 2007. This unit, located at the mouth of the Walla Walla River west of the City of Walla Walla, features a mix of cottonwood forests, various shrubs, wetlands, sagebrush, and agricultural lands that support many species, including waterfowl, shorebirds, songbirds, raptors, upland game birds, mule deer, white-tailed deer, furbearers, and small mammals.

Washington Department of Fish and Wildlife (WDFW) maps priority habitats and species. A waterfowl concentration is mapped at the south end of the City near Yellowhawk Creek. Ferruginous hawks are mapped at the Township level and the City is within that species' historic range. A few Ferruginous hawk breeding areas are mapped in the City. The field on the north bank of Mill Creek east of Eastgate Lion Park is mapped as a Ferruginous hawk breeding area. A smaller Ferruginous hawk breeding area is mapped in the UGA along Yellowhawk Creek. Ring-necked pheasant areas are mapped along Mill Creek, Garrison Creek and Yellowhawk Creek. Shrubsteppe habitat patches are also present throughout the City and UGAs (WDFW 2023).

The aquatic habitats in the City of Walla Walla support a variety of species. The main aquatic priority habitats on non-federal lands in the City are located along the Walla Walla River tributaries. The species range from federally listed to priority, focal, and species of interest identified in the Walla Walla Subbasin Plan. WDFW and the Washington State Department of Natural Resources' (DNR) Natural Heritage Program (NHP) compile and map fish and wildlife habitats throughout the state. Numerous studies focus on specific species and habitat types relevant to the City of Walla Walla. The Priority Habitat and Species (PHS) database provides the most comprehensive information on the presence

and distribution of priority habitats and wildlife species. This PHS provides lists of species and habitats which may occur in Walla Walla County, shown in Table 2.

Table 2. WDFW Designated Priority Habitats and Species that Occur in Walla Walla County

	Species/ Habitats	State Status	Federal Status
Habitats	Aspen Stands		
	Biodiversity Areas & Corridors		
	Eastside Steppe		
	Inland Dunes		
	Juniper Savannah		
	Riparian		
	Shrubsteppe		
	Freshwater Wetlands & Fresh Deepwater		
	Instream		
	Caves		
	Cliffs		
	Snags and Logs		
	Talus		
Fishes	Pacific Lamprey		
	White Sturgeon		
	Leopard Dace	Candidate	
	Umatilla Dace	Candidate	
	Mountain Sucker	Candidate	
	Bull Trout/ Dolly Varden	Candidate *	Threatened *
	Chinook Salmon		Threatened (Upper Columbia Spring run is Endangered)
	Coho Salmon		Threatened – Lower Columbia
	Kokanee		
	Rainbow Trout/ Steelhead/ Inland Redband Trout	Candidate **	Threatened **
	Sockeye Salmon		Threatened – Ozette Lake Endangered – Snake River
	Westslope Cutthroat Trout		
	Margined Sculpin	Sensitive	
Amphibians	Columbia Spotted Frog	Candidate	
	Rocky Mountain Tailed Frog	Candidate	
	Western Toad	Candidate	
Reptiles	Striped Whipsnake	Candidate	
	Sagebrush Lizard	Candidate	
Birds	American White Pelican	Sensitive	
	Western grebe	Candidate	
	E WA breeding concentrations of: Grebes, Cormorants		
	E WA breeding: Terns		
	Black-crowned Night-heron		
	Great Blue Heron		
	Cavity-nesting ducks: Wood Duck, Barrow's Goldeneye, Common Goldeneye, Bufflehead, Hooded Merganser		
	Tundra Swan		
	Waterfowl Concentrations		
	Ferruginous Hawk	Endangered	
	Golden Eagle	Candidate	
	Northern Goshawk	Candidate	
	Prairie Falcon		
	Dusky Grouse		
	Mountain Quail		

	Species/ Habitats	State Status	Federal Status
	Ring-necked Pheasant		
	Wild Turkey		
	Upland Sandpiper	Endangered	
	E WA breeding occurrences of: Phalaropes, Stilts and Avocets		
	Burrowing Owl	Candidate	
	Flammulated Owl	Candidate	
	Vaux's Swift		
	Black-backed Woodpecker	Candidate	
	Loggerhead Shrike	Candidate	
	Sage Thrasher	Candidate	
Mammals	Roosting Concentrations of: Big-brown Bat, Myotis bats, Pallid Bat		
	Townsend's Big-eared Bat	Candidate	
	Black-tailed Jackrabbit	Candidate	
	White-tailed Jackrabbit	Candidate	
	Washington Ground Squirrel	Candidate	Candidate
	Gray Wolf	Endangered	Endangered: only in Western two-thirds of Washington
	Marten		
	Bighorn Sheep		
	Northwest White-tailed Deer		
	Elk		
	Mule Deer (formerly called Rocky Mountain Mule Deer)		
Invertebrates	Columbia Oregonian	Candidate	
	California Floater	Candidate	
	Monarch	Candidate	Candidate
	Western Bumble Bee	Candidate	Candidate
		* Bull Trout only ** Steelhead only	

Source: WDFW 2025[1]

[1] *Priority Habitats and Species List | Washington Department of Fish & Wildlife-https://wdfw.wa.gov/species-habitats/at-risk/phs/list*

7. REFERENCES

DNR. 2012. "State Department of Natural Resources." Olympia, Washington. http://www.dnr.wa.gov/Publications/frc_na_apr11_natural_areas_map.pdf.

HDR, Inc. 2008. *Walla Walla County; Critical Areas Ordinance Best Available Sience Review*.

HDR, Inc. 2019. *Technical Memorandum-Final: To: Austin Melcher*. Washington State Department of Ecology, Water Resources Program.

WDFW (Washington Department of Fish and Wildlife. 2023. Priority Habitat and Species List. Olympia, Washington. 291 pp.

APPENDIX A. Walla Walla County CAO Update Best Available Science Review *Final*

Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications



A Priority Habitats and Species Document of the Washington Department of Fish and Wildlife

Washington Department of FISH and WILDLIFE

Updated July 2020

Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications

Published May 2018, updated July 2020

Technical Editors
Timothy Quinn
George F. Wilhere
Kirk L. Krueger

Production Manager
Alison Hart

Publication should be cited as follows:
Quinn, T., G.F. Wilhere, and K.L. Krueger, technical editors. 2020. Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications. Habitat Program, Washington Department of Fish and Wildlife, Olympia.

Example citation for chapter within publication:
Quinn, T., K.L. Krueger, and G.F. Wilhere. 2020. Introduction. Pages 1-14 *in* T. Quinn, G.F. Wilhere, and K.L. Krueger, technical editors. Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications. Habitat Program, Washington Department of Fish and Wildlife, Olympia.

Accessibility:
This document is available in alternative formats upon request. Please contact WDFW's ADA Program Manager at 360-902-2349, TTY (711), or ADAProgram@dfw.wa.gov.

Acknowledgements

Many people were involved with the creation of this document. WDFW would like to acknowledge the Washington Department of Ecology and US Environmental Protection Agency for the funds that made this document possible. Contract planning and budgeting for this work was led by Keith Folkerts. We appreciatively acknowledge the participation of our Technical Advisory Group:

Nichole Embertson, PhD	Whatcom Conservation District
Martin Fox, PhD	Muckleshoot Tribe
Aimee Fullerton, PhD	NOAA Fisheries
Marc Hayes, PhD	WA Department of Fish and Wildlife
Tim Hyatt	Skagit River System Cooperative
Jack Janisch	WA Department of Ecology
Peter Leinenbach	US Environmental Protection Agency
Chris May, PhD	Kitsap County
Michael Pollock, PhD	NOAA Fisheries
Jeremy Sikes	WA Department of Ecology
Carol Smith, PhD	WA State Conservation Commission
Steve Wondzell, PhD	US Forest Service

The scientific rigor of this document was improved through the peer review provided by the Washington State Academy of Sciences, with coordination provided by Dr. Robert Bates. Draft versions of this document were reviewed by numerous staff in state agencies, including the Department of Ecology, Department of Natural Resources, Department of Commerce, Recreation and Conservation Office, State Conservation Commission, and Puget Sound Partnership. These reviews improved the document and we appreciate the helpful feedback. We also appreciate the reviews by federal and tribal entities including EPA, NOAA Fisheries, Northwest Indian Fisheries Commission, Columbia River Inter-Tribal Fish Commission, Upper Columbia United Tribes, and individual tribes. We express our appreciation for all local governments and individuals who provided feedback during our public comment period. Finally, thank you to Peggy Ushakoff for creating graphics that help us better portray the science.

While we acknowledge and appreciate all review comments, WDFW bears sole responsibility for the content of this document.

Table of Contents

Acknowledgments i
Preface iv
List of Acronyms v

CHAPTER 1. INTRODUCTION

1.1 Document Description 1
1.2 Scope of Volume 1 7
1.3 Document Development 9
1.4 Literature Cited 12

CHAPTER 2. STREAM MORPHOLOGY

2.1 Introduction 15
2.2 Conceptual Context 16
2.3 Streamflow Processes 18
2.4 Erosion and Sedimentation Processes 20
2.5 Disturbances 30
2.6 Fish and Wildlife Habitat 37
2.7 Conclusions 39
2.8 Literature Cited 41

CHAPTER 3. WOOD

3.1 Introduction 51
3.2 The Ecological Role of Instream Wood 51
3.3 Recruitment of Instream Large Wood 55
3.4 Abundance of Instream Wood 62
3.5 Fish, Wildlife, and Instream Wood 65
3.6 Land Use Effects 69
3.7 Conclusions 72
3.8 Literature Cited 73

CHAPTER 4. STREAM TEMPERATURE

4.1 Introduction 81
4.2 Conceptual Model 85
4.3 Species Sensitivity 90
4.4 Land Use Effects 95
4.5 Conclusions 97
4.6 Literature Cited 100

CHAPTER 5. POLLUTANT REMOVAL

5.1 Introduction 111
5.2 The Pollutant Removal Function of Riparian Areas 112
5.3 Processes Influencing the Pollutant Removal Function 113
5.4 Specific Pollutants 122
5.5 Effect of Riparian Buffer Width on Pollutant Removal 141
5.6 Reanalysis of Meta-Analyses 146

5.7 Conclusions 150
5.8 Literature Cited 151

CHAPTER 6. NUTRIENT DYNAMICS IN RIPARIAN ECOSYSTEMS
6.1 Introduction 163
6.2 Hydrologic Connectivity and Nutrient Dynamics 178
6.3 State of Riparian Nutrient Dynamics Science 182
6.4 The Role of Management 183
6.5 Conclusions 185
6.6 Literature Cited 187

CHAPTER 7. RIPARIAN AREAS OF THE COLUMBIA PLATEAU
7.1 Introduction 197
7.2 Historical Context 204
7.3 Beaver 212
7.4 Ecosystem Functions 214
7.5 Conclusions 224
7.6 Acknowledgements 226
7.7 Literature Cited 227

CHAPTER 8. WATERSHEDS
8.1 Introduction 237
8.2 Conceptual Framework 239
8.3 The Role and Limitations of Site-Scale Riparian Management 252
8.4 Integrated Effects of Site-Scale Riparian Areas Management 253
8.5 Managing Riparian Areas from a Watershed Perspective 255
8.6 Conclusions 259
8.7 Literature Cited 261

CHAPTER 9. SCIENCE SYNTHESIS TO MANAGEMENT IMPLICATIONS
9.1 Introduction 265
9.2 Summary of Chapters 2 through 8 265
9.3 Key Management Implications from Chapters 1 through 8 270
9.4 Width of Riparian Ecosystems 272
9.5 The Condition of Riparian Ecosystems 274
9.6 Other Important Issues 276
9.7 Uncertainty and Management 279
9.8 Adaptive Management 282
9.9 Literature Cited 284

APPENDIX 1. GLOSSARY 289

APPENDIX 2. CATEGORIZATION OF INFORMATION SOURCES
A2.1 Legal Requirement: RCW 34.05.271 295
A2.2 Meeting the Intent of RCW 34.05. 271 295



Leopard Frog Lithobates pipiens/*Scott Fitkin, WDFW*

Preface

This Priority Habitats and Species (PHS) document of the Washington Department of Fish and Wildlife (WDFW) is provided in support of the agency's mission to preserve, protect, and perpetuate the state's fish, wildlife, and ecosystems while providing sustainable fish and wildlife recreational and commercial opportunities. WDFW works cooperatively with land use decision makers and landowners to facilitate solutions that accommodate local needs and needs of fish and wildlife. One of WDFW's important roles in land use decision making is that of technical advisor: we provide information about the habitat needs of fish and wildlife and the likely implications of various land use decisions for fish and wildlife.

The nine chapters of Volume 1 are a partial update of a 1997 document entitled *Management Recommendations for Washington's Priority Habitats: Riparian.* This document, called *Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications* is a partial update because it addresses only aquatic species. Riparian needs of terrestrial species will be updated in the future. Until that update is complete, readers can consult the 1997 document, available at **http://wdfw.wa.gov/publications/00029/**, for information about riparian ecosystems and terrestrial species.

Priority Habitats are places that warrant special consideration for protection when land use decisions are made. For more information, see *Washington Department of Fish and Wildlife. 2008. Priority Habitat and Species List,* available at **https://wdfw.wa.gov/species-habitats/at-risk/phs.**

The PHS program provides land use decision support to clients such as local governments, tribes, government agencies, non-governmental organizations, and landowners. PHS consists of a PHS List, PHS Maps available at **https://wdfw.wa.gov/species-habitats/at-risk/phs/maps**, PHS Management Recommendations, and technical assistance from our regional habitat biologists.

This PHS document compliments a family of PHS documents including *Landscape Planning for Washington's Wildlife: Managing for Biodiversity in Developing Areas* and *Land Use Planning for Salmon, Steelhead and Trout: A land use planner's guide to salmonid habitat protection and recovery,* available at **https://wdfw.wa.gov/species-habitats/at-risk/phs/recommendations**.

List of Acronyms

BAS	best available science
BFW	bankfull width
CMZ	channel migration zone
DBH	diameter at breast height
DNR	(Washington) Department of Natural Resources
EPA or (US)EPA	United States Environmental Protection Agency
FEMAT	Forest Ecosystem Management Assessment Team
HCP	habitat conservation plan
IMW	intensively monitored watersheds
LWD	large woody debris
NOAA	National Oceanographic and Atmospheric Administration
NRC	National Research Council
PHS	Priority Habitats and Species
PNW	Pacific Northwest
RCW	Revised Code of Washington
RMZ	riparian management zone
SMA	Shoreline Management Act
SPTH	site-potential tree height
$SPTH_{200}$	site-potential tree height at tree age equal to 200 years
TAG	Technical Advisory Group
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WNHP	Washington Natural Heritage Program
WSAS	Washington State Academy of Sciences



Bank of the Chehalis River/Kaysie Cox, WDFW

Chapter 1. Introduction

By: Timothy Quinn, Kirk L. Krueger, and George F. Wilhere

1.1. Document Description

Volume 1 is part one of a two-volume set. It contains reviews and syntheses of scientific literature for the purpose of informing the development of policies related to management of riparian areas and watersheds of Washington State. Volume 1 adds additional information to the science summarized in the PHS report titled *Management Recommendations for Washington's Priority Habitats: Riparian* (Knutson and Naef 1997).

Volume 1 was designed to answer the following three general questions:

- What is currently known about the key ecological functions of riparian areas?
- How do riparian areas and watersheds affect the freshwater habitats of fish and wildlife?
- How do human activities affect the capacity of riparian areas and watersheds to provide habitat for fish and wildlife in rivers and streams?

Volume 1 is intended to serve two goals. The first goal is to be a source of best available science (BAS) for understanding how riparian areas and surrounding



Chehalis River meander paths between 1938 and 2013/Ken Pierce, WDFW

watersheds affect ecological functions and aquatic habitats. The second goal is to provide a scientific foundation for management recommendations presented in Volume 2, which are consistent with Washington Department of Fish and Wildlife's (WDFW) mandate (RCW 77.04.012) to protect, preserve, and perpetuate Washington's fish and wildlife. Both goals also relate to WDFW's responsibility to support and provide technical assistance for conservation and protection measures necessary to preserve or enhance anadromous fisheries under the Growth Management Act (GMA; RCW 36.70A.172) and the Shoreline Management Act (SMA; WAC 173-26-221(5)(b)).

Volume 1 does not directly address instream flows as affected by water withdrawal for domestic and commercial uses, or instream water quality, both of which are regulated by the Washington Department of Ecology. However, because water quality is affected by land use, we discuss this issue in the context of riparian and watershed science. In addition, Volume 1 does not specifically address riverine wetlands, i.e., wetland associated with rivers and streams and commonly found in floodplains. Rather, riverine wetlands are usually considered part of riparian ecosystems, which are the focus of this document. Other specific wetland management guidance is available from Washington Department of Ecology (https://ecology.wa.gov/Water-Shorelines/Wetlands).

Volume 2 translates these science reviews and syntheses into land use guidance for local governments and other organizations to conserve watershed processes and riparian ecosystems in support of aquatic species and their habitats. The guidance presented in Volume 2 is not in and of itself "best available science." Rather, it represents the recommendations of WDFW as to how a local government could include the best available science in policies, plans, and regulations to protect riparian ecosystems and their associated aquatic habitats.

WDFW recognizes that natural resource management and land use policies must often balance competing ecological, economic, and social goals (Wilhere and Quinn 2018). In fact, one of WDFW's conservation principles is that management decisions should integrate ecological, economic, and social perspectives. This volume addresses only the ecology of riparian areas within the context of watershed conditions; it does not cover economic and social aspects. Determining an acceptable balance requires a political process involving stakeholders, local governments, tribes, and state agencies. Such a process would establish society's goals for freshwater habitats for salmon and other species of fish and wildlife, and lead to management for achieving those goals. This volume can help to inform that process.

1.1.1. Ecosystems

The ecosystem, a fundamental concept in natural resource management, can be defined as "a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment" (Likens 1992). Throughout this document we use the term ecosystem composition to mean "the different parts (components) which something is made of" (Oxford Dictionary 2015). We define ecosystem structure as the "arrangement of and relations among the parts or elements of something complex" (Oxford Dictionary 2015). We define ecosystem function(ing) to include the first and second definitions of ecological function by Jax (2005): 1) the process, or the cause-effect-relationship underlying two or more interacting components, and 2) the sum of processes that sustain the system. Note that the definitions of functions we use here are broader and more inclusive than "functions" defined solely as ecosystem outputs that benefit humans, namely goods and services (Jax 2005; MEA 2005).

In this volume, we explicitly consider the composition, structure, and function of riparian ecosystems in the context of the surrounding watershed. This is especially important in light of the challenges of managing ecosystems sustainably and the risks associated with scientific uncertainty, i.e., the consequences of being wrong.

The composition, structure, and function of ecosystems describe the organization of biotic and abiotic elements and the processes occurring among elements. These concepts are closely related but not equally well studied nor understood. For example, describing an ecosystem's composition and structure is easier than describing its functions (Hunter et al. 1988; Noss 1992). Likewise, management objectives are often expressed in terms of composition and structure, not functions, because they are easier to characterize.

Composition and structure versus function have a chicken-and-egg relationship. That is, functions (processes) are in large part responsible for maintaining composition and structure, but some functions could not exist without an ecosystem's particular composition and structure. Myster (2001), for instance, argues that ecosystem structure can be defined as the minimal organization necessary for a function to operate. Others argue that managing for functions (Beechie and Bolton 1999) is likely to be more successful than managing for composition and structure because processes likely exert stronger influences on composition and structure than the other way around (Odum 1953), and processes are more directly affected by land use activities (Reid 1998). Furthermore, some land use laws or regulations stipulate no net loss of ecological functions, not no net loss of composition and structure (RCW 90.58, WAC 173-26-186, WAC 365-196-830), however, compliance is often determined through evaluating ecosystem composition and structure, not functions. Such conceptual ambiguity suggests that we consider the entire ecosystem, i.e., composition, structure, and functions, when studying riparian areas, and furthermore, that land managers understand how composition and structure manifest ecological functions. The following chapters synthesize our review of the relationships among composition, structure, and functions of riparian ecosystems in the Pacific Northwest.

1.1.2. Riparian Ecosystems

WDFW has adopted the following conceptual definition of riparian ecosystems:

Riparian areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., a zone of influence).



Riparian ecosystem/Scott Fitkin, WDFW

Riparian ecosystems are sometimes referred to by different names: riparian areas, riparian zones, or riparian habitats. To compound confusion, the "riparian zone" is sometimes identified as a distinctive area within riparian ecosystems (Sedell et al. 1989; Naiman et al. 1992; Steiner et al. 1994). Some definitions include the adjacent waters whereas others do not. Unless stated otherwise, we consider riparian area, riparian habitat, riparian corridor, and riparian ecosystem to be synonyms. Furthermore, our definition of riparian ecosystem does not include adjacent waters (i.e., rivers or streams) and recognizes the riparian zone as a distinctive area within riparian ecosystems. The riparian zone contains wet or moist soils and plants adapted to growing conditions associated with periodically saturated soils.

Recent definitions reflect common conceptual understanding and identify similar composition, structure, and functions, including distinct plant communities and soil types; disturbance regimes unique to fluvial systems; gradients in soil, vegetation, and microclimate that manifest an ecotone between terrestrial and aquatic environments; and essential interactions between terrestrial and aquatic ecosystems. Riparian areas are the loci of terrestrial and aquatic interactions, however, the exact boundaries of riparian ecosystems can be difficult to delineate because: 1) ecosystems are not uniquely identified entities (Karr 1996); 2) the environmental heterogeneity of riparian areas is expressed in a variety of plant life history strategies and successional patterns; and 3) some ecosystem functions depend on environmental setting (Naiman et al. 1998).

Following Naiman et al. (1998), our definition of riparian ecosystem includes the active floodplain, including riverine wetlands, and the terraces or adjacent uplands that directly contribute organic matter or large wood to the active channel or active floodplain (Figure 1.1 and 1.2). Terraces and adjacent uplands that contribute organic matter or large wood are located in the "zone of influence." The active channel is defined by the lower limit of continuous riparian vegetation (Naiman et al. 1998), and it may be delineated by absence of both moss on rocks and rooted vegetation (USFS 2008). The upper most elevation of the active channel is sometimes equated with the ordinary high water mark. The active floodplain is located between the active channel and adjacent terrace or hillslopes (Fetherston et al. 1995; Harris 1987). Depending on the watershed, the flood return interval of the active floodplain varies between 1 and 10 years (Wolman and Leopold 1957; Ward and Stanford 1995; Lichvar et al. 2006; Williams et al. 2009; BLM 2015).

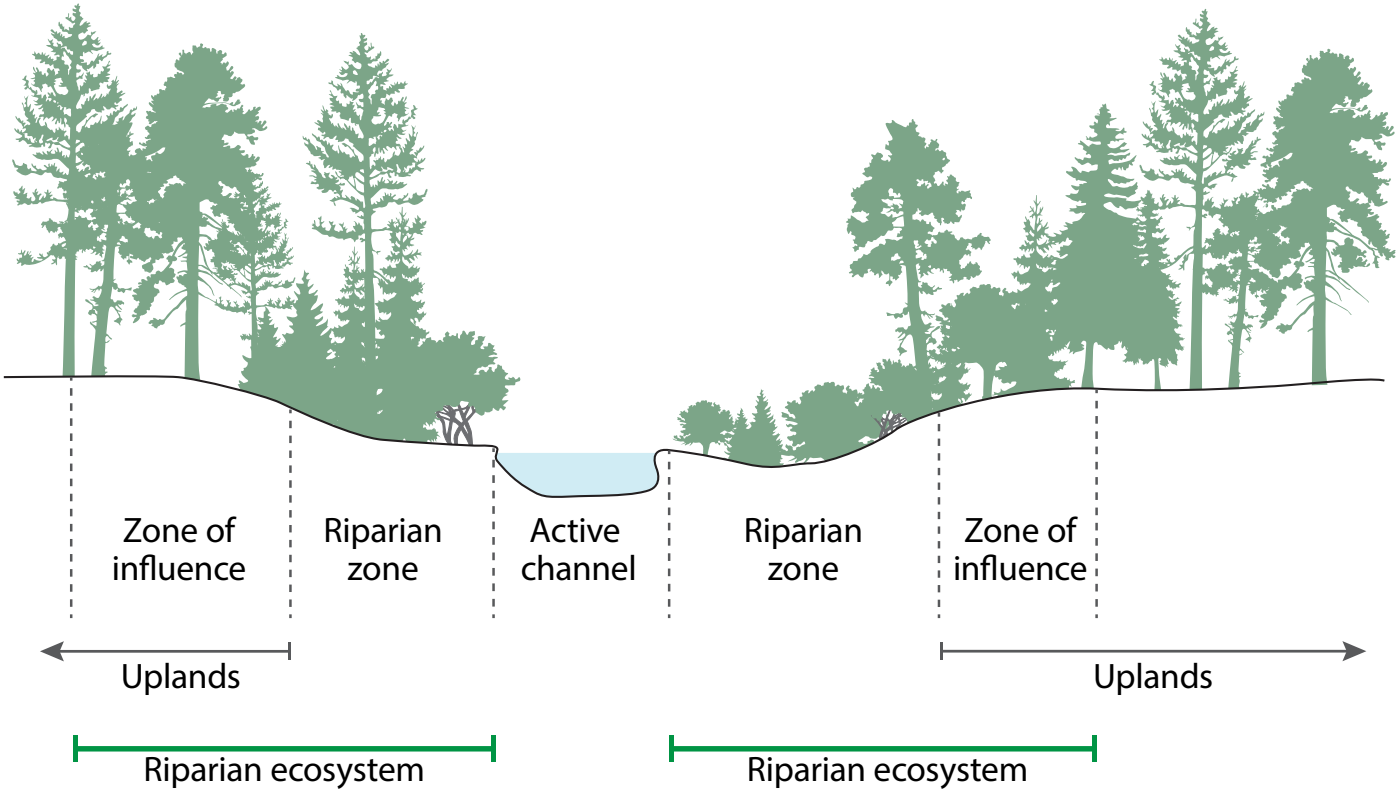
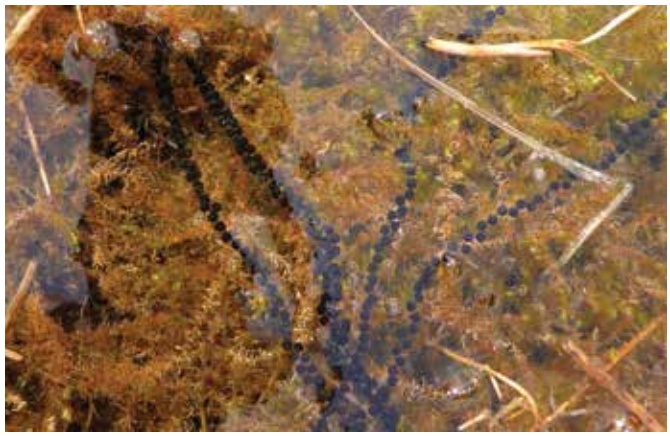


Figure 1.1. A generalized diagram of the riparian ecosystem. The NRC (2002) states that, "Riparian areas are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., the zone of influence)." The portion of the ecosystem characterized by moist soils and plants adapted to periodically saturated soils is the riparian zone. The width of the riparian ecosystem is typically based on riparian functions (i.e., wood recruitment to the stream in forested regions and the pollution removal function in dryland regions).

Riparian ecosystems are priority habitats in part because wildlife occurs more often and in greater variety in riparian areas than in any other habitat type. "Natural riparian corridors are the most diverse, dynamic, and complex biophysical habitats on the terrestrial portion of the earth" (Naiman et al. 1993). Although riparian ecosystems constitute a small portion of the surface landscape, approximately 85% of Washington's wildlife species are known to use riparian areas associated with rivers and streams (Knutson and Naef 1997). Of these, 170 species including 134 mollusks, 11 amphibians, 3 reptiles, 10 birds, and 9 mammals may be riparian obligates, i.e., require riparian habitat to survive (T. Quinn, unpublished). In addition, habitat for many upland and aquatic species is directly enhanced by the presence of adjacent riparian areas. A principal reason for high fish and wildlife diversity is that riparian ecosystems are exceptionally productive. Riparian



Western Toad Anaxyrus boreas *egg strings/Scott Fitkin, WDFW*

ecosystems are characterized by the availability of water, milder microclimate, and relatively fertile soils. These factors enhance the productivity of plant communities and support a complex food web that includes a rich variety and abundance of fish, invertebrates, amphibians, plants, bacteria, fungi, reptiles, birds, and mammals (Cummins 1974; Johnson and Carothers 1982). It is not surprising then, that $1.4 billion (57%) of $2.5 billion spent to recover salmon in Pacific Northwest since 2000 has been directed at enhancing, restoring, and maintaining salmon habitat (e.g., large wood supplementation, riparian planting, fine sediment remediation, land acquisition) previously provided in large part by functioning riparian areas (NOAA 2015).

In addition to their essential role as fish and wildlife habitats, riparian areas provide other significant benefits to humans (Naiman and Bilby 1998; NRC 2002). Briefly, riparian areas help provide a variety of ecosystem goods and services: provisioning services such as food and water; regulating services such as decreasing flood flows; supporting services such as nutrient cycling, sediment and pollutant filtering, and carbon sequestration; and cultural services such as recreational, spiritual, and other nonmaterial benefits (MEA 2005). These services provide real but often unquantified economic benefits to individuals and society; benefits that largely go unnoticed until they are lacking. According to the NRC (2002), protection and restoration of riparian areas should be a national goal because they have a major influence on achieving important national standards of the Clean Water Act, the Endangered Species Act, and flood damage control programs.

This document includes consideration of river-associated wetlands but does not consider other types of wetlands, which are covered by the Washington

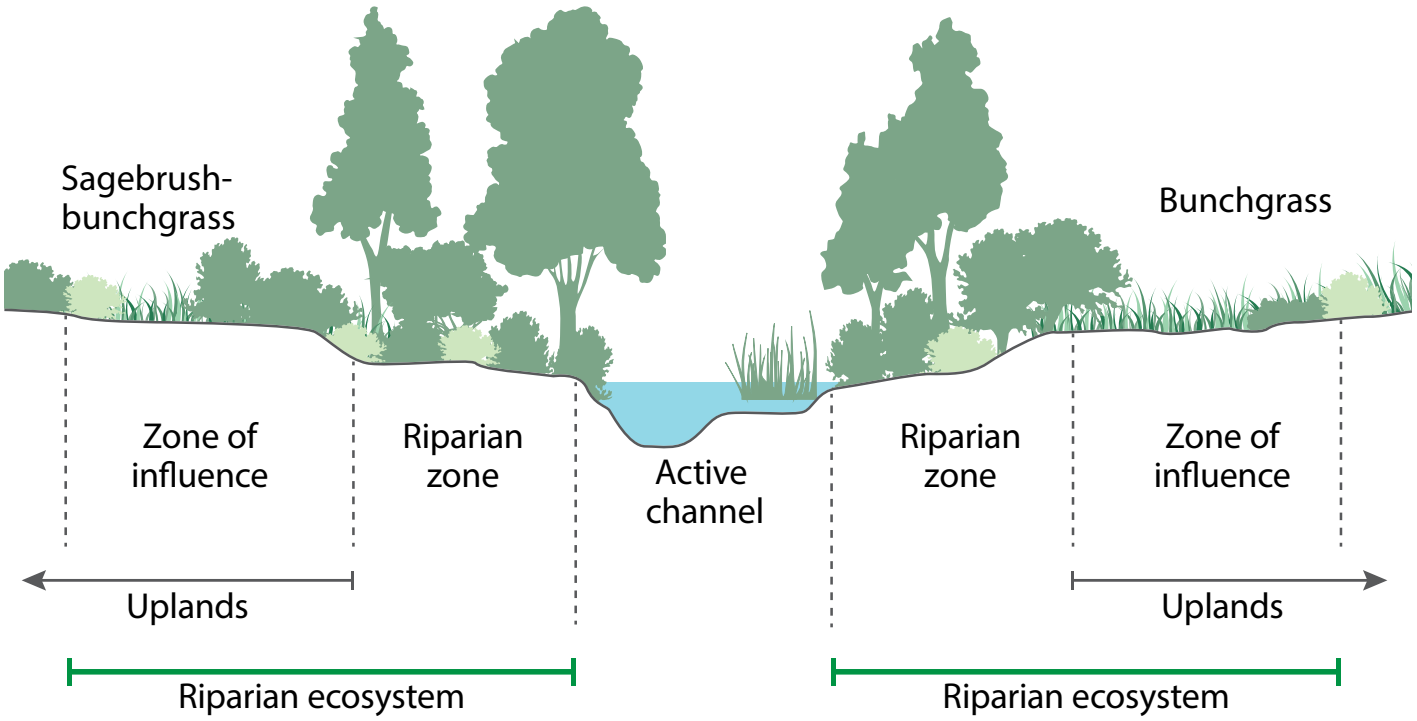


Figure 1.2. Dryland Riparian Ecosystem. The riparian ecosystem consists of two zones: riparian and zone of influence. The riparian zone extends from the edge of the active channel towards the uplands. This zone includes areas where terrestrial biota and soils are influenced, at least periodically, by surface or subsurface waters. Beyond this is the riparian "zone of influence." This includes areas where ecological processes significantly influence the stream (diagram modified from USFS 2004).

Department of Ecology, or areas bordering marine or estuarine (brackish) waters despite the potential applicability of this work to those environmental settings. A 2009 review of riparian functions of marine shorelines is available at https://wdfw.wa.gov/publications/00693.

1.2. Scope of Volume 1

1.2.1. Riparian Ecosystem Management

Riparian ecosystem management is often couched in terms of maintaining riparian functions thought to be important to fish and wildlife and their habitats (e.g., Bolton and Shellberg 2001, Everest and Reeves 2007). Some commonly identified riparian functions are described in FEMAT (1993) and the Forests and Fish Report (DNR 1999). The riparian ecosystem functions we discuss in this document, including some associated compositional and structural elements, are organized by chapter:

- Chapter 2. *Stream Morphology*—the interplay of water, sediment, and vegetation on channel form and riparian areas
- Chapter 3. *Wood*—effects of wood on channel morphology and habitat, and the recruitment of wood from riparian areas
- Chapter 4. *Stream Temperature*—effects of hydrology and shading on the thermal regime of streams
- Chapter 5. *Pollutant Removal*—the interception or filtration of fine sediments, excessive nutrients, pathogens, pesticides, and other contaminants in overland and shallow subsurface flows
- Chapter 6. *Nutrients Dynamics in Riparian Ecosystems*—dynamics and fate of the primary macro-nutrients: nitrogen, phosphorus, and carbon
- Chapter 7. *Riparian Areas of the Columbia Plateau*
- Chapter 8. *Watersheds*—relationship of watershed-scale management to the goal of achieving beneficial effects for fish and wildlife

Riparian functions are affected and in turn affect aquatic and terrestrial systems at multiple spatial scales. We focus much attention on riparian functions at the site (e.g., stream reach or land parcel) scale for three reasons. First, riparian areas are disproportionately important, relative to area, for fish and wildlife and other ecosystem services (Naiman and Bilby 1998; NRC 2002). Second, local governments and individual landowners, important users of WDFW's PHS guidance, typically manage at the parcel scale. Most land use activity, outside of public lands, occurs at the site-scale on ownership parcels that are relatively small compared to the watershed in which they occur. Third, effective and efficient conservation of fish and wildlife habitats requires management at multiple scales and thus good site-scale riparian management is an essential complement to good watershed management (Chapter 8), although approaches at different scales can vary dramatically.

1.2.2. Watershed Management

Even when all riparian functions are protected, rivers, streams, and riparian ecosystems are not immune to the effects of upland management. To varying degrees, riparian and stream structure, composition, and function reflect land uses and conditions throughout watersheds.

Regardless of its size, no ecosystem is entirely closed. Upslope activities can considerably alter the magnitude and timing of stream flows; the mobilization, routing, and storage of sediment, wood, and fine organic matter; and the quality of water, thereby influencing riparian ecosystem functions (NRC 2002; Figure 1.3). Thus, the management of riparian ecosystems at the site or reach scale should be considered just one important part, not

the sole requirement, of holistic watershed management for the protection of fish and wildlife and other values. We include Chapter 8, which focuses on watershed-scale issues that are important to the management of aquatic systems as a whole, with the intent of increasing the effectiveness of collective riparian conservation efforts. This chapter provides a conceptual framework that identifies the key watershed processes and their primary influences by, on, and through riparian areas and adjacent watercourses.

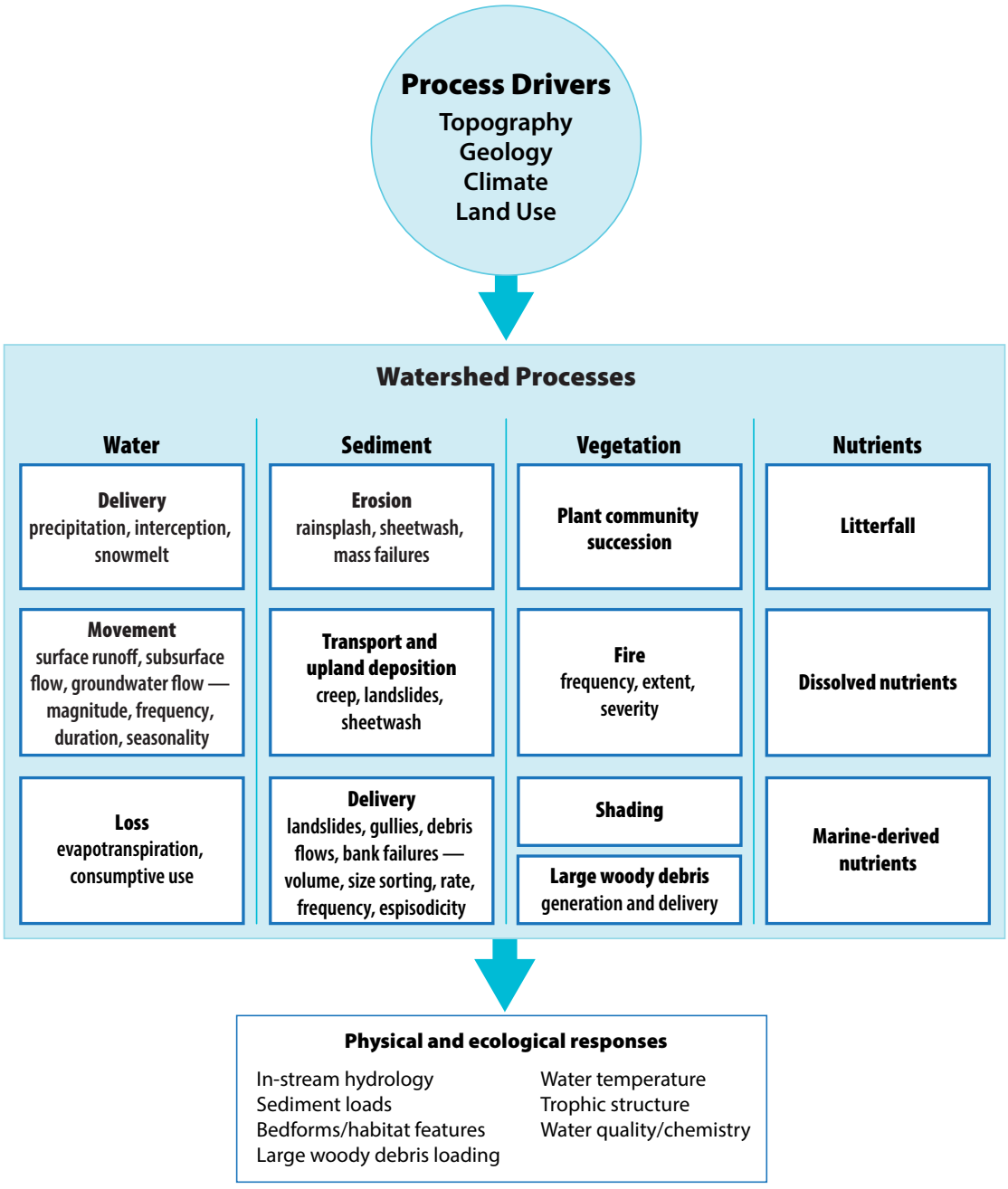


Figure 1.3. Conceptual framework for the hierarchical relationship of invariant, large-scale "process drivers," the suite of watershed processes that are determined by these drivers, and the instream physical and biological responses to those processes. Multiple additional interactions between elements and levels are not shown on this diagram to emphasize the primary influences; but in any given setting, one or more of these secondary interactions may temporarily achieve equivalent importance. This framework embraces the definition of watershed processes from Stanley et al. (2011): "[t]he dynamic physical and chemical interactions that form and maintain the landscape and ecosystems."



Devil's Club Oplopanax horridus *is common in wet soils of western Washington riparian areas/Ned Pittman, WDFW*

1.2.3. Science Synthesis

Chapter 9, *Science Synthesis to Management Implications,* of this volume summarizes important scientific finding from chapters 1-8 and provides a brief discussion of scientific themes that can inform thoughtful approaches to protecting aquatic systems.

1.2.4. Scope: Protection and Restoration

Protection and restoration of riparian ecosystems and watersheds are both essential for Washington's fish and wildlife, and especially for endangered and threatened salmonids. However, planning, management practices, regulations, and legal context for protection are different from those for restoration, and thoroughly covering both topics was beyond our scope. Thus, restoration is not explicitly incorporated in the scope of this document. Nevertheless, much of the science presented in this document can inform restoration activities. For instance, while this document does not review scientific literature on instream large wood placement, a common restoration activity, it does summarize large wood recruitment and reference conditions for the amount and size of instream large wood. Thus, the body of science that informs protection also helps to inform restoration, at least in terms of establishing resource goals and objectives.

1.3. Document Development

We employed the following approach to developing this document. We first established a Technical Advisory Group (TAG) of scientists from the region. Second, with guidance from the TAG, we conducted a literature review designed to inform the general state of knowledge regarding ecosystem protection and another literature review more focused on recent developments in riparian ecology and management. Third, we contracted with regional topic experts to author and co-author chapters. WDFW staff provided conceptual and technical guidance as possible. Finally, we subjected the draft final documents to several rounds of peer review. Each of these steps is discussed below.

1.3.1. Technical Advisory Group

The TAG helped provide overall science guidance, that is, contribute expertise and scientific perspective, provide important references and other sources of information, and review draft products. The TAG was composed of 13 individuals who were selected by virtue of their scientific expertise as opposed to affiliation with particular organization or stakeholder group. However, given the broad potential applicability of this document, it is conceivable that TAG members belong to one or more stakeholder groups. All TAG members were expected to attend three all-day meetings over the course of the project. Members of the TAG volunteered their time, except one who was paid a small stipend because she was employed by a non-profit organization. The first meeting was designed to introduce TAG members to the nature of the PHS update, to discuss different approaches to conducting a literature review and synthesizing new scientific information, and to

secure their ongoing commitment to helping WDFW meet high scientific standards. The second and third TAG meetings were designed to solicit review and feedback from TAG members on draft products. As part of their review process, we invited all TAG members to edit draft chapters and provide additional citations for WDFW's considerations. Although the TAG played a key role in advising WDFW on the science of riparian management and conservation, WDFW bears sole responsibility for the contents of this document.

1.3.2. Literature Review

We organized summaries around ecological functions including stream channel morphology, wood, pollution removal, nutrients, water temperatures, and watershed processes. Note that many of the issues we address here are directly or indirectly related to fish and wildlife habitats and other ecosystem services. We did not, however, explicitly consider cultural services that are important values for many stakeholders (e.g., spiritual, cultural and aesthetic values of riparian areas).

We enlisted the assistance of scientists with specific areas of expertise as technical advisors, authors, and informal and formal reviewers to help ensure that our summaries of pertinent scientific information were sufficiently accurate and inclusive. We were most interested in characterizing the state of knowledge and important, recent findings about each topic. That is, we tried to assesses what we know, how well we know it, and what we do not know. The summary statements in each chapter are important to the development of management recommendations because they often identify important management challenges that are not well described in the published literature (e.g., the importance of habitat connectivity to fish population persistence). To this end, when appropriate, we encouraged authors to consider the broad body of scientific information and how it might be extrapolated to unstudied locales; in other words, to consider the body of literature with regard to our ability to make reliable predictions.

Where information existed and as time allowed, we also attempted to summarize how riparian composition, structure, and functions differ among natural plant communities. In most cases, we used the broadest division called Major Vegetational Areas, which is made up of two groups in Washington State, i.e., Forested Regions and Steppe Regions (Franklin and Dyrness 1988). Regions can be further subdivided into forested zones (e.g., *Tsuga heterophylla* Zone) and steppe communities (e.g., shrub-steppe with *Artemisia tridentata*) that contain similar climax plant communities influenced by similar disturbance regimes. When information was available, for example, in the case of large wood in forested regions, we report that information at the finer division within the vegetation classification.

In addition, and as time and resources allowed, we summarized some potential effects of common land use activities on stream and riparian areas as a precursor to providing useful land use advice. We considered four general categories of land use: 1) urban, which includes commercial, industrial, urban, suburban, and rural development, 2) agricultural, which includes cultivated crops and grazing uses, 3) forestry, which includes timber management and associated activities such as

Chapter 9 summarizes scientific findings from chapters 1 through 8 and includes a brief discussion of scientific themes that can inform thoughtful approaches to protecting aquatic systems.

road building and maintenance, and 4) other activities (e.g., mining), which were not discussed due to the paucity of available research results.

We started this work by assembling topical literature reviews including Bolton and Shellberg (2001), Pizzimenti (2002), Bezener and Bishop (2005), Mayer et al. (2005), and Naiman et al. (2005). We compiled relevant literature cited in these review articles, from other reference materials we encountered, and from recommendations of TAG members. We also did an extensive literature search on computerized databases. We mostly focused our literature search on peer reviewed articles published after 1993, published in English, and conducted in proximity to Washington State. This last criterion was designed to focus on studies thought most relevant to Washington State's ecological conditions.



The North Fork Skokomish River runs through mature conifer forests of the Olympic National Park/Tim Quinn, WDFW

We also documented the type of review the study received according to RCW 34.05.271 (Appendix 1). Studies with no record of review were not considered further. As we (authors) reviewed the published literature, we noted important study findings that we believed would be especially useful for writing the PHS document. For empirical studies, our notes typically included the primary research questions or objectives, key results, management implications, and study limitations or assumptions. For literature reviews and syntheses, our notes summarized main conclusions by subject area. The intent here was to capture a sufficient level of detail for each paper so that we could use our collective notes as sources for writing the synthesis.

We found a massive quantity of literature related to riparian and watershed science despite focusing on information published after 1993. Due to the sheer volume of information, we could not cover all the literature in depth, so we covered those topics that were most relevant for management of riparian areas in Washington State. This document provides a comprehensive review on the current state of the science regarding certain riparian functions. Further, as described above, we enlisted the services of experts with specific areas of expertise as technical advisors, authors, and informal and formal reviewers to help ensure that our summaries of pertinent scientific information were sufficiently accurate and inclusive.

1.3.3. Peer Review

The peer review for Volume 1 consisted of a series of iterative steps, wherein we tried to gain as much agreement about the science synthesis as possible among those involved in the writing and reviewing process. Our intent was to provide the best available science. As described above, the TAG reviewed and often edited incomplete chapter drafts during the literature review and synthesis stage of the project. These draft syntheses were then given to topic experts to complete.

In cases, where WDFW lacked sufficient topic expertise, we provided stipends up to $10,000 to outside authors (i.e., contractors) for completing a chapter. The steps involved in completion of drafts included adding one or more conceptual models describing the system and its functioning and a synthesis or summary of the important findings over the last approximately 20 years. These steps often entailed a series of editing and reediting by WDFW staff and contractors. Once completed by contractors and returned to WDFW, the drafts were reviewed a final time by TAG members. This last review by TAG members was to ensure that completion of the chapters was consistent with their earlier guidance and with their understanding of the literature. WDFW attempted to resolve all disagreement that occurred between contractors and TAG members and provided a written description of how those issues were resolved to both the contractor and the TAG. After final WDFW review, the document was submitted for review by the Washington State Academy of Sciences (WSAS).

We enlisted the WSAS to conduct the final, independent peer review of the PHS document. Modeled after the National Academy of Science, which is charged with providing independent, objective advice to the nation on matters related to science and technology, the WSAS provides expert scientific analysis to inform public policy making at the state level (WSAS 2015). The final peer review with the WSAS was also iterative. That is, WDFW in consultation with authors and TAG members, addressed WSAS comments, made appropriate changes to the document, and then discussed those comments with the WSAS in an attempt to resolve differences. This process proceeded until we reached agreement about scientific contents and conclusions.

1.4. Literature Cited[1]

Beechie, T., and S. Bolton. 1999. An approach to restoring salmonid habitat-forming processes in Pacific Northwest watersheds. Fisheries 24:6-15. (i)

Bezener, A.M., and C.A. Bishop. 2005. Literature review of riparian habitat requirements for aquatic and terrestrial wildlife and its application to habitat restoration projects: a case example in the South Okanagan and Similkameen Valleys, British Columbia. Technical Report Series No. 379. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia. (viii)

BLM (Bureau of Land Management). 2015. Riparian area management: proper functioning condition assessment for lotic areas. Technical Reference 1737-15. National Operations Center, Denver, Colorado. (viii)

Bolton, S.M., and J. Shellberg. 2001. Ecological issues in floodplains and riparian corridors. Center for Streamside Studies, University of Washington, Seattle. (viii)

Cummins, K.W. 1974. Structure and function of streams ecosystems. BioScience 24:631-641. (i)

DNR (Washington Department of Natural Resources). 1999. Forests and Fish Report. Forest Practices Division, Olympia. (viii)

Everest, F.H., and G.H. Reeves. 2007. Riparian and aquatic habitats of the Pacific Northwest and southeast Alaska: ecology, management history, and potential management strategies. PNW-GTR-692. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic and social assessment. U.S. Department of Agriculture and U.S. Department of the Interior, Portland, Oregon. (viii)

[1] References are classified according to RCW 34.05.271 (see Appendix 1) denoted by a lower case roman numeral (i – viii) in parentheses at the end of the citation.

Fetherston, K.L., R.J. Naiman, and R.E. Bilby. 1995. Large woody debris, physical process, and riparian forest succession in montane river networks of the Pacific Northwest. Geomorphology 13:133-144. (i)

Franklin, J.F., and C.T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University Press, Corvallis. (i)

Harris, R.R. 1987. Occurrence of vegetation on geomorphic surfaces in the active floodplain of a California alluvial stream. American Midland Naturalist 118:393-405. (i)

Hunter, M.L. Jr., G.L. Jacobson Jr., and T. Web III. 1988. Paleoecology and the coarse filter approach to maintaining biological diversity. Conservation Biology 2:375-385. (i)

Jax, K. 2005. Function and "functioning" in ecology: what does it mean? Oikos 111:641-648. (i)

Johnson, R.R., and S.W. Carothers. 1982. Riparian habitat and recreation: interrelationships and impacts in the southwest and Rocky Mountains region. Eisenhower Consortium Bulletin 12. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. (viii)

Karr, J.R. 1996. Ecological integrity and ecological health are not the same. Pages 97-109 *in* P.C. Schulze, R. Frosch, and P. Risser, editors. Engineering within ecological constraints. National Academy of Engineering, Washington, D.C. (viii)

Knutson, K.L., and V.L. Naef. 1997. Management recommendations for Washington's priority habitats: Riparian. Washington Department of Fish and Wildlife, Olympia. (iv)

Lichvar, R.W., D.C. Finnegan, M.P. Ericsson, and W. Ochs. 2006. Distribution of ordinary high water mark (OHWM) indicators and their reliability in identifying the limits of "waters of the United States" in arid southwestern channels. ERDC/CRREL TR-06-5. U.S. Army Corps of Engineers, Washington, D.C. (viii)

Likens, G. 1992. An ecosystem approach: its use and abuse. Ecology Institute, Oldendorf/Luhe Germany. (i)

Mayer, P.M., S.K. Reynolds, M.D. McMutchen, and T.J. Canfield. 2005. Riparian buffer width, vegetative cover, and nitrogen removal effectiveness: a review of current science and regulations. EPA/600/R-05/118. USEPA, Office of Research and Development, Washington, D.C. (viii)

MEA (Millennium Ecosystem Assessment). 2005. Ecosystems and human well-being: synthesis. Island Press, Washington, D.C. (i)

Myster, R.W. 2001. What is ecosystem structure? Caribbean Journal of Science 37(1-2):132-134. (i)

Naiman, R.J., T.J. Beechie, L.E. Benda, D.R. Berg, P.A. Bisson, L.H. MacDonald, M.D. O'Conner, P.L. Olsen, and E.A. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest Coastal Ecoregion. Pages 127-188 *in* R.J. Naiman, editor. Watershed management: balancing sustainability and environmental change. Springer, New York. (i)

Naiman R.J., and R.E. Bilby, editors. 1998. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer Science & Business Media, New York. (i)

Naiman, R.J., H. Decamps, and M.E. McClain. 2005. Riparia: ecology, conservation, and management of streamside communities. Elsevier Academic Press, San Francisco. (i)

Naiman, R.J., H. Decamps, and M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3:209-212. (i)

Naiman, R.J., K.L. Fetherston, S.J. McKay, and J. Chen. 1998. Riparian forests. Pages 289-323 *in* R.J. Naiman and R.E. Bilby, editors. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer, New York. (i)

NOAA (National Oceanic and Atmospheric Administration). 2015. Pacific Coastal salmon recovery funds: project and performance metric database. Available: **https://www.webapps.nwfsc.noaa.gov/apex/f?p=309:13**. (January 2019). (viii)

Noss, R.F. 1992. The Wildlands Project: land conservation strategy. Wild Earth (Special Issue):10-25. (i)

NRC (National Research Council). 2002. Riparian areas: functions and strategies for management. National Academy Press, Washington, D.C. (i)

Odum, E.P. 1953. Fundamentals of ecology. W. B. Saunders, Philadelphia. (i)

Oxford Dictionary. 2015. Available: https://www.lexico.com/en/definition/structure. (January 2019). (viii)

Pizzimenti, J. 2002. Efficacy and economics of riparian buffers on agricultural lands, State of Washington. GEI Consultants, Inc., Englewood, Colorado. (viii)

Reid, L.M. 1998. Cumulative watershed effects and watershed analysis. Pages 476-501 *in* R.J Naiman and R. E. Bilby, editors. River ecology and management. Springer-Verlag, New York. (i)

Stanley, S., S. Grigsby, D.B. Booth, D. Hartley, R. Horner, T. Hruby, J. Thomas, P. Bissonnette, R. Fuerstenberg, J. Lee, P. Olson, and G. Wilhere. 2011. Puget Sound characterization. volume 1: the water resources assessments (water flow and water quality). Publication #11-06-016. Washington State Department of Ecology, Olympia. Available: https://fortress.wa.gov/ecy/publications/documents/1106016.pdf. (January 2019). (iv)

Steiner, F., S. Pieart, E. Cook, J. Rich, and V. Coltman. 1994. State wetlands and riparian area protection programs. Environmental Management 18:183–201. (i)

Sedell, J.R., F.H. Everest, and D.R. Gibbons. 1989. Streamside vegetation management for aquatic habitat. Pages 115-125 *in* Proceedings of the National Silviculture Workshop, U.S. Forest Service, Washington, D.C. (viii)

USFS (U.S. Forest Service). 2008. Stream simulation: an ecological approach to providing passage for aquatic organisms at road-stream crossings. National Technology and Development Program, San Dimas, California. (viii)

Ward, J.V., and J.A. Stanford. 1995. Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. Regulated Rivers: Research & Management 11:105-119. (i)

Williams, P.B., E. Andrews, J.J. Opperman, S. Bozkurt, and P.B. Moyle. 2009. Quantifying activated floodplains on a lowland regulated river: its application to floodplain restoration in the Sacramento Valley. San Francisco Estuary and Watershed Science 7(1). (i)

Wolman, M.G., and L.B. Leopold. 1957. River flood plains: some observations on their formation. Geological Survey Professional Paper 282-C. U.S. Government Printing Office, Washington, D.C. (i)

Wilhere, G.F., and T. Quinn. 2018. How wide is wide enough?: values, science, and law in riparian habitat conservation. Natural Resources Journal 58:279-318. (i)

WSAS (Washington State Academy of Science). 2015. Available: http://www.washacad.org/aboutus/. (January 2019). (v)

Chapter 2. Stream Morphology

By: Jane B. Atha, Mike Liquori, Kirk L. Krueger, George F. Wilhere, and Timothy Quinn

2.1. Introduction

The composition, structure, and functions of lotic systems are largely due to dynamic interactions of water, sediment, wood, and riparian vegetation. The nature of these interactions is affected by topography (e.g., channel slope), flow regime, sources and characteristics of sediment, the size, strength, and density of riparian vegetation (Naiman and Bilby 1998), and the actions of some animal species, most notably the American Beaver *Castor canadensis* and salmon. The influences of water and channel slope on sediment results in channel patterns (i.e., straight, meandering, braided) (Leopold and Wolman 1957) and geomorphic zones (i.e., source, transport, depositional) (Schumm 1977) that occur somewhat predictably from headwaters to river mouth. Furthermore, variation in fluvial processes (e.g., frequency and intensity of floods) and controls (e.g., lithology, large wood, riparian vegetation) result in a wide range of channel forms or reach types that are often described based on their bedform (e.g., slope, sinuosity, distribution of sediment sizes, etc.) (Montgomery and Buffington 1997). These channel forms can be useful descriptors of aquatic species' habitats. Tributary junctions (Kiffney et al. 2006), natural disturbances (Frissell et al. 1986), and artificial structures (Stanford and Ward 2001) can create discontinuities in these general patterns.

The composition and structure of riparian vegetation affects channel morphology, which in turn affects riparian vegetation (Hupp and Osterkamp 1996; Corenblit et al. 2007; Osterkamp and Hupp 2010; Gurnell 2014). Additionally, channel morphology and the processes that shape it can be impacted by human activities (e.g., levees, dams, Beaver trapping), usually resulting in loss of habitats, reduced habitat diversity, and diminished habitat functions for aquatic species. Management actions such as bank armoring, channelization, and riparian vegetation removal tend to reduce natural variability of geomorphic processes, often amounting to stream habitat degradation greater than the sum of its parts.



Yakima River/Justin Haug, WDFW

Knowledge of the fluvial processes that affect riparian and aquatic systems is important for making sound policy and management decisions. This chapter provides an overview of water and sediment in fluvial processes, their interactions with riparian vegetation, and potential alterations of fluvial processes by human activities. We first describe a general conceptual model for considering how physical processes affect channel morphology. Next, we describe stream flow and sediment processes in more detail. We then consider the watershed-scale context that directly influences fluvial processes. Lastly, we review impacts of human activities on stream functioning, introduce the "riverscape" concept for the management of fish habitats, and describe some physical stream habitat associations of herpetofauna. Some related topics are discussed in other chapters. For example, see Chapter 3 for a description of fluvial process interactions with large wood and Chapter 8 for a thorough examination of influences and management that occur at the watershed scale.

2.2. Conceptual Context

The concept of equilibrium is one of the most important ideas in fluvial geomorphology (Thorn and Welford 1994; Grant et al. 2013). The equilibrium concept posits that rivers tend to work toward long-term equilibrium (Gilbert 1877 as cited by Grant et al. 2013). *Dynamic equilibrium* describes a state of relative stability that results from the interaction of opposing forces (e.g., flowing water and substrate resistance). That is, over the long term and assuming that process drivers like climate and land use remain unchanged (see Chapter 8), overall progression of the composition and structure of stream reaches in a watershed remains largely unchanged. A stream network may undergo significant changes during an extreme flood event, and yet return to equilibrium as smaller flows rework the sediment distributed by floodwaters to re-establish roughly the same relative abundance of stream reach types that existed prior to the flood event.

Lane (1955) conceptualized equilibrium within a stable channel as a balance among stream discharge, channel slope, sediment load, and sediment size (Figure 2.1). Lane's conceptual model was described by Heede (1980) as:

$$Q_s D \propto Q_w S$$

where Q_s is sediment load (i.e., sediment discharge), Q_W is water discharge, D is sediment size, and S is channel slope.

What remains "in balance" over time are the processes of streambed degradation (erosion) and aggradation (sediment deposition). If an increase occurs in stream discharge, for instance, then the resulting increase in stream power can cause an increase in streambed degradation. The channel "adjusts" by decreasing channel slope, which reduces stream power and causes a return to the balance between degradation and aggradation. If a shift in stream discharge or sediment supply occurs, then the channel returns to equilibrium through adjustments in one or more other variables. However, persistent changes in one or more variables of sufficient magnitude may exceed a threshold that causes an abrupt shift to a new equilibrium state (Schumm 1979).

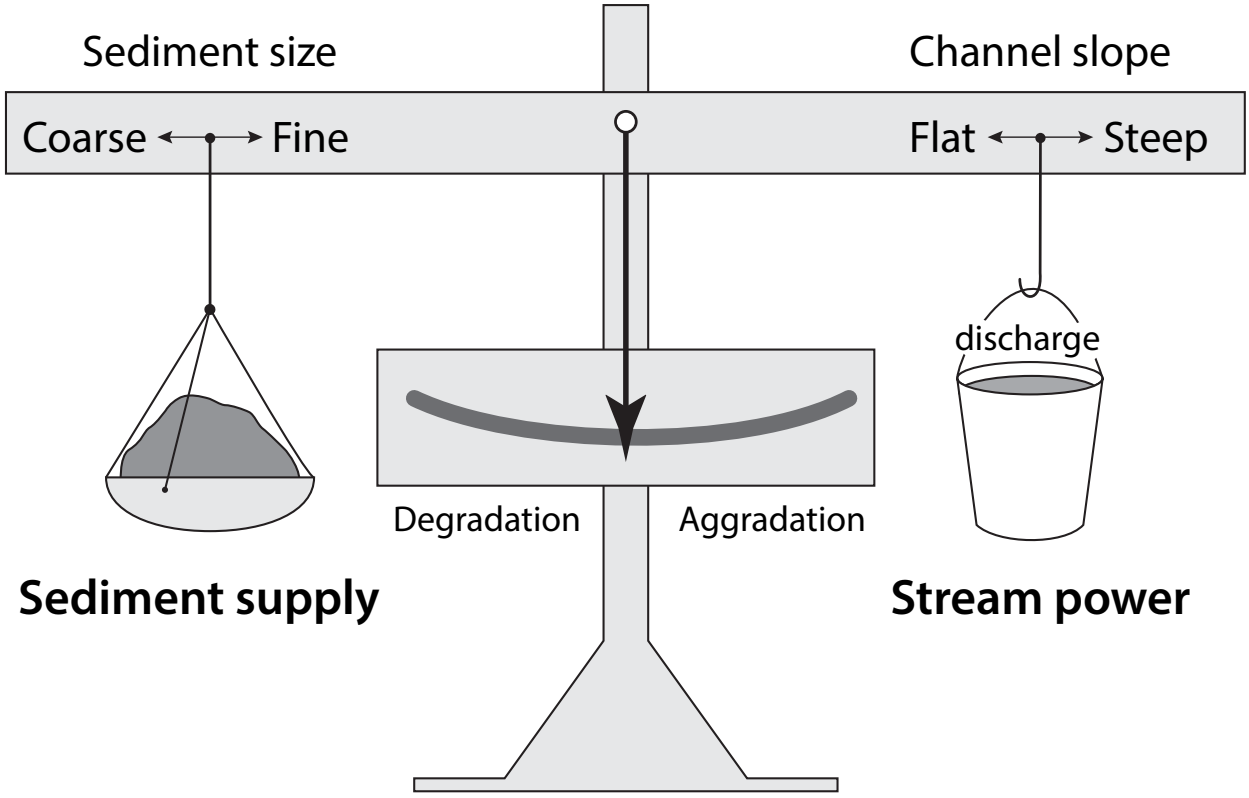


Figure 2.1. Lane's Balance illustrating the concept of channel adjustment (i.e., vertical aggradation or degradation of the streambed) in response to changes in water or sediment yield (from Dust and Wohl 2012).

While Lane's Balance is a useful conceptual model, it does not address complexity at the watershed scale nor the interactions between fluvial processes and riparian vegetation that affect channel morphology (Corenblit et al. 2007; Gurnell 2014) (Figure 2.2). These interactions are reciprocal and feedbacks exist between fluvial processes and vegetation composition and structure (Hupp and Osterkamp 1996; Osterkamp and Hupp 2010). Vegetation influences channel form and channel forming processes help shape riparian plant communities. Human activities that alter these interactions can cause significant changes to channel morphology and fish habitats.

Many geomorphic and ecosystem processes are coupled and occur in parallel at similar spatial and temporal scales. This results in mutual dependence between processes (Renschler et al. 2007). While such processes have received much attention from the scientific community in the last fifteen years, a theoretical synthesis within a holistic conceptual framework is still needed to address how riparian management interacts with this complex system (Smith et al. 2002; Stallins 2006). Interdisciplinary research of these interactions could result in better predictability of impacts caused by management. From an ecosystem management perspective, the choice of spatiotemporal boundaries—often dictated by geomorphic processes—is of profound importance to conceptualization of the system and its ecologic processes (Post et al. 2007).

We frame the hydrologic and physical processes as they shape the riverscape from the context of equilibrium and mutual dependence among water, sediment, and vegetation.

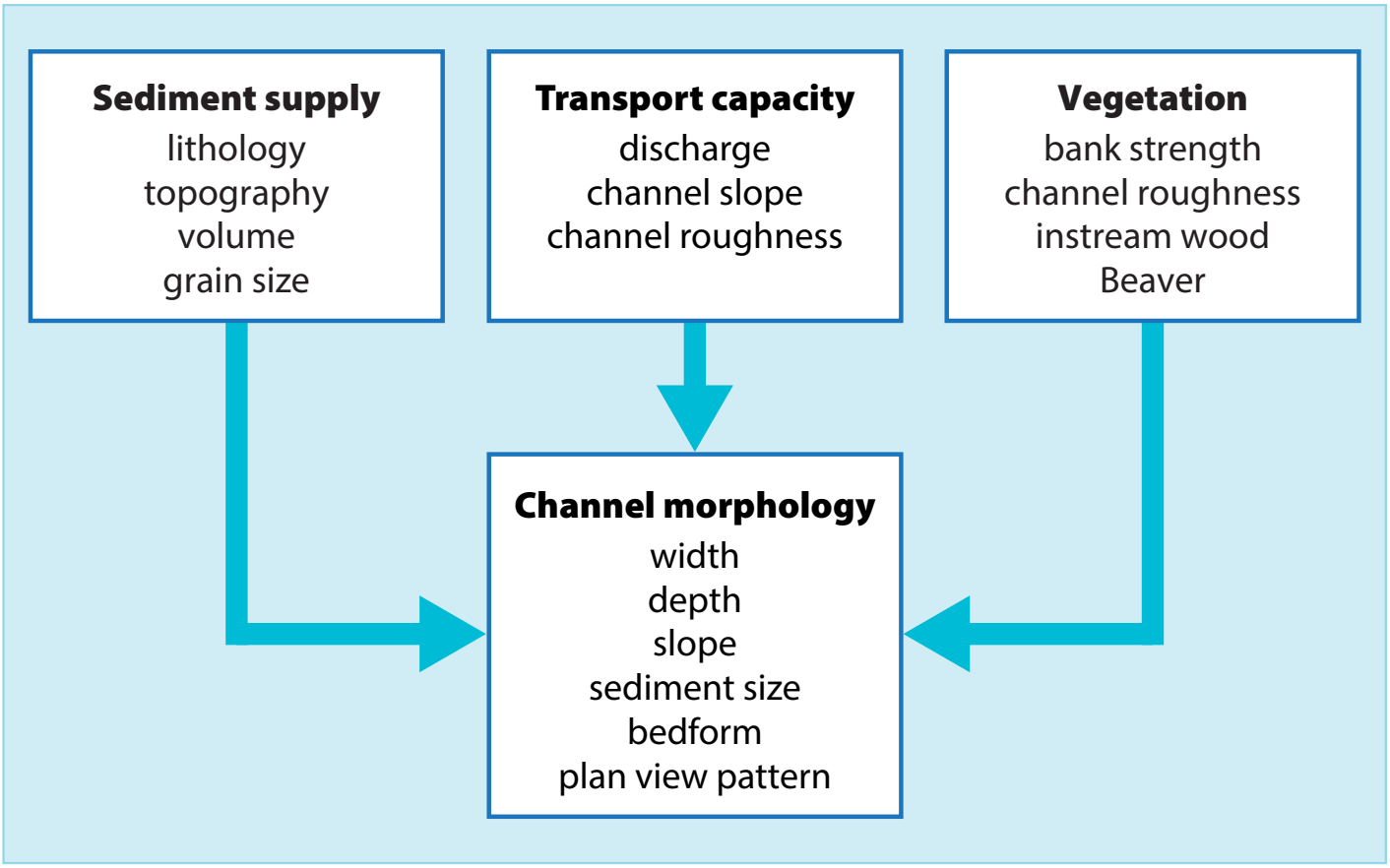


Figure 2.2. Influences on channel morphology (modified from Naiman and Bilby 1998).

2.3. Streamflow Processes

The pathways that water takes to reach a river exert a strong influence on the amount and timing of streamflow in the channel (Figure 2.3). Differences in the relative contributions of these pathways among locations and seasonal variability (e.g., presence or absence of snow) in environmental conditions produce a wide range of stream flow responses to precipitation events.

The fate of precipitation that is not lost through evaporation and transpiration is highly dependent on soil cover. Rain or melted snow that infiltrates the soil can flow downslope in the vadose zone (unsaturated), above the water table as through flow, or below the water table as groundwater in the phreatic zone (saturated).

When precipitation rates exceed soil infiltration rates (Horton 1933) or when local soils are saturated (Dunne and Black 1970a, 1970b; Dunne 1978), water moves downslope as surface runoff. Surface runoff or overland flow remains outside the confines of a channel, and is most common where vegetation is sparse. Human activities that compact soil or destroy permeable, near-surface soil layers reduce infiltration capacity and promote overland flow. A second type of runoff, saturated overland flow, occurs at convergent zones (such as hillslope concavities) and is a combination of direct precipitation onto saturated areas and return flow from the subsurface as it becomes saturated (Wohl 2014) (Figure 2.3).

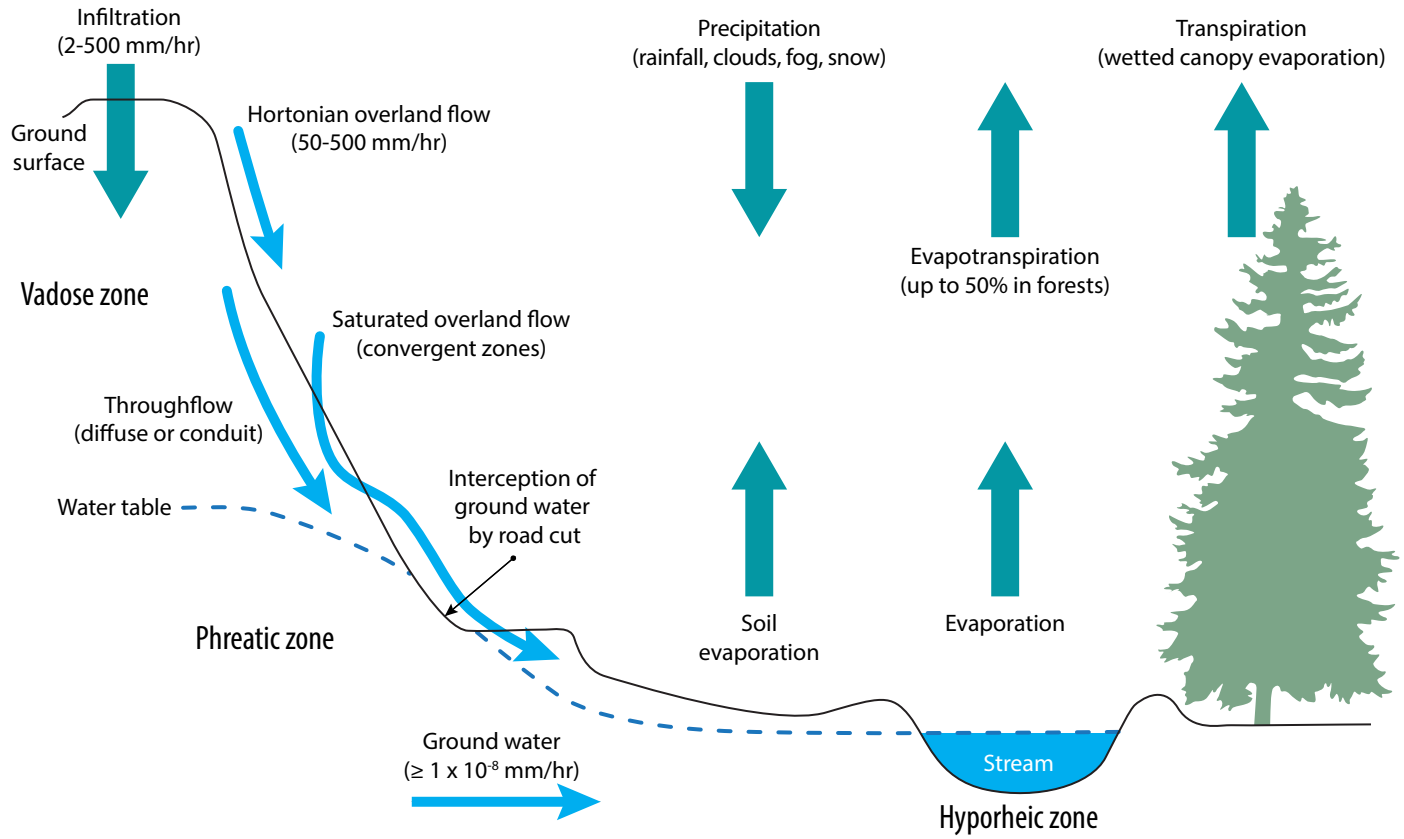


Figure 2.3. Illustration of different types and rates of downslope movement of water on a hillslope (modified from Ziemer and Lisle 1998, and Wohl 2014).

Runoff originates from variable source areas in response to precipitation and soil saturation conditions (Betson 1964; Hewlett and Nutter 1970). Conceptually, the amount of runoff within a single small drainage basin can be highly varied in space and time because many factors influence water infiltration and movement. Much of the variability in areas contributing water to the channel reflects the groundwater levels and activation[1] thresholds for lateral subsurface flow existing immediately after a precipitation event (McDonnell 2003).

Riparian vegetation influences preferential flow pathways in both surface and subsurface environments (Swanson et al. 1998; McDonnell 2003) and the manner in which surface flows create and maintain channel and floodplain morphology. During periods of active runoff, riparian areas quickly become saturated, and become the first areas within the watershed to contribute runoff into the channel (McDonnell 2003). Riparian areas account for the majority of the runoff at the beginning of a flood event, whereas hillslopes contribute more as the runoff tapers off at the end of an event. Flow resistance provided by riparian vegetation and related organic material slows water velocities, reduces peak discharge, and lengthens a flood's duration (Tabacchi et al. 2000; Nilsson and Svedmark 2002).

In a reciprocal manner, stream hydrology plays a large role in shaping riparian vegetation communities. The rate at which the river water surface lowers after a spring freshet influences seedling germination and recruitment (Mahoney and Rood 1998). Thus vegetation species composition and age structure vary due to flow frequencies that determine sediment mobilization and effective discharge (Pike and Scatena 2010).

[1] Activation of subsurface water means that subsurface water is flowing, i.e., the velocity deviates significantly from zero. Activation threshold often refers to the amount of precipitation needed to activate subsurface flow.

Interactions between stream water and groundwater occur in the hyporheic zone. In other words, the *hyporheic zone* is the ecotone between a surface stream and deeper groundwater (Boultan et al. 1998). The extent of the hyporheic zone is determined by the volume of sediment stored within the channel and active floodplain (Moore and Wondzell 2005). Two-way exchanges of water occurring in the hyporheic zone are important in regulating hydrological, biogeochemical, and thermal processes (Krause et al. 2011), which strongly influence the volume, chemistry, and temperature of streamflow. Along this ecotone, upwelling subsurface water supplies the stream ecosystem with mineral nutrients while downwelling stream water provides dissolved oxygen and organic matter to organisms inhabiting the interstitial spaces of alluvial sediments (Boultan et al. 1998). The hyporheic zone can account for a fifth of the invertebrate production in an aquatic ecosystem (Smock et al. 1992). Water flows laterally from the hyporheic zone into alluvial sediment deposits, and can extend out more than 1.2 miles (2 km) in wide valleys and to depths of 33 ft (10 m) (Stanford and Ward 1988). Hyporheic flows can also affect riparian vegetation, although the interactions between riparian communities and hyporheic conditions are not well understood (NRC 2002).



Cape Creek, Lane County, Oregon/Jane Atha, WDFW

2.4. Erosion and Sedimentation Processes

2.4.1. Sediment Sources and Delivery

Sediment sources and delivery within a watershed can vary significantly depending upon geology, climate, landform, soil erodibility, vegetation, and the magnitude and frequency of dominant disturbances. Delivery of sediment to channels by surface erosion is generally low in undisturbed watersheds, but can vary greatly by year (Swanston 1991). Annual differences are caused by variation in weather patterns, changes in exposed surface area, and changes in the amount of erodible material. Sediment can move downslope in aggregates through mass wasting (mass movement, mass failure, or slope movement) categorized as landslides, debris flows, or heaves. Mass wasting events are typically seasonal as a function of soil moisture and freeze-thaw processes (Hales and Roering 2009). Soil on a hillslope will remain stable if the sum of the applied shear stresses does not exceed the sum of the shear strengths of slope materials (soils, roots, etc.). Mass wasting is initiated when shear stress on a material exceeds its shear strength threshold (Ritter et al. 2002). The volume of material generated from hillslope mass wasting events can be very large, and is often the predominant source of sediment and large wood delivered to streams in the Pacific Northwest (Swanson et al. 1982).

Sediment can also move downslope through gradual, diffuse processes such as rainsplash and rills that form from overland flow. Rainsplash takes place when raindrops loosen the soil particles making them more



Skagit Valley agriculture/Jane Atha, WDFW

susceptible to entrainment by overland flow (Furbish et al. 2009; Dunne et al. 2010). Overland flow can be concentrated into small, narrow, shallowly incised micro-channels that are carved into hillslope soils (Selby 1993). These channels, termed rills and gullies (with gullies being deeper) can form effective conduits for sediment erosion into stream channels (Wohl 2014).

Sediment delivered from riparian areas can be generated by mechanisms other than direct streambank erosion. Riparian sediment sources can be associated with treefall that results in the uprooting of trees (root throw; Hairston-Strang and Adams 2000; Liquori 2006). The primary causes of treefall include wind along newly created edges in riparian forest (Liquori 2006; Reid and Hilton 1998), undercutting streambank erosion, and large-scale disturbances such as fire or pest infestation. Root throw can provide direct sediment inputs to the channel (Lewis 1998; Reid and Hilton 1998; Gomi et al. 2005). Harris (1977) found that windthrow-related sediment production along a stream in coastal Oregon was responsible for 33 tons of sediment per mile of stream per year (18.6 metric tons per kilometer per year) (as cited in Gomi et al. 2005).

Riparian vegetation can effectively trap and store sediment transported downslope from overland flow (Naiman et al. 2010). This topic is fully explored in Chapter 5, Pollutant Removal. Once the sediment is deposited in riparian areas, plant roots facilitate stabilization and continued storage of sediment (Allmendinger et al. 2005; Tal and Paola 2007).

2.4.2. Instream Sediment Transport and Deposition

Sediment that has entered the stream channel can be transported downstream as dissolved load, suspended load, or bed load. Dissolved load carries sediment within solution, which can be substantial in some rivers (Knighton 2014). The concentration of solute is highest in water entering the channel through subsurface pathways because slower rates of subsurface water

movement allow for longer reaction times with the surrounding environment. Solute concentrations through subsurface pathways tend to lessen with greater discharge (Wohl 2014). Suspended load refers to sediment carried as suspended particulates in the water, and originates predominantly from bank erosion and surface erosion from upland areas. The finest size fractions of suspended transport, known as wash load, are more likely to be supply limited, i.e., the amount in transport is limited by the amount available. In contrast, the coarser bed load, which consists of larger rocks that bounce along the channel bed, is typically limited by transport capacity of flowing water (stream energy). Bed load may not get suspended; it can roll and slide during low flows, saltate (bounce) at intermediate flows, and move as sheetflow during high flows (Wohl 2014). Bed load transport processes are surprisingly complicated because many factors, some of which interact, determine the threshold for movement. These factors include the range of sediment sizes, their spatial arrangement, and channel form within a reach (Knighton 1984).

Bedforms are bed undulations that result from sediment transport and deposition. Montgomery and Buffington (1997) classified stream channels based on common bedforms (i.e., cascade, step-pool, plane-bed, pool-riffle, and dune-riffle), their dominant sediment transport process, and behaviors of debris flows and instream wood. The role that sediment plays in aquatic habitat can differ dramatically among those classes. For example, sediment in headwater channels (often classified as cascade or step-pool) tends to be stored behind boulder and wood obstructions. In lower gradient channels, sediments become sorted into pools and riffles depending on instream wood load, gradient, and a wide variety of other factors (Benda et al. 2005; Gomi et al. 2005).

All bedforms are depositional features. Deposition occurs when the flow or shear velocity in the stream falls below the settling threshold velocity of the sediment particle. Settling thresholds are lower than entrainment thresholds, and deposition can be localized or extended across a channel length depending on fluctuations in flow velocity (Wohl 2014). Riparian vegetation can be especially instrumental in facilitating deposition within channels and along banks (Tal et al. 2004). Establishment of riparian vegetation can initiate a positive feedback process as plants trap and stabilize sediments and organic matter that provides sites for germination of plants, which can then reinforce the development of floodplains, instream islands, and other landforms.

Erosional forces in the streambed can be increased due to topographic constrictions or locally steep gradients. Where hydraulic forces overcome surface resistance, channel incision can occur (Wells et al. 2009). Channel incision that occurs at the channel head, known as a headcut, results in vertical faces that separate upslope unchanneled environments from downslope channels. Headcuts that destabilize or incise an otherwise stable channel bed result in significant increases in sediment yield (Meyer et al. 1975; Bryan 1990). Headcuts can also occur as an upstream-migrating "step" in the channel bed that forms as a result of hydraulic scour, often from manipulations to the channel or flow conditions (e.g., culverts, diversions, etc.). This type of headcut can migrate upstream and change channel form for long distances.

Establishment of riparian vegetation can initiate a positive feedback process as plants trap and stabilize sediments and organic matter that provide sites for germination of plants, which can then reinforce the development of floodplains, instream islands, and other landforms.

A combination of field, experimental, and theoretical research has dramatically advanced our understanding of sediment transport dynamics as well as the role of vegetation in stream morphology. Sophisticated flume experiments and computational models have confirmed the importance and complexity of interactions among water, sediment, wood, and vegetation (Gurnell 2014). Recent modeling efforts have placed these phenomena on solid theoretical footings and have allowed researchers to explore scale dependence. We know much less about these interactions at small scales (single plant), however, understanding smaller scale phenomena is crucial to fully understanding longer-term and larger-scale geomorphic form and process (Gurnell 2014).



Bank erosion along the upper Chehalis River/Jane Atha, WDFW

2.4.3. Streambank Erosion

Streambank erosion is a geomorphic process that is integral to a watershed's natural disturbance regime and necessary for long-term ecological sustainability (Florsheim et al. 2008). Bank erosion is a key process for maintaining the structural diversity of aquatic and riparian habitats; it initiates community succession that promotes ecological diversity of riparian areas, and contributes coarse sediment to streambeds that is an essential habitat element for benthic invertebrates and spawning salmon. Bank erosion commonly occurs on the outside of river bends, but it can also occur in straight channels where changes in water or sediment supply cause channel incision. Instream large wood or mid-channel gravel bars that divert flows toward a bank (Florshiem et al. 2008) can also cause bank erosion. Local bank erosion is a naturally occurring process that is often indicative of a channel in dynamic equilibrium. Despite this fact, bank erosion at any scale is commonly misinterpreted as a sign of channel instability. Human disturbances can increase rates of bank erosion, and thus, understanding whether bank erosion is triggered by human activities or natural geomorphic processes is important for site-scale management (Polvi et al. 2014).

Two types of processes result in bank erosion: fluvial erosion and mass wasting (ASCE 1998). Fluvial erosion is the separation of sediments from a streambank's surface by the forces of flowing water. Fluvial erosion may destabilize riparian vegetation by exposing plant roots or undercutting vegetation (Florsheim et al. 2008). Fluvial erosion can eventually lead to mass wasting ("bank failure"). Mass wasting at streambanks is caused by scour of the streambed and bank toe that increases bank height and angle. When gravitational forces on the bank (weight of soil, water, and overlying vegetation) exceed the shear strength of the bank material, a portion of the bank collapses along a failure plane (Simon et al. 2000). Both types of bank erosion occur mainly during peak flows, but the association between flow magnitude and amount of bank erosion varies greatly among



Building in danger from streambank erosion on Newaukum River/Kaysie Cox, WDFW

watersheds. Wolman (1959, as cited in ASCE 1998), for instance, reported that significant bank erosion on a creek in Maryland occurred more than ten times per year during relatively small but frequent peak flow events. Studies of other alluvial systems have found that significant bank erosion was caused mostly by large floods with recurrence intervals of decades or more (ASCE 1998).

The stability of streambanks is influenced by soil characteristics, groundwater, and vegetation (Hickin 1984; NRC 2002). Mass wasting failure mechanics, for example, are quite different for cohesive and noncohesive soils (ASCE 1998). Adjacent surface waters or ground water affects pore water pressure, and positive pore water pressure destabilizes banks by reducing cohesion and friction amongst soil particles. Water in soil also adds mass, thereby increasing gravitational forces acting on a streambank. Bank failure often occurs shortly after flood waters recede because soils are at or near saturation and the laterally confining hydraulic pressure of the floodwaters decreases to zero (Rinaldi et al. 2004).

Vegetation may have mechanical and hydrologic effects on bank stability, and these effects can be stabilizing or destabilizing (Simon and Collison 2002; Langendoen et al. 2009; Pollen-Bankhead and Simon 2010). Soil is generally strong in compression, but weak in tension. Woody and herbaceous plant roots are strong in tension, but weak in compression. Consequently, the root-permeated soil of streambanks behaves as a composite material with enhanced strength (Simon and Collision 2002; Pollen and Simon 2005). However, the additional bank strength provided by roots is species dependent (Polvi et al. 2014). Simon et al. (2006), for instance, found that Lemmons's Willow *Salix lemmonii* provided an order of magnitude more root reinforcement of streambanks than Lodgepole Pine *Pinus contorta*. Dense root networks also physically restrain or bind soil particles. In addition, exposed roots on the bank surface increase channel roughness, which dampens stream flow velocities, thereby reducing fluvial erosion (Griffin et al. 2005; Gorrick and Rodríguez 2012). In fact, fluvial erosion of well-vegetated banks is 10 to 100 times less than erosion of unvegetated banks (ASCE

1998). Reduction of stream velocities by roots may also cause sediment deposition, which further stabilizes streambanks.

Vegetation has destabilizing mechanical effects as well (ASCE 1998; Simon and Collison 2002). The weight of vegetation adds a "surcharge"[2] load to soil. Hence, the weight of vegetation increases the vertical shear stress near a streambank and adds to the lateral earth pressure[3] at the streambank surface, however, these effects can be minimal relative to soil's weight (Simon et al. 2006). Additionally, tall, stiff vegetation may impose destabilizing forces on streambanks during windstorms (ASCE 1998).

The hydrologic effects of plants on streambank stability are those that influence soil moisture. Through canopy interception, vegetation reduces the amount of precipitation that reaches soil. Transpiration, which extracts water from the soil column within the root zone, creates negative pore water pressures (matric suction) that increase soil shear strength (Simon and Collison 2002). Plants destabilize streambanks by facilitating infiltration of water into soil via flow pathways ("macropores") created by live and decayed roots. In addition, stemflow tends to concentrate precipitation around the base of stems, creating higher local pore water pressure. The net hydrological effect of vegetation can be significant. Simon and Collision (2002), for instance, found in their study conducted in northern Mississippi that following a very dry period the stabilizing hydrological effect of tree cover was two times greater (220%) than tree cover's stabilizing mechanical effect. However, this result was reversed following a wet period; the stabilizing mechanical effect of tree cover was 159% of tree cover stabilizing hydrological effect.

The bank stability function of riparian vegetation has important implications for riparian area management. FEMAT (1993:V-27) created a generalized curve of root strength versus distance from channel based on expert opinion informed by scientific literature. The radius of Douglas-fir *Pseudotsuga menziesii* root networks are highly correlated with tree crown radius (Smith 1964).[4] Hence, FEMAT (1993) assumed the contribution of root strength to maintaining streambank integrity declines at distances greater than one-half a crown diameter. Using linear regression, Roering et al. (2003) derived a power-law relationship for coniferous trees between root network radius and tree diameter. This relationship suggests that large diameter conifers (36 to 48 inches [91 to 122 cm] diameter breast height) have root network radii that measure 16 to 33 ft (5 to 10 m). Hence, in an undisturbed old-growth riparian forest, the full contribution of root strength to streambank stability is provided by trees within approximately 33 ft (11 m) of the streambank.

2.4.4. Lateral Channel Migration

Lateral channel migration affects sediment erosion and deposition, local topographic relief, flood inundation patterns, river planform, alluvial architecture, and riparian vegetation patterns, which in turn results in a complex arrangement of aquatic and riparian habitats across a river's floodplain (Naiman et al. 1993). Lateral channel migration occurs through the processes of meander bend development, avulsions, and channel widening and narrowing (Rapp and Abbe 2003). These processes occur through fluvial erosion of intact bank material and mass failure of streambanks under gravity, followed by mobilization and transport of the disturbed material (Burckhardt and Todd 1998).

2 A surcharge load is any load imposed upon the soil surface close enough to a streambank to cause lateral pressure to act on the bank. "Surcharge" denotes an extra force in addition to the weight of the soil.

3 Lateral earth pressure is the pressure (i.e., force per area) that soil exerts in the horizontal direction.

4 The ratio of root spread to crown width for small Douglas-fir and Western Hemlock *(Tsuga heterophylla)* (mean dbh about 13 inches [33 cm]) was reported by Smith (1964) to be about 1. Data in Eis (1987) for these same tree species suggest a ratio of about 2.

One mechanism of channel migration is meandering, which is one of the most common river-channel patterns (Güneralp and Marston 2012). Given time, and lacking physical obstructions, a natural unimpeded meandering channel can swing and shift across its valley in the downstream direction, completely disturbing the floodplain (Schumm 1977). The floodplains of meandering rivers are low-lying depositional features that store large volumes of sediment, and reflect the history of erosion and deposition of a river occupying the valley floor (Dunne and Leopold 1978). The time needed for a channel to migrate and occupy its entire floodplain is expressed as a "floodplain turnover rate," which may take tens to thousands of years in western Washington. Beechie et al. (2006) found, for example, that braided channels in rivers of the Cascades and Olympic mountains had a turnover rate of 25 years. In contrast, O'Connor et al. (2003) estimated turnover rates for two large rivers on the Olympic Peninsula to be approximately 200 to 2000 years. The channel migration rates for the rivers in O'Connor et al.'s study ranged from 13 ft (4.0 m) to 42 ft (12.7 m) per year.

Sediment erosion and deposition patterns that result in channel migration are caused by complex flow patterns along meander bends. Water tends to develop a horizontal swirling flow as a result of greater roughness along the banks than in the center of the channel. This swirling flow, termed "helical flow", is generated by the super elevation of the water's surface as it flows along the outside of a bend (Callander 1978). Helical flow creates large cross-stream variation in velocity (Dietrich et al. 1984), and the reduced velocity and bed shear stress at the inside of a bend creates pointbar deposition. In addition, pointbars deflect flow laterally toward the cutbank, creating topographically driven secondary flow that further induces an outward velocity shift toward the cutbank (Güneralp and Marston 2012).

Movements of individual meanders are described as: 1) simple migration (or translation), which is a downstream shift without significant shape change; 2) extension (or growth), where the amplitude of the bend extends by migrating across the valley; 3) rotation, in which the bend axis changes orientation; and 4) lobing and compound growth, where the bends become less regular and symmetrical (Hooke 1984). Individual bends along a meandering channel can have different styles and rates of migration, and typically deform and become asymmetrical with migration. Meander migration that increases the amplitude and tightness of bends can lead to a cutoff channel that creates a shorter flow path across the inside of a pointbar or a neck cutoff at the base of the bend. The increase in channel gradient from the cutoff causes it to become the main channel, and the longer flow path becomes a secondary or overflow channel on the floodplain. Secondary channels may function as side channels that are important rearing habitat for juvenile salmonids (Rosenfeld et al. 2008) or



Chehalis River meander bend/Jane Atha, WDFW



Mid-channel bar/Jane Atha, WDFW

oxbow lakes, which are habitat for amphibians (Henning and Schirato 2006). The increased habitat diversity for aquatic and riparian organisms can persist for decades to centuries depending on rates of sediment filling.

Another mechanism for channel migration is avulsion, which is the rapid abandonment of a river channel and the formation of a new river channel. Avulsions can occur with little erosion of the land between the old and new channel locations (Allen 1965; Butler 2004). An avulsion can cause rapid, dramatic shifts in channel location from one side of the valley bottom to the other, and can occur during a single flood event. Avulsions are often associated with aggrading channels, but this is not a necessary requirement (Tooth et al. 2007). Meander cutoffs, for example, are a type of avulsion not derived from aggradation. In the Pacific Northwest, wood jams often cause and mediate avulsions, acting to maintain a multiple-channel pattern. Wood jams can cause avulsions by plugging channels and diverting flow into a relict channel that then becomes the main channel (Collins and Montgomery 2002).

Along alluvial rivers, spatial and temporal patterns of riparian vegetation composition and structure are controlled by rates of channel migration and vegetation response to disturbance (Figure 2.4). As channels migrate laterally, pointbars create conditions for recruitment of early successional plant species. Over long periods, pointbar growth is followed by the succession of terrestrial plant communities. Consequently, a pointbar may support a chronological series of successional stages arranged from youngest closest to the active channel to oldest farthest from the channel (Shankman 1993). A limited number of species consistently dominate the accreting edge of pointbar landforms, while progressively more species establish as the pointbar aggrades to a higher surface elevation (Meitzen 2009). Opposite these pointbars, eroding cutbanks expose and remove previously established mature vegetation, but also open edge habitat for colonization by new plant species. Kupfer and Malanson (1993) found that cutbank edge forests have higher stem densities and greater species richness than floodplain interior forests.

Lateral channel migration and related streambank erosion processes can pose risks to human communities located near rivers and large streams. Likewise, human actions intended to limit channel migration can degrade aquatic and riparian habitats. For these reasons, geomorphologists have developed protocols for determining the channel migration zone (CMZ). A CMZ includes the outer extent of historical channels, plus the area where future channel migration could occur over some time period (e.g., 100 years). CMZ delineation considers the historical migration zone, i.e., the area encompassing all historical channels; the avulsion hazard zone, i.e., areas not in the historical record that are at risk of avulsion; and the erosion hazard area, i.e., the area at risk of bank erosion from stream flow or mass wasting over the time horizon of the CMZ (Rapp and Abbe 2003). The CMZ typically encompass floodplains and some portion of terraces (landform remnants of the former floodplain). The CMZ also includes channels and terrace banks that are at risk of mass wasting due to erosion of the toe.

Lateral channel migration produces a spatially dynamic riparian ecosystem. Because the riparian ecosystem (i.e., the riparian zone and zone of influence) is defined by proximity to water, as the active channel moves back

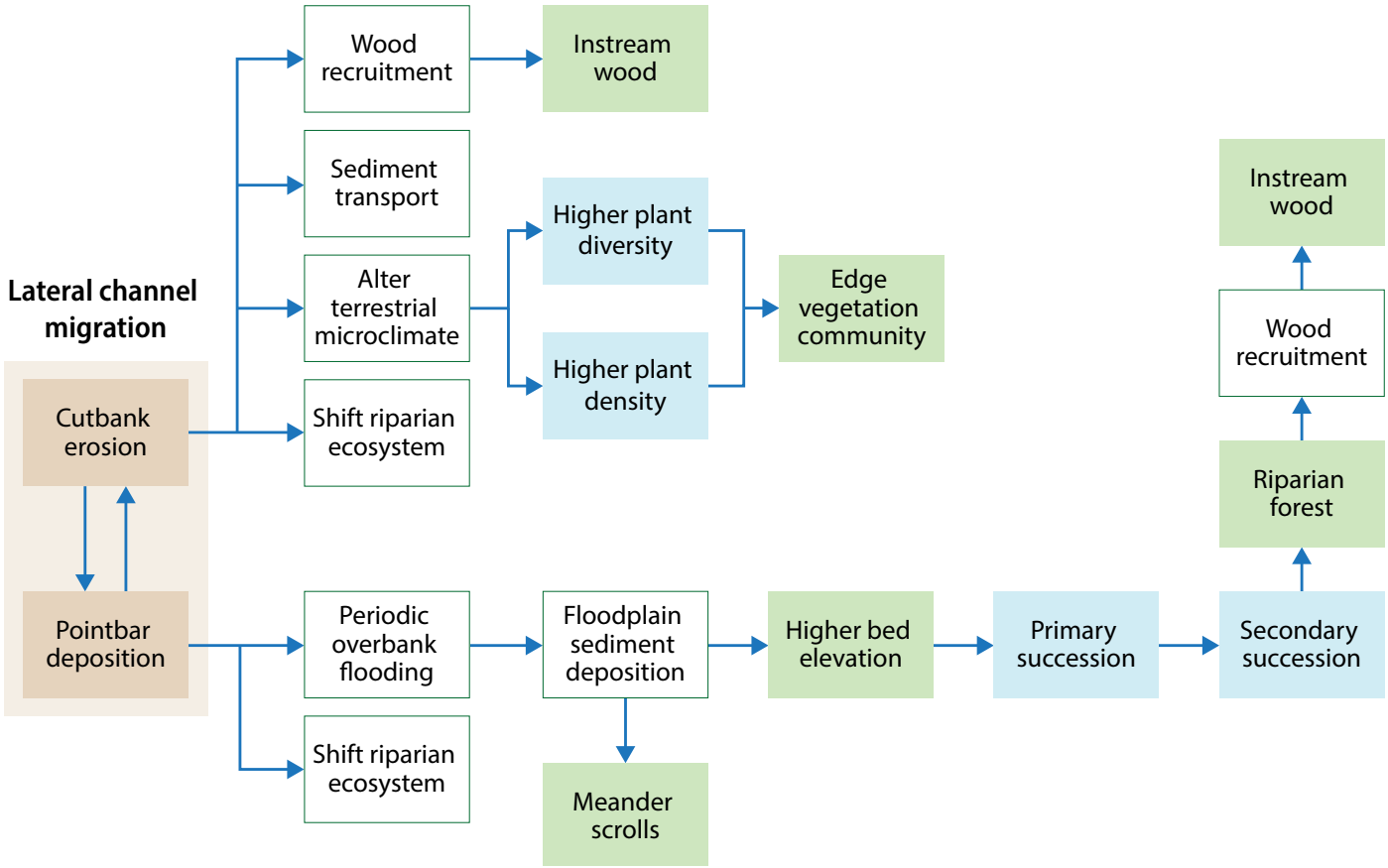
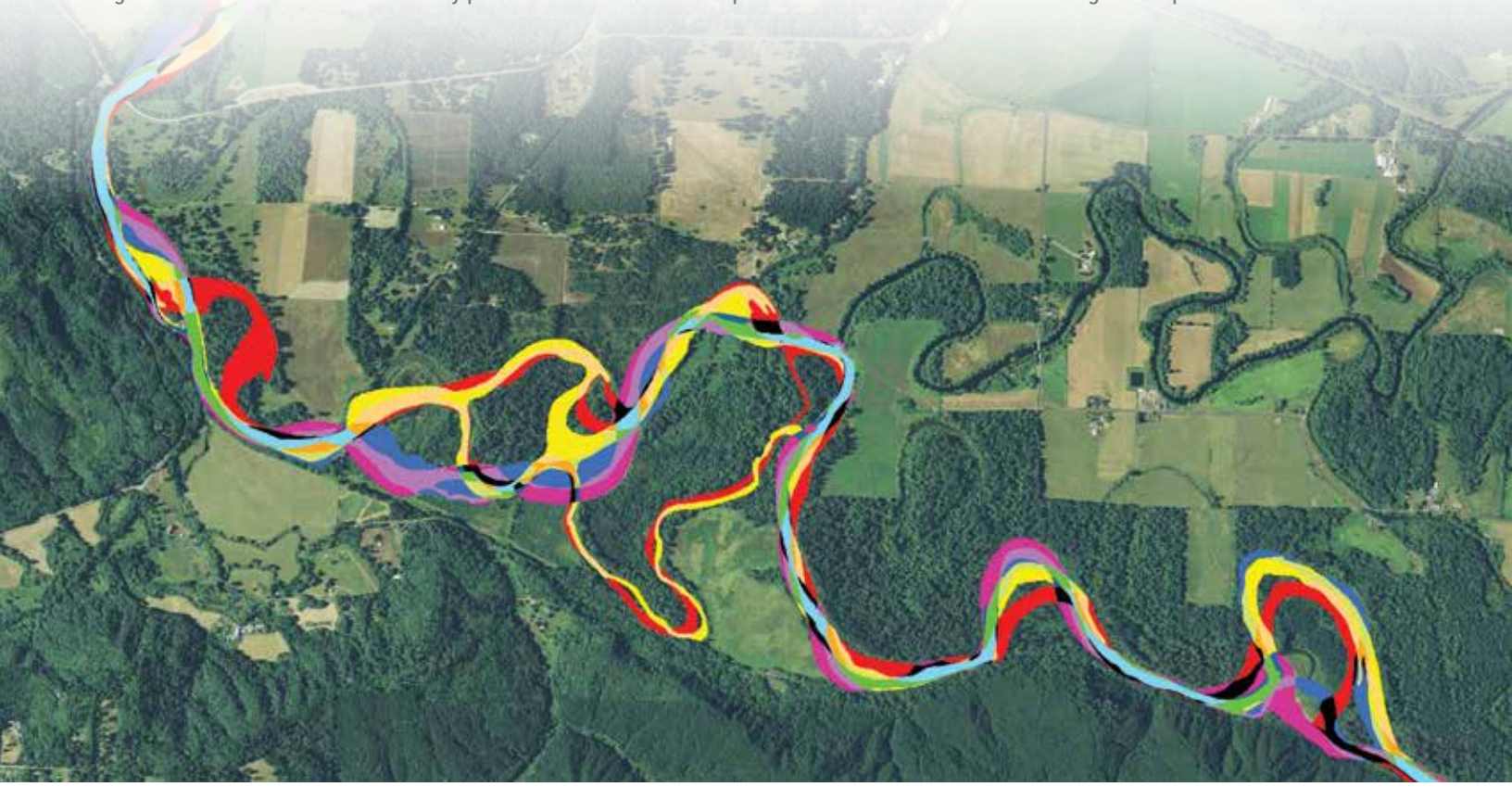


Figure 2.4. A conceptual model of lateral channel migration processes and riparian forest responses (modified from Meitzen 2009). Arrows indicate the hypothesized directions of causal relationships. Brown boxes represent proximal processes leading to channel migration. White boxes are secondary processes. Green boxes depict structures. Blue boxes are biological responses.



Chehalis River meander paths between 1938 and 2013/Ken Pierce, WDFW

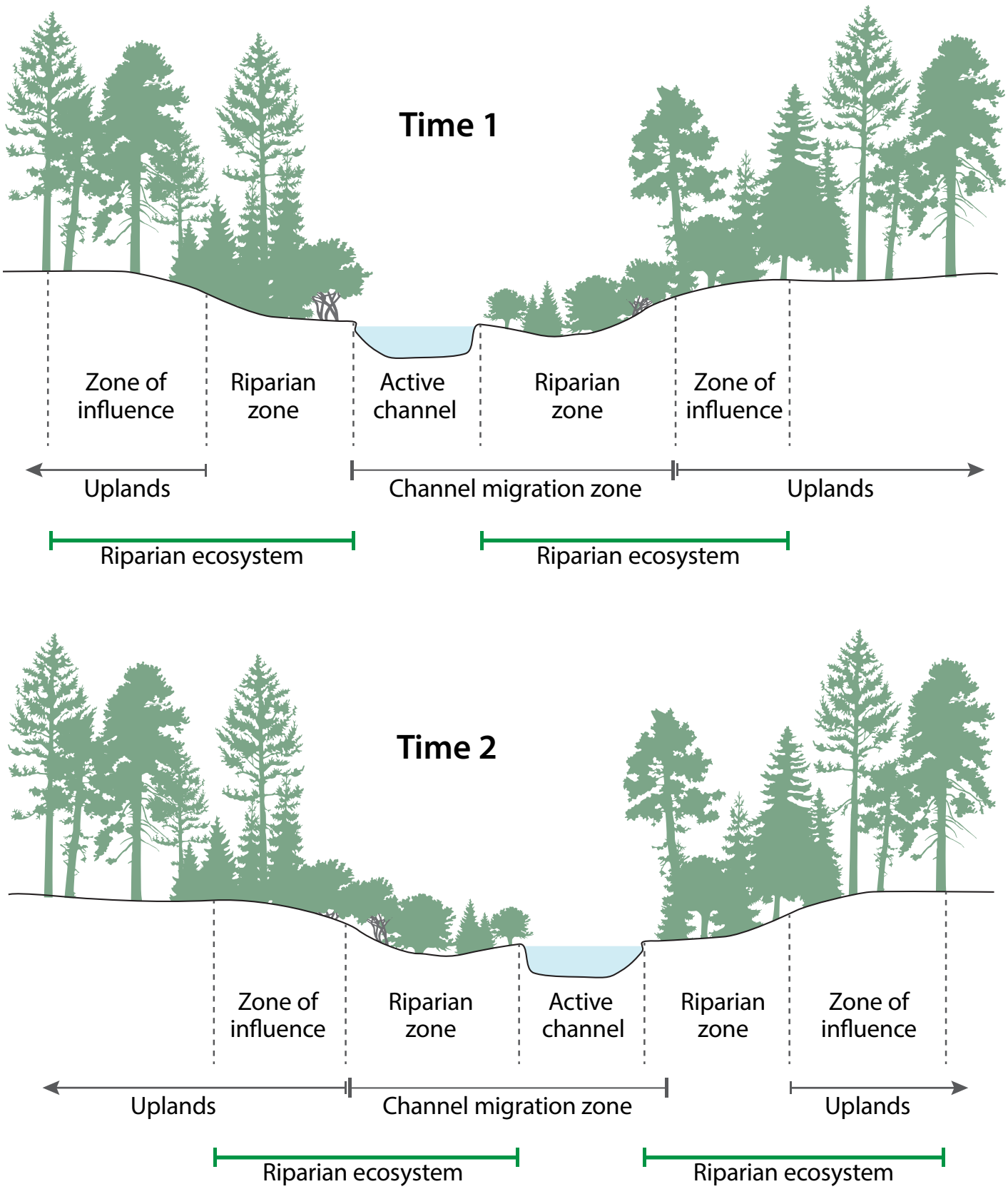


Figure 2.5. Spatial relationships between the riparian ecosystem and channel migration zone (CMZ) over time. As the active channel moves laterally within the CMZ the riparian ecosystem moves with it. Time 1 and time 2 could be separated by days or centuries.



Quinault River/Jane Atha, WDFW

and forth across the CMZ, the riparian ecosystem moves with it (Figure 2.5). Consequently, over long periods of time, a riparian ecosystem will occupy different parts of the CMZ. Furthermore, when an active channel reaches the outside limit of its CMZ, the riparian ecosystem lies outside and adjacent to the CMZ. Hence, to maintain riparian ecosystem functions, management must anticipate and protect future locations of the riparian ecosystem.

2.5. Disturbances

2.5.1. Geomorphic Process Domains

The spatial variability of sediment sources and the varying capacity of water to transport sediment result in a mosaic of different channel forms within a watershed. Channel forms can be described by attributes such as bed and bank sediment size distributions, pool and riffle depths, bankfull widths, gradient, and sinuosity. The classification of channel forms has been refined over the last 30-40 years beginning with Schumm (1977), who distinguished a headwater production zone, mid-basin transfer zone, and downstream depositional zone. This longitudinal arrangement is also reflected in more recent work that defines geomorphic *process domains*. Process domains characterize differences in the types and frequency of disturbance events, and provide a way to represent spatial differences in disturbance regimes (Montgomery 1999).

Six common geomorphic process domains have been identified for forested watersheds of Washington State: hillslope, unchanneled hollows, debris-flow channels, bedrock-fluvial channels, coarse-bed alluvial channels, and fine-bed alluvial channels (Montgomery et al. 1996; Sklar and Dietrich 1998; Montgomery 1999). These process domains are important to distinguish since they

each function differently in terms of sediment dynamics and transport capacity. Note that although geomorphic process domains often occur in a regular longitudinal sequence, there are many exceptions in Washington State where this is not the case.

Hillslopes are unchannelized and are typically dominated by diffusive transport or rain-facilitated transport of sediment downslope. Unchanneled hollows are hillslope concavities that serve as sediment storage sites and source zones for hillslope mass movement (Dietrich and Dunne 1978; Montgomery et al. 2009). Debris-flow channels are dominated by mass wasting sediment dynamics but channel geometry may still be influenced by fluvial processes. Bedrock-fluvial channels have underlying exposed bedrock that limits boundary erosion. In these channels, overlying alluvium is transported by scour during higher flows, and transport capacity exceeds sediment supply, resulting in exposed bedrock. Coarse-bed alluvial channels are dominated by unconsolidated gravels, cobbles, and boulders and are more likely to be supply limited, rather than stream energy limited. Lastly, fine-bed alluvial channels have non-cohesive sand-sized sediment and are more likely to be transport limited by flow energy rather than sediment supply (Wohl 2014).

Using process domains, it is possible to identify within a watershed where different geomorphic processes, disturbance regimes, and responses to disturbance dominate, and predict riparian vegetation dynamics (Naiman et al. 2000; Polvi et al. 2011). Channel morphology correlates well with bed gradient and sediment supply (Montgomery and Buffington 1997). The differences in the balance of hydraulic forces and available sediment among these channels likely lead to differences in overbank processes that can affect vegetation establishment, growth, and mortality. For example, in higher gradient channels, energy is expended on transporting sediment downstream and is not available to reshape the riparian area.

Disturbances are relatively discrete disruptive events that change the physical environment or resource availability, and are essential for developing habitat to support native biota.

2.5.2. Natural Disturbance Regimes

From an ecological perspective, disturbances are relatively discrete disruptive events that change the physical environment or resource availability (Pickett and White 1985); thereby creating opportunities for other species to become established (Nakamura and Swanson 2003). Natural disturbances result in dynamic habitats of varying physical conditions that allow for a variety of species to coexist. Community succession theory recognizes that large-scale disturbances, such as low frequency, high magnitude floods, continually reinitiate community succession in riparian areas (Pickett et al. 1987; Corenblit et al. 2007). The cycle of disturbance and succession occurring throughout a watershed maintains compositional and structural diversity in aquatic and riparian ecosystems. Disturbances that influence streams and riparian areas include wildfire, floods, landslides, tree infestations by insects, and human-induced disturbances such as residential development, timber harvest, and road construction.

Disturbance processes are essential for developing the range of habitat conditions necessary to support native biota (Swanson et al. 1998; Tabacchi et al. 2000). For example, the coarse sediments and large wood delivered to streams via mass wasting are thought to be essential components of freshwater salmonid habitats (Reeves et al. 1995). A natural disturbance regime can be characterized by frequency (how often), magnitude

(how big), duration (how long), and predictability. Wildfires of a given magnitude, for example, occur with a particular statistical probability in the absence of human manipulation of a watershed (Agee 1993). In general, smaller, frequent, and varied disturbances increase the heterogeneity of channel forms, leading to an environment that is more diverse and species rich (Kauffman and Martin 1989; Malanson 1993; Tabacchi et al. 2000; Everett et al. 2003). For example, the dynamics of stream channels that result from frequent, low intensity wildfires determine short-term patterns such as seed germination and animal foraging behavior (Hughes 1997). The influence of moderate and frequent disturbances such as fire (Wright and Bailey 1992) or insect-induced tree mortality (Mattson and Addy 1975) may lead to minor reductions in the riparian canopy, but more diverse habitat conditions that are generally beneficial for salmonids (Naiman and Bilby 1998). By contrast, disturbances that are large and infrequent tend to lead to widespread alterations that have larger and longer-lasting physical impacts. Large disturbances could cause a geomorphic threshold to be exceeded, and the resulting fluvial response could manifest a new geomorphic state with different physical conditions that support a different biological community (Hughes 1997).

Human activities can either dampen or amplify disturbance processes. While natural disturbance processes are ongoing, they are modified by human alterations (e.g., dams eliminate or dampen flood flows and land management can reduce the frequency and severity of fires). Too little or too much disturbance may have detrimental impacts on the physical structure of streams and riparian areas. For example, too little flooding can lead to cementation of the streambed or loss of riparian vegetation, especially in arid regions. Conversely, too much flooding caused by land cover change, for example, can lead to less habitat complexity due to excessive scouring of the channel. The past and current management of a site–and of its greater watershed–may alter the natural disturbance regime resulting in ecosystem states that did not exist historically.

Process domains within a watershed exhibit different disturbance regimes which manifest different aquatic and riparian ecosystems. Disturbances, and where they occur within a watershed, play key roles in structuring ecosystems. Important advances have shifted focus from single channel reaches and disturbance events to processes occurring at larger geographic extents over longer periods of time, that establish linkages between watershed-scale conditions and natural disturbance regimes (Naiman and Bilby 1998; Nakamura and Swanson 2003).

2.5.3. Human Alteration Impacts

Thus far, this chapter has largely focused on the hydrologic and geomorphic processes and their interactions with riparian area vegetation as they naturally occur within a watershed. However, human influences on channel form are ubiquitous, and therefore should be considered in management of riparian areas.

How a channel responds to human alterations of the landscape or riparian areas depends on its sensitivity and resilience (Brunsden and Thornes 1979).



Narrow riparian buffers along Badger Creek/Jennifer Nelson, WDFW

A sensitive channel reach changes in response to human alterations. A resilient channel reach also changes in response to human alterations but will return to its prior condition at some later time. The idea that some parts of a river are more or less sensitive or resilient is critical to predicting channel adjustments. For example, stream reaches with high transport capacity may adjust relatively quickly to an increase in upstream sediment yield but a similar change in sediment yield may cause significant changes in channel morphology in reaches with low transport capacity. The shape, hydraulics, and natural disturbance regime of a reach may indicate its sensitivity to anthropogenic disturbance. For example, a channel that is degrading (lowering bed elevation) may be more sensitive to riparian large wood additions than a channel that is in equilibrium. In addition, sensitivity to changes in hydrology is inversely proportional to channel gradient (Wohl et al. 2007). Hence, managers should anticipate that high gradient streams will be more sensitive to changes in stream flow than lower gradient streams. Other drivers such as the flow regime or controls such as lithology might also be used to determine a reach's sensitivity and resilience, and thereby inform management decisions.

Forestry

An extensive body of scientific literature documents the effects of forestry on stream channels (see Foley et al. 2005; Scanlon et al. 2007; and Wohl 2013 for thorough reviews). Cutting of trees and road building associated with forestry can greatly increase sediment yields and affects water yields over multiple decades as vegetation recovers (Wohl 2014). Impacts from road networks—for logging and otherwise—are numerous and are discussed below. Changes in sediment supply and water yield due to logging can alter the streamflow, stream chemistry, and channel morphology of a stream reach (Liquori et al. 2008). In addition, the resilience of channels in response to such alterations can be quite variable. For example, Madej and Ozaki (1996) found that channel recovery (defined as returning to a former bed-elevation) after a sediment wave following extensive logging in Redwood Creek basin, Northern California varied from 8 years in one creek to 15 years in another. A third channel had not yet recovered.



Clearcut hillslope/Jane Atha, WDFW



Big Beef Creek, Kitsap Peninsula/Ned Pittman, WDFW

There is substantial agreement among scientists as to the potential magnitude and consequences of peak flow changes due to forestry. Grant et al. (2008) assessed the effects of forestry on peak flows and consequent channel response in the Pacific Northwest in a state of the science report. Their findings, primarily synthesized from long-term monitoring, show that responses are complex, and vary with runoff type (snowmelt, rainfall or rain-on-snow), local hydrology, harvest treatment, and channel type. The authors generally noted that geomorphic changes from harvest-related peak flow effects are limited to low-gradient channels (below 2% grade) and are generally minor as compared to other anthropomorphic impacts. Other literature reviews (e.g., Liquori et al. 2008; Grant et al. 1999) had similar conclusions.

The degree to which forestry practices alter water and sediment yields depends on where the logging occurs within a drainage basin. In one study, logging at lower elevations in snowmelt-dominated basins of southwestern Canada caused little to no change in peak flow because of relatively small snowpack, whereas in the higher elevations the peak flow changed significantly (Whitaker et al. 2002). Similarly, characteristics such as climate, topography, and soils also determine landscape sensitivity to forestry. Several studies have shown that mean annual precipitation is a reasonable indicator of impact (e.g. Anderson et al. 1976; Coe 2006; CBOF-TAC 2008). A road network may deliver 20% of sediment to stream channels in areas with 22 in (500 mm) per year average precipitation compared with 50% of the sediment when precipitation exceeds 118 in (3,000 mm) per year (Coe 2006). In areas of high topographic relief, it is particularly challenging for researchers to differentiate channel adjustments induced by logging from change that would have occurred without interference (Marston 2008).

Conversion of riparian areas from forest to other land uses can cause channel narrowing and deepening (Anderson et al. 2004; Sweeney et al. 2004; Faustini et al. 2009). Furthermore, streams without riparian forests often exhibit channels with less wood that are narrower, deeper, have fewer obstructions, less variability in active channel width, higher proportions of run and glide habitats, and lower habitat diversity (Jackson et al. 2014).

Road Infrastructure

Road networks are similar to stream networks in that they are often widely distributed, transport energy and material across a landscape, and have a high edge length per unit area enabling interaction with adjacent hillslopes (Jones et al. 2000). Stream networks and road networks commonly occur in similar densities in wet-climate forested mountains where logging has occurred (Wemple et al. 1996).

The biggest impact of unpaved roads on aquatic systems is sedimentation. Road construction and maintenance disturbs a layer of soil on the road tread, adjacent drainage ditch, and cutslopes that becomes easily eroded material (Megahan 1974). In conjunction with other loose material on roads, higher erodibility increases the total sediment yield from a road segment (Luce and Black 1999). In managed forests of Washington State, unpaved roads and trails are the most significant management activity that affects

sediment production and delivery into streams (Lewis 1998; Gomi et al. 2005; CBOF TAC 2008). Roads can initiate mass movements that tend to result in longer runout zones and more sediment than their naturally occurring counterparts do (May 2002). Sediment generated from roads can be delivered to streams via ditches and gullies below cross-draining culverts that concentrate and route runoff. Road sediment production varies substantially with the type of surfacing material, road slope, mean annual precipitation, geology, traffic type and volumes, and road area (Cafferata and Munn 2002; MacDonald et al. 2004; Coe 2006). Roads and water crossings with improper design or maintenance are often the most significant sources of erosion and sediment delivery to streams in forested watersheds (Madej 2001; Cafferata and Munn 2002). Jones et al. (2000) found that unpaved roads continue to contribute sediment fines to channels long after harvested vegetation has reestablished.

Agriculture

Agriculture, in the form of livestock grazing or crop production, can reduce and alter vegetation cover, compact soils,and reduce water infiltration. It can also increase runoff and sediment yield, and cause associated changes in streamflow, channel morphology, and channel stability.

Cattle grazing can severely degrade riparian areas particularly through vegetation reduction and trampling of streambanks. Grazing animals can create ramps along streambanks and trails along the floodplain that enhance localized erosion (Trimble and Mendel 1995). Grazing-disturbed streams are usually characterized by a lack of overhanging banks, wide and shallow channels, smaller pool area, high sediment yields and turbidity, steep gradients, and channel beds typified by long stretches of glides or runs. Along streams with enclosures that kept cattle out of riparian areas, Magilligan and McDowell (1997) found that channel widths became narrower due to increased roughness by grassy riparian vegetation, which ultimately traps sediment leading to width reductions. The channel narrowing effects of grassy vegetation were also reported by Sweeney et al. (2004) and Allmendinger et al. (2005).

Understanding a channel's state of equilibrium (or disequilibrium) and its potential future states is critical for restoration and protection of salmon habitats.

A common effect of planting crops is increased sediment yield and associated changes in channel pattern and stability (Wohl 2014). The magnitude of these changes is dependent on the type and extent of crops, as well as the topographic and soil characteristics at a site. Numerous case studies indicate that soil erosion from conventional agriculture exceeds rates of natural erosion by up to several orders of magnitude (Montgomery 2007).

Urban/Suburban

Research on the effects of urbanization on sediment yield and channel response date back almost 50 years and is global in reach (Wolman 1967). The results of this research draw similar conclusions regarding the sequence of changes that occur within a drainage basin, with differences occurring only in the magnitude and timing (Chin 2006).

Erosion rates can reach up to 40,000 times pre-disturbance rates on land surfaces cleared for building that remain bare for up to a year (Harbor 1999). Construction sites can dramatically increase sediment yield from an urbanizing basin (Fusillo et al. 1977). For example, sediment production from Issaquah Creek



Mill Creek, Walla Walla, Washington/Jane Atha, WDFW

watershed in western Washington had two- to five-fold increases when only 0.3% of its 55.6 mi^2 (144 km^2) drainage area was under construction (Nelson and Booth 2002). Upon completion of construction, sediment yield usually decreases to negligible amounts as urbanizing areas are stabilized beneath roads, buildings, and lawns.

Research on the effects of urbanization on hydrology and flooding is also extensive, and dates back at least 50 years. Collectively, this research clearly shows that urban development, and associated increases in impervious surfaces, leads to larger and more frequent floods (Leopold 1968). The key metrics of change are peak discharge, lag time, flood frequency, and total runoff or water yield. Morphological adjustments have been studied in response to hydrologic changes, with most studies showing increases in channel width (Chin 2006).

Stream Channel Modifications

Humans have been directly altering stream flow and channel form for centuries (Poff et al. 1997). Flow regulation, through dams, reduces the size and variation of annual peak flows (Williams and Wolman 1984), increases minimum flows (Hirsch et al. 1990), shifts the timing of seasonal flows, and can alter diurnal flow fluctuations if the dam is used for hydroelectric power generation (Magilligan and Nislow 2001).

Dams can have dramatic effects on aquatic and riparian systems (Nilsson et al. 1997; Nilsson and Berggren 2000; Katz et al. 2005; Merritt and Wohl 2006). Dams disconnect the channel from the floodplain by reducing peak flows. This decreases or eliminates freshly scoured surfaces necessary for seedling establishment in riparian areas. Flow regulation can disrupt downstream transport of seeds to germination sites, and seedlings established on gravel bars may die from prolonged submersion when managed flows are higher than natural flows. Changes in sediment size distributions and moisture content can also adversely impact riparian vegetation. The cumulative effects on riparian communities downstream of dams can result in fewer plant species and lower plant density (Jansson et al. 2000).

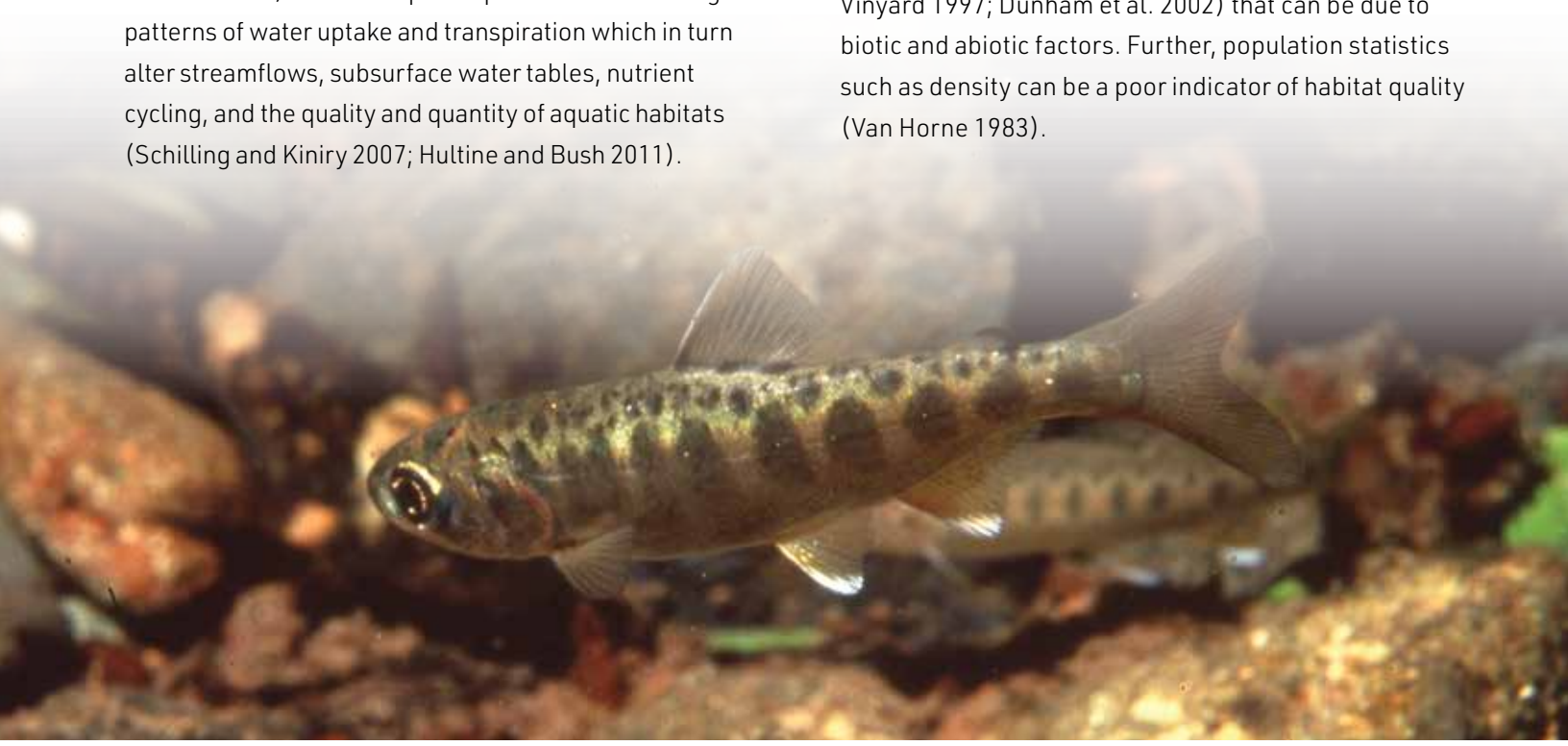
Humans regularly alter channel form through dredging, channel straightening, removing instream wood or Beaver dams, building check dams, extending channel networks via canals, burying or laterally shifting inconvenient channels, and simply reconfiguring a channel to be more esthetically pleasing. (Wohl 2014). Levees are a direct form of channel alteration particularly ubiquitous in lowland rivers. Levees are mounds built parallel to stream channels that limit overbank flooding, and are also known as dikes or embankments (Petroski 2006). Levees severely reduce or eliminate channel-floodplain exchanges, facilitate higher magnitude floods, and exacerbate flooding in downstream areas without levees. Disconnection between the channel and floodplain reduces deposition of sediment and organic matter in floodplains, leading to loss of habitat, reduced animal abundance, and lower biodiversity in riparian areas (Hohensinner et al. 2004).

Lastly, humans can indirectly and severely alter channel form by introducing invasive, exotic species to riparian areas. Invasive plants may displace native riparian plants and thus impact streambank resistance to erosion and overbank sedimentation dynamics (Graf 1978; Allred and Schmidt 1999). Invasive riparian plants can also change patterns of water uptake and transpiration which in turn alter streamflows, subsurface water tables, nutrient cycling, and the quality and quantity of aquatic habitats (Schilling and Kiniry 2007; Hultine and Bush 2011).

2.6. Fish and Wildlife Habitat

2.6.1. Fish

The fisheries and fish ecology literature are replete with studies that report relationships between fish and physical habitat conditions. Such studies demonstrate the profound importance of instream conditions for fish and they have helped guide habitat management and restoration. For example, Nickelson et al. (1992) found seasonal differences in the use of pool and riffle habitat by juvenile Coho Salmon *Oncorhynchus kisutch* and suggested that additional pool habitats might improve their survival. Such correlative approaches have been expanded by considering shifts in habitat use within species and differential habitat requirements among species in attempts to identify optimal habitat type configurations (Rosenfeld 2003; Bain and Jai 2012). However, the success of such approaches has been limited by high spatiotemporal variability in, for example, habitat-density relations among streams (Dunham and Vinyard 1997; Dunham et al. 2002) that can be due to biotic and abiotic factors. Further, population statistics such as density can be a poor indicator of habitat quality (Van Horne 1983).



Juvenile Chinook Salmon Oncorhynchus tshawytscha/*David Price, WDFW*

Recent scientific advances regarding the protection and restoration of fish habitats (and habitats for other vagile aquatic species) include the following: 1) acknowledgement of the importance and frequency of fish movement (Schlosser 1991, 1995; Gowan et al. 1994), 2) greater acknowledgement of the importance of habitat heterogeneity and spatial variability in fish-habitat relationships (Torgersen et al. 2006), and 3) the concept of riverscapes (Ward 1998; Fausch et al. 2002; Allan 2004), which describes a dynamic mosaic of habitat types and environmental gradients that are characterized by high connectivity and complexity.

The riverscape concept expands on the classic stream continuum concept of Vannote et al. (1980) mostly by explicitly incorporating spatial and temporal heterogeneity, discontinuities, and connectivity between stream reaches (longitudinal), the stream and uplands (lateral), and the stream and groundwater (vertical). Fausch et al. (2002) provide several principles for effective research and management given the riverscape concept. These include: 1) conduct research (and management) at appropriate scales for the question, 2) the importance of physical and ecological processes are revealed at different spatiotemporal scales and processes will interact among scales, 3) rare or unique features can be very important, and 4) unintended consequences of habitat degradation propagate in all directions, including upstream. Cumulatively, these principles and the vast research that supported their development suggest that the spatial extent and temporal duration of research and management must be matched to the scales at which populations of species use habitat and at which suitable habitat conditions are created and maintained. Further, they emphasize the importance of maintaining and restoring longitudinal and lateral connectivity of stream systems (Sedell et al. 1989) to allow for proper functioning of habitat forming processes and maintenance and restoration of supplementary and complimentary habitats to account for expected variability in local suitability.

Conducting research and management that incorporates the riverscape concept is challenging because it often requires study at large spatial and long temporal extents as well as monitoring biotic and abiotic processes at fine spatial and temporal resolutions. Perhaps the best examples of such work in Washington are the Intensively Monitored Watersheds (IMW) projects that are designed to assess the efficacy of stream restoration for increasing the freshwater survival and production of salmon (Bilby et al. 2005). The IMW projects are conducted at the spatial extent of watersheds and over the course of several salmon life cycles. Important physical and ecological processes are monitored within and among individual stream reaches with the intent of identifying rare features and measuring changes in habitat complexity and connectivity (Bennett et al. 2016). This approach should yield reliable inferences regarding the efficacy of restoration efforts that can be used to inform decisions via adaptive management (Bennett et al. 2016).

2.6.2. Amphibians and Reptiles

Amphibians are less conspicuous inhabitants of instream habitats than fish, but in much of the Pacific Northwest, particular groups of stream-breeding amphibian species that include giant salamanders (*Dicamptodon* spp.), tailed frogs (*Ascaphus* spp.), and torrent salamanders (*Rhyacotriton* spp.) dominate fishless headwater

The riverscape concept expands on Vannote et al.'s (1980) classic stream continuum concept by including lateral and vertical connectivity and incorporating spatial and temporal heterogeneity.



Coastal Tailed Frog Ascaphus truei *in metamorphosis/Marc Hayes, WDFW*

streams. Headwater streams represent a large majority (up to 80%) of the overall stream network based on its length (Meyer and Wallace 2001). Stream-breeding amphibian dominance in headwaters partly reflects the flow conditions in headwater habitats and the suitable physical conditions those flows create. Amphibian abundance is highest in step-pool and cascade reach morphologies characterized by armored beds, stable bedforms, refuge spaces amongst coarse bed material, and reduced tractive forces as a result of tumbling flow (Dupuis and Friele 2006). For example, torrent salamanders, the only stream-breeding amphibian group that does not attach their eggs to rocky substrates, deposit and conceal them in the lowest flow headwater ends of streams and their tributaries; higher flow habitats will dislodge or damage their eggs. In contrast, giant salamanders and tailed frogs, which glue their eggs to coarse rocky substrates, use concealed oviposition sites in stable step structures typically found further downstream in the headwater network (Hayes et al. 2006). Stream-breeding amphibians seem to become less abundant below headwater streams at least in part because substrate and flow conditions that provide either oviposition or refuge sites become less frequent (Brummer and Montgomery 2003). Other conditions, such as predation by fishes, also play a role.

The freshets (high water events) in larger streams or rivers that have an alluvial floodplain, when coupled with wood, are also critical to both creation and maintenance of off-channel amphibian habitats (Amoros and Bornette 2002). Off-channel habitats comprise among the most important lowland stillwater habitats representing key breeding and rearing areas for the largest group of native amphibians (stillwater breeders) (Richter 2005) and the garter snakes (*Thamnophis* spp.) that feed on them. Such off-channel habitats are also critical rearing and foraging habitat for native turtles (Holland 1994).

2.7. Conclusions

The interactions of water, sediment, wood, and riparian vegetation create complex channel morphologies and diverse aquatic habitat conditions. Reach-scale differences in sediment erosion, transport, and deposition result in a mosaic of aquatic habitat conditions within and among stream reaches.

Understanding a channel's state of equilibrium (or disequilibrium) and its potential future states is critical for restoration and protection of salmon habitats. Consistent with the idea of process domains, not all stream reaches within a watershed are equally sensitive or resilient to human land uses or other anthropogenic disturbances. Describing a channel's historical range of natural variability can aid in understanding a reach's potential response to human disturbance. A historical perspective may also aid in identifying biological communities that are in most need of habitat restoration (McDonald et al. 2004; Brierley and Fryirs 2009). By adopting a historical perspective, we may be able to move closer to the ecosystem composition and structure, and the resulting habitat heterogeneity, essential for fish and wildlife.

Historically, disturbance and successional processes were key drivers for the creation of aquatic habitats (Reeves et al. 1995). Now and into the future, both natural and anthropogenic disturbances will affect the creation, maintenance, destruction, and recreation of aquatic habitats. Management may most reliably result in high quality habitat when it emulates historical disturbances and their effects on a watershed (Poff et al. 1997). An idea offered by Naiman et al. (2000) is to base management on historical patterns of watershed conditions and natural disturbances. If flooding was a major natural disturbance in a watershed, then with empirical data and/or models on the extent to which flooding has affected the watershed, one could describe the dynamic equilibrium conditions of channels and floodplains over time, and then tailor riparian management to the unique conditions of that watershed. If wildfires followed by landslides were the historical disturbance pattern in a watershed, then watershed-scale, long-term forest management plans might schedule timber harvests such that historical natural patterns are partially emulated (Reeves et al. 1995; Bisson et al. 2009). Emulating flood or wildlife disturbances for the benefit of salmon and other aquatic species will be a much more complicated project in residential (i.e., rural, suburban, urban) areas.

The importance of riparian ecosystems in maintaining channel, off-channel, and floodplain habitats is increasingly well supported by the scientific literature. In particular, the importance of longitudinal, lateral, and vertical connectivity to the quality of habitat conditions and the importance of riparian vegetation to stream channel stability are increasingly emphasized. Management of riparian ecosystems should consider connectivity among the geomorphic process domains, the influences of natural disturbance, the historical range of natural variability, and the inextricable influence that riparian vegetation has on geomorphic processes.



Bridge on Strait of Juan de Fuca Highway/Ned Pittman, WDFW

2.8. Literature Cited[5]

Agee, J.K. 1993. Fire ecology of Pacific Northwest forests. Island Press, Washington, D.C. (i)

Allan, J.D. 2004. Landscapes and riverscapes: the influence of land use on stream ecosystems. Annual Review of Ecology, Evolution, and Systematics 35:257-284. (i)

Allen, J.R.L. 1965. A review of the origin and characteristics of recent alluvial sediments. Sedimentology 5:89-191. (i)

Allmendinger, N.E., J.E. Pizzuto, N. Potter, T.E. Johnson, and W.C. Hession. 2005. The influence of riparian vegetation on stream width, eastern Pennsylvania, USA. Geological Society of America Bulletin 117:229-243. (i)

Allred, T.M., and J.C. Schmidt. 1999. Channel narrowing by vertical accretion along the Green River near Green River, Utah. Geological Society of America Bulletin 111:1757-1772. (i)

Amoros, C., and G. Bornette. 2002. Connectivity and biocomplexity in waterbodies of riverine floodplains. Freshwater Biology 47:761-776. (i)

Anderson, J.R., E.E. Hardy, J.T. Roach, and R.E. Witmer. 1976. A land use and land cover classification system for use with remote sensor data. Geological Survey Professional Paper 964. U.S. Geological Survey, Arlington, Virginia. (viii)

Anderson, R.J., B.P. Bledsoe, and W.C. Hession. 2004. Widths of streams and rivers in response to vegetation, bank material, and other factors. Journal of the American Water Resources Association 40:1159-1172. (i)

ASCE (American Society of Civil Engineers Task Committee on Hydraulics, Bank Mechanics, and Modelling of River Width Adjustment). 1998. River width adjustment. I: processes and mechanisms. Journal of Hydraulic Engineering 124:881-902. (i)

Bain, M.B., and H. Jai. 2012. A habitat model for fish communities in large streams and small rivers. International Journal of Ecology 2012:962071. (i)

Beechie, T.J., M. Liermann, M.M. Pollack, S. Baker, and J. Davies. 2006. Channel pattern and river-floodplain dynamics in forested mountains river systems. Geomorphology 78:124-141. (i)

Benda, L., M.H. Hassan, M. Church, and C.L. May. 2005. Geomorphology of steepland headwaters: the transition from hillslopes to channels. Journal American Water Resources Association 41:835-851. (i)

Bennett, S., G. Pess, N. Bouwes, P. Roni, R.E. Bilby, S. Gallagher, J. Ruzycki, T. Buehrens, K. Krueger, W. Ehinger, J. Anderson, C. Jordan, B. Bowersox, and C. Greene. 2016. Progress and challenges of testing the effectiveness of stream restoration in the Pacific Northwest using intensively monitored watersheds. Fisheries 41:92-103. (i)

Betson, R.P. 1964. What is watershed runoff? Journal of Geophysical Research 69:1541–1552. (i)

Bisson, P.A., J.B. Dunham, and G.H. Reeves. 2009. Freshwater ecosystems and resilience of Pacific salmon: habitat management based on natural variability. Ecology and Society 14(1):45. (i)

Bilby, R., W. Ehinger, T. Quinn, G. Volkhardt, K. Krueger, D. Seiler, G. Pess, C. Jordan, M. McHenry, and D. Poon. 2005. Study evaluates fish response to management actions. Western Forester 50:14-15. (i)

Boulton, A.J., S. Findlay, P. Marmonier, E.H. Stanley, and H.M. Valett. 1998. The functional significance of the hyporheic zone in streams and rivers. Annual Review Ecology and Systematics 29:59-81. (i)

Brierley, G., and K. Fryirs. 2009. Don't fight the site: three geomorphic considerations in catchment-scale river rehabilitation planning. Environmental Management 43:1201-1218. (i)

Brummer, C.J., and D.R. Montgomery. 2003. Downstream coarsening in headwater channels. Water Resources Research 39:1-13. (i)

Brunsden, D., and J.B. Thornes. 1979. Landscape sensitivity and change. Transactions of the Institute of British Geographers 4:463-484. (i)

Bryan, R. 1990. Knickpoint evolution in rillwash. Catena Supplement 17:111-132. (i)

[5] References are classified according to RCW 34.05.271 (see Appendix 1) denoted by a lower case roman numeral (i – viii) in parentheses at the end of the citation.

Burckhardt, J.C., and B.L. Todd. 1998. Riparian forest effect on lateral stream channel migration in the glacial till plains. Journal of the American Water Resources Association 34:179-184. (i)

Butler, B. 2004. Channel migration zones. Chapter 4 *in* Best available science, volume 1: a review of science literature. King County, Seattle. (viii)

Cafferata, P.H., and J.R. Munn. 2002. Hillslope monitoring program: monitoring results from 1996 through 2001. Monitoring Study Group Final Report prepared for the California State Board of Forestry and Fire Protection. Sacramento, California. (viii)

Callander, R.A. 1978. River meandering. Annual Review of Fluid Mechanics 10:129-158. (i)

CBOF-TAC (California Board of Forestry and Fire Protection Technical Advisory Committee). 2008. Primer on water riparian exchanges related to forest management in the western U.S., Version 2.0. Sacramento, California. (viii)

Chin, A. 2006. Urban transformation of river landscapes in a global context. Geomorphology 79:460-487. (i)

Coe, D. 2006. Sediment production and delivery from forest roads in the Sierra Nevada, California. Master's thesis. Colorado State University, Fort Collins. (i)

Collins, B.F., and D.R. Montgomery. 2002. Forest development, wood jams, and restoration of floodplain rivers in the Puget Lowland, Washington. Restoration Ecology 10:237-247. (i)

Corenblit, D., E. Tabacchi, J. Steiger, and A.M. Gurnell. 2007. Reciprocal interactions and adjustments between fluvial landforms and vegetation dynamics in river corridors: a review of complementary approaches. Earth-Science Reviews 84:56-86. (i)

Dietrich, W., and T. Dunne. 1978. Sediment budget for a small catchment in a mountainous terrain. Pages 31- 48 *in* O. Slaymaker, editor. Fluvial geomorphology. Rutledge, New York. (i)

Dietrich, W.E., J.D. Smith, and T. Dunne. 1984. Boundary shear stress, sediment transport, and bed morphology in a sand-bedded river meander during high and low flow. Pages 632-639 *in* C.M. Elliot, editor. River meandering: proceedings of the conference rivers '83. American Society of Civil Engineers, New York. (viii)

Dunham, J.B., B.S. Cade, and T.W. Terrell. 2002. Influences of spatial and temporal variation on fish-habitat relationships defined by regression quantiles. Transactions of the American Fisheries Society 131:86-98. (i)

Dunham, J.B., and G.L. Vinyard. 1997. Incorporating stream level variability into analyses of site level fish habitat relationships: some cautionary examples. Transactions of the American Fisheries Society 126:323-329. (i)

Dunne, T. 1978. Field studies of hillslope flow processes. Pages 227-293 *in* M.J. Kirby, editor. Hillslope hydrology. John Wiley, Chichester, United Kingdom. (i)

Dunne, T., and R.D. Black. 1970a. Partial-area contributions to storm runoff in a small New England watershed. Water Resources Research 6:1296-1311. (i)

Dunne, T., and R.D. Black. 1970b. An experimental investigation of runoff production in permeable soils. Water Resources Research 6:170-191. (i)

Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. WH Freeman and Company, San Francisco. (i)

Dunne, T., D.V. Malmon, and S.M. Mudd. 2010. A rain splash transport equation assimilating field and laboratory measurements. Journal of Geophysical Research 115:F01001. (i)

Dupuis, L, and P. Friele. 2006. The distribution of the Rocky Mountain Tailed Frog (*Ascaphus montanus*) in relation to the fluvial system: implications for management and conservation. Ecological Research 21:489-502. (i)

Dust, D., and E. Wohl. 2012. Conceptual model for complex river responses using an expanded Lane's relation. Geomorphology 139:109-121. (i)

Eis, S. 1987. Root systems of older immature hemlock, cedar and Douglas-fir. Canadian Journal of Forest Research 17:1348-1354. (i)

Everett, R., R. Schellhaas, P. Ohlson, D. Spurbeckand, and D. Keenum. 2003. Continuity in fire disturbance between riparian and adjacent sideslope Douglas-fir forests. Forest Ecology and Management 175:31-47. (i)

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic and social assessment. U.S. Department of Agriculture and U.S. Department of the Interior, Portland, Oregon. (viii)

Fausch, K.D., C.E. Torgersen, C.V. Baxter, and H.W. Li. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. BioScience 52:1-16. (i)

Faustini, J.M., Kaufmann, P.R., and A.T. Herlihy. 2009. Downstream variation in bankfull width of wadeable streams across the conterminous United States. Geomorphology 108:292-311. (i)

Florsheim, J.L., J.F. Mount, and A. Chin. 2008. Bank erosion as a desirable attribute of rivers. BioScience 58:519-529. (i)

Foley, J.A., R. DeFries, G.P. Asner, C. Barford, G. Bonan, S.R. Carpenter, F.S. Chapin, M.T. Coe, G.C. Daily, and H.K. Gibbs. 2005. Global consequences of land use. Science 309:570-574. (i)

Frissell, C.A., W.J. Liss, C.E. Warren, and M.D. Hurley. 1986. A hierarchical framework for stream classification: Viewing streams in a watershed context. Environmental Management 10:199-214. (i)

Furbish, D.J., E.M. Childs, P.K. Haff, and M.W. Schmeeckle. 2009. Rain splash of soil grains as a stochastic advection dispersion process, with implications for desert plant soil interactions and land surface evolution. Journal of Geophysical Research 114:F00A03. (i)

Fusillo, T.V., G. Nieswand, and T. Shelton. 1977. Sediment yields in a small watershed under suburban development. Pages 34-88 *in* Proceedings from the international symposium on urban hydrology, hydraulics, and sediment control. University of Kentucky Press, Lexington. (viii)

Gilbert, G.K. 1877. Report on the geology of the Henry Mountains. U.S. Government Printing Office, Washington, D.C. (viii)

Gomi, T., R.D. Moore, and M. Hassan. 2005. Suspended sediment dynamics in small forest streams of the Pacific Northwest. Journal of the American Water Resources Association 41:877-898. (i)

Gorrick, S., and J.F. Rodrígue. 2012. Sediment dynamics in a sand bed stream with riparian vegetation. Water Resources Research 48:W02505. (i)

Gowan, C., M.K. Young, K.D. Fausch, and S.C. Riley. 1994. Restricted movement of resident stream salmonids: a paradigm lost. Canadian Journal of Fisheries and Aquatic Sciences 51:2626-2637. (i)

Graf, W.L. 1978. Fluvial adjustments to the spread of tamarisk in the Colorado Plateau region. Geological Society of America Bulletin 89:1491-1501. (i)

Grant, G.E., S.L. Lewis, F.J. Swanson, J.H. Cissel, and J.J. McDonnell. 2008. Effects of forest practices on peak flows and consequent channel response: a state-of-the-science report for western Oregon and Washington. PNW-GTR-760. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

Grant, G., W. Megahan, and R. Thomas. 1999. A re-evaluation of peak flows: do forest roads and harvesting cause floods? Paper presented at the 1999 NCASI west coast regional meeting. National Council for Air and Stream Improvement, Corvallis, Oregon. (viii)

Grant G.E., J.E. O'Connor J.E., and M.G. Wolman. 2013. A river runs through it: conceptual models in fluvial geomorphology. Pages 6-21 *in* J.F. Shroder, editor. Treatise on geomorphology, volume 9. Academic Press, San Diego, California. (i)

Griffin, E., J. Kean, K. Vincent, J. Smith, and J. Friedman. 2005. Modeling effects of bank friction and woody bank vegetation on channel flow and boundary shear stress in the Rio Puerco, New Mexico. Journal of Geophysical Research: Earth Surface 110:F04023. (i)

Güneralp, I., and R.A. Marston. 2012. Process-form linkages in meander morphodynamics: bridging theoretical modeling and real world complexity. Progress in Physical Geography 36:718-746. (i)

Gurnell, A. 2014. Plants as river system engineers. Earth Surface Processes and Landforms 39:4-25. (i)

Hairston-Strang, A.B., and P.W. Adams. 2000. Riparian management area condition for timber harvests conducted before and after the 1994 Oregon water protection rules. Western Journal of Applied Forestry 15:147-153. (i)

Hales, T., and J. Roering. 2009. A frost "buzzsaw" mechanism for erosion of the eastern Southern Alps, New Zealand. Geomorphology 107:241-253. (i)

Harbor, J. 1999. Engineering geomorphology at the cutting edge of land disturbance: erosion and sediment control on construction sites. Geomorphology 31:247-263. (i)

Harris, D.D. 1977. Hydrologic changes after logging in two small Oregon coastal watersheds. Water Supply Paper 2037. U.S. Geological Survey, Washington, D.C. (i)

Hayes, M., T. Quinn, D. Dugger, T. Hicks, M. Melchiors, and D. Runde. 2006. Dispersion of Coastal Tailed Frog (*Ascaphus truei*): a hypothesis relating occurrence of frogs in non-fish-bearing headwater basins to their seasonal movements. Journal of Herpetology 40:533-545. (i)

Heede, B.H. 1980. Stream dynamics: an overview for land managers. PNW-GTR-72. U.S. Forest Service. Rocky Mountain Research Station, Fort Collins, Colorado. (viii)

Henning, J.A., and G. Schirato. 2006. Amphibian use of Chehalis River floodplain wetlands. Northwestern Naturalist 87:209-214. (i)

Hewlett, J.D., and W.L. Nutter. 1970. The varying source area of streamflow from upland basins. Pages 65-83 *in* Proceedings of the symposium on interdisciplinary aspects of watershed management. American Society of Civil Engineers, New York. (viii)

Hickin, E.J. 1984. Vegetation and river channel dynamics. Canadian Geographer 28:111-126. (i)

Hirsch, R., J. Walker, J. Day, and R. Kallio. 1990. The influence of man on hydrologic systems. Pages 329–359 *in* M.G. Wolman and H.C. Riggs, editors. Surface water hydrology. Geological Society of America, Boulder, Colorado. (viii)

Hohensinner, S., H. Habersack, M. Jungwirth, and G. Zauner. 2004. Reconstruction of the characteristics of a natural alluvial river-floodplain system and hydromorphological changes following human modifications: the Danube River (1812-1991). River Research and Applications 20:25-41. (i)

Holland, D.C. 1994. The Western Pond Turtle: habitat and history. Final Report to the U.S. Department of Energy, Bonneville Power Administration, Portland, Oregon. (viii)

Hooke, J.M. 1984. Changes in river meanders: a review of techniques and results of analyses. Progress in Physical Geography 8:473-508. (i)

Horton, R.E. 1933. The role of infiltration in the hydrologic cycle. Transactions American Geophysical Union, 14:446-460. (i)

Hultine, K., and S. Bush. 2011. Ecohydrological consequences of non-native riparian vegetation in the southwestern United States: a review from an ecophysiological perspective. Water Resources Research 47:W07542. (i)

Hughes, F.M.R. 1997. Floodplain biogeomorphology. Progress in physical geography 21:501–529. (i)

Hupp, C.R., and W.R. Osterkamp. 1996. Riparian vegetation and fluvial geomorphic processes. Geomorphology 14:277-295. (i)

Jackson, C., D. Leigh, S. Scarbrough, and J. Chamblee. 2014. Herbaceous versus forested riparian vegetation: narrow and simple versus wide, woody and diverse stream habitat. River Research and Applications 31:847-857. (i)

Jansson, R., C. Nilsson, M. Dynesius, and E. Andersson. 2000. Effects of river regulation on river-margin vegetation: a comparison of eight boreal rivers. Ecological applications 10:203-224. (i)

Jones, J.A., F.J. Swanson, B.C. Wemple, and K.U. Snyder. 2000. Effects of roads on hydrology, geomorphology, and disturbance patches in stream networks. Conservation Biology 14:76-85. (i)

Katz, G.L., J.M. Friedman, and S.W. Beatty. 2005. Delayed effects of flood control on a flood-dependent riparian forest. Ecological Applications 15:1019-1035. (i)

Kauffman, J.B., and R.E. Martin. 1989. Fire behavior, fuel consumption, and forest floor changes following prescribed understory fires in Sierra Nevada mixed conifer forests. Canadian Journal of Forest Resources 19:455-462. (i)

Kiffney, P.M., C.M. Greene, J.E. Hall, and J.R. Davies. 2006. Tributary streams create spatial discontinuities in habitat, biological productivity and diversity in mainstem rivers. Canadian Journal of Fisheries and Aquatic Sciences 63:2518-2530. (i)

Knighton, D. 2014. Fluvial forms and processes: a new perspective. Routledge, London. (i)

Krause, D., D.M. Hannah, J.H. Fleckenstein, C.M. Heppell, D Kaeser, R. Pickup, G. Pinay, A.L. Robertson, and P.J. Wood. 2011. Inter-disciplinary perspectives on processes in the hyporheic zone. Ecohydrology 4:481-499. (i)

Kupfer, J., and G.P. Malanson. 1993. Observed and modeled directional change in riparian forest composition at a cutbank edge. Landscape Ecology 8:185-199. (i)

Lane, E.W. 1955. The importance of fluvial morphology in hydraulic engineering. Proceedings of American Society of Civil Engineers 81:1-17. (i)

Langendoen, E.J., R.R. Lowrance, and A. Simon. 2009. Assessing the impact of riparian processes on streambank stability. Ecohydrology 2:360-369. (i)

Leopold, L.B. 1968. Hydrology for urban land planning: A guidebook on the hydrologic effects of urban land use. Geological Survey Circular 554. U.S. Geological Survey, Reston, Virginia. (i)

Leopold, L.B., and G. Wolman. 1957. River channel patterns: braided, meandering and straight. U.S. Geological Survey Professional Paper 282-B. U.S. Government Printing Office, Washington, D.C. (i)

Lewis, J. 1998. Evaluating the impacts of logging activities on erosion and sediment transport in the Caspar Creek watersheds. Pages 55-69 *in* R.R. Ziemer, technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story. PSW-GTR-168. U.S. Forest Service, Pacific Southwest Research Station, Albany, California. (viii)

Liquori, M.K. 2006. Post-harvest riparian buffer response: implications for wood recruitment modeling and buffer design. Journal of American Water Resources Association 42(1):177-189. (i)

Liquori, M.K., D. Martin, R. Coats, L. Benda, and D. Ganz. 2008. Scientific literature review of forest management effects on riparian functions for anadromous salmonids. Sound Watershed Consulting, Oakland, California. (viii)

Luce, C.H., and T.A. Black. 1999. Sediment production from forest roads in western Oregon. Water Resources Research 35:2561-2570. (i)

MacDonald, L.H., D.B. Coe, and S.E. Litschert. 2004. Assessing cumulative watershed effects in the central Sierra Nevada: hillslope measurements and catchment-scale modeling. Pages 149-157 *in* D.D. Murphy and P.A. Stine, editors. Proceedings of the Sierra Nevada science symposium. PSW-GTR-193. U.S. Forest Service, Pacific Southwest Research Station, Albany, California. (viii)

Madej, M.A. 2001. Erosion and sediment delivery following removal of forest roads. Earth Surface Processes and Landforms 26:175-190. (i)

Madej, M.A., and V. Ozaki. 1996. Channel response to sediment wave propagation and movement, Redwood Creek, California, USA. Earth Surface Processes and Landforms 21:911-927. (i)

Magilligan, F.J., and P.F. McDowell. 1997. Stream channel adjustments following elimination of cattle grazing. Journal of the American Water Resources Association 33:867-878. (i)

Magilligan, F.J., and K.H. Nislow. 2001. Long-term changes in regional hydrologic regime following impoundment in a humid-climate watershed. Journal of the American Water Resources Association 37:1551-1569. (i)

Mahoney, J.M., and S.B. Rood. 1998. Streamflow requirements for cottonwood seedling recruitment -an integrative model. Wetlands 18:634-645. (i)

Malanson, G.P. 1993. Riparian Landscapes. Cambridge University Press, Cambridge, United Kingdom. (i)

Marston, R.A. 2008. Land, life, and environmental change in mountains. Annals of the Association of American Geographers 98:507-520. (i)

Mattson, W.J., and N.D. Addy. 1975. Phytophagous, insects as regulators of forest primary production. Science 190:515-522. (i)

May, C.L. 2002. Debris flows through different forest age classes in the central Oregon Coast Range, Journal of the American Water Resources Association 38:1097-1113. (i)

McDonald, A., S.N. Lane, N.E. Haycock, and E. Chalk. 2004. Rivers of dreams: on the gulf between theoretical and practical aspects of an upland river restoration. Transactions of the Institute of British Geographers 29:257-281. (i)

McDonnell, J.J. 2003. Where does water go when it rains? Moving beyond the variable source area concept of rainfall-runoff response. Hydrological Processes 17:1869-1875. (i)

Megahan, W.F. 1974. Erosion over time on severely disturbed granitic soils: a model. INT-156. U.S. Forest Service, Intermountain Forest & Range Experiment Station, Ogden, Utah. (i)

Meitzen, K.M. 2009. Lateral change migration effects on riparian forest structure and composition, Congaree River, South Carolina, USA. Wetlands 29:465-475. (i)

Merritt, D.M., and E.E. Wohl. 2006. Plant dispersal along rivers fragmented by dams. River Research and Applications 22:1-26. (i)

Meyer, L., G. Foster, and S. Nikolov. 1975. Effect of flow rate and canopy on rill erosion. Transactions of the American Society of Agricultural Engineers 18:905-911. (i)

Meyer, J.L., and J.B. Wallace. 2001. Lost linkages and lotic ecology: rediscovering small streams. Pages 295-317 *in* M.C. Press, N.J. Huntly, and S. Levin, editors. Ecology: achievement and challenge. Blackwell Science, Oxford, United Kingdom. (i)

Montgomery, D.R. 1999. Process domains and the river continuum. Journal of the American Water Resources Association 35:397-410. (i)

Montgomery, D.R. 2007. Is agriculture eroding civilization's foundation? GSA Today 17(10):4-9. (i)

Montgomery, D.R., T.B. Abbe, J.M. Buffington, N.P. Peterson, K.M. Schmidt, and J.D. Stock. 1996. Distribution of bedrock and alluvial channels in forested mountain drainage basins. Nature 381:587-589. (i)

Montgomery, D.R., and J.M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109:596-611. (i)

Montgomery, D.R., K.M. Schmidt, W.E. Dietrich, and J. McKean. 2009. Instrumental record of debris flow initiation during natural rainfall: implications for modeling slope stability. Journal of Geophysical Research 114:F01031. (i)

Moore, R.D., and S.M. Wondzell. 2005. Physical hydrology and the effects of forest harvesting in the Pacific Northwest: a review. Journal of the American Water Resources Association 41:763-784. (i)

Naiman, R.J., and R.E. Bilby. 1998. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. (i)

Naiman, R.J., R.E. Bilby, and P.A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. BioScience 50:996-1011. (i)

Naiman, R.J., H. Decamps, and M.E. McClain. 2010. Riparia: ecology, conservation, and management of streamside communities. Academic Press, London. (i)

Naiman, R.J., H. Decamps, and M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3:209-212. (i)

Nakamura, F., and F.J. Swanson. 2003. Dynamics of wood in rivers in the context of ecological disturbance. Pages 279-298 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Bethesda, Maryland. (i)

NRC (National Research Council). 2002. Riparian areas: strategies for management. National Academies Press, Washington, D.C. (i)

Nelson, E.J., and D.B. Booth. 2002. Sediment sources in an urbanizing, mixed land-use watershed. Journal of Hydrology 264:51-68. (i)

Nickelson, T.E., J.D. Rodgers, S.L. Johnson, and M.F. Solazzi. 1992. Seasonal changes in habitat use by juvenile Coho Salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences 49:783-789. (i)

Nilsson, C., and K. Berggren. 2000. Alterations of riparian ecosystems caused by river regulation. BioScience 50:783-792. (i)

Nilsson, C., R. Jansson, and U. Zinko, U., 1997. Long-term responses of river-margin vegetation to water-level regulation. Science 276:798-800. (i)

Nilsson, C., and M. Svedmark. 2002. Basic principles and ecological consequences of changing water regimes: riparian plant communities. Environmental Management 30:468-80. (i)

O'Connor, J.E., M.A. Jones, and T.L. Haluska. 2003. Floodplain and channel dynamics of the Quinault and Queets Rivers, Washington, USA. Geomorphology 51:31-59. (i)

Osterkamp, W.R., and C.R. Hupp. 2010. Fluvial processes and vegetation – glimpses of the past, the present, and perhaps the future. Geomorphology 116:274-285. (i)

Petroski, H. 2006. Levees and other raised ground. American Scientist 94(1):7-11. (i)

Pickett, S., S. Collins, and J. Armesto. 1987. A hierarchical consideration of causes and mechanisms of succession. Vegetatio 69:109-114. (i)

Pickett, S.T., and P.S. White. 1985. The ecology of natural disturbance and patch dynamics. Academic Press, San Diego, California. (i)

Pike, A.S., and F.N. Scatena. 2010. Riparian indicators of flow frequency in a tropical montane stream network. Journal of Hydrology 382:72-87. (i)

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B. Richter, R. Sparks, and J. Stromberg. 1997. The natural flow regime: a new paradigm for riverine conservation and restoration. BioScience 47:769-784. (i)

Pollen, N., and A. Simon. 2005. Estimating the mechanical effects of riparian vegetation on stream bank stability using a fiber bundle model. Water Resources Research 41:W07025. (i)

Pollen-Bankhead, N., and A. Simon. 2010. Hydrologic and hydraulic effects of riparian root networks on streambank stability: is mechanical root-reinforcement the whole story? Geomorphology 116:353–362. (i)

Polvi, L.E., E.E. Wohl, and D.M. Merritt. 2011. Geomorphic and process domain controls on riparian zones in the Colorado Front Range. Geomorphology 125:504-516. (i)

Polvi, L.E., E.E. Wohl, and D.M. Merritt. 2014. Modeling the functional influence of vegetation type on streambank cohesion. Earth Surface Processes and Landforms 39:1245-1258. (i)

Post, D.M., M.W. Doyle, J.L. Sabo, and J.C. Finlay. 2007. The problem of boundaries in defining ecosystems: a potential landmine for uniting geomorphology and ecology. Geomorphology 89:111-126. (i)

Rapp, C.F., and T.B. Abbe. 2003. A framework for delineating channel migration zones. Ecology Publication #03-06-027. Washington State Department of Ecology and Washington State Department of Transportation, Olympia. (viii)

Reeves, G.H., L.E. Benda, K.M. Burnett, P.A. Bisson, and J.R. Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionarily significant units of anadromous salmonids in the Pacific Northwest. American Fisheries Society Symposium 17:334-349. (i)

Reid, L.M., and S. Hilton. 1998. Buffering the buffer. Pages 71-80 *in* R.R. Ziemer, technical coordinator. Proceedings of the conference on coastal watersheds: the Caspar Creek story. PSW-GTR-168. U.S. Forest Service, Pacific Southwest Research Station, Albany, California. (i)

Renschler, C.S., M.W. Doyle, and M. Thomas. 2007. Geomorphology and ecosystems: challenges and keys for success in bridging disciplines. Geomorphology 89:1-8. (i)

Richter, K.O. 2005. Wetlands. Pages 22-23 *in* L.L.C. Jones, W.P. Leonard, and D.J. Olson, editors. Amphibians of the Pacific Northwest. Seattle, Audubon Society, Seattle. (vi)

Rinaldi, M., N. Casagli, S. Dapporto, and A. Gargini. 2004. Monitoring and modelling of pore water pressure changes and riverbank stability during flow events. Earth Surface Processes and Landforms 29:237-254. (i)

Ritter, D.F., R.C. Kochel, and J.R. Miller. 2002. Process geomorphology. McGraw-Hill, Boston. (i)

Roering, J.J., K.M. Schmidt, J.D. Stock, W.E. Dietrich, and D.R. Montgomery. 2003. Shallow landsliding, root reinforcement, and the spatial distribution of trees in the Oregon Coast Range. Canadian Geotechnical Journal 40:237-253. (i)

Rosenfeld, J. 2003. Assessing the habitat requirements of stream fishes: an overview and evaluation of different approaches. Transactions of the American Fisheries Society 132:953-968. (i)

Rosenfeld J.S., E. Raeburn, P.C. Carrier, and R. Johnson. 2008. Effects of side channel structure on productivity of floodplain habitats for juvenile Coho Salmon. North American Journal of Fisheries Management 28: 1108–1119. (i)

Scanlon, B.R., I. Jolly, M. Sophocleous, and L. Zhang. 2007. Global impacts of conversions from natural to agricultural ecosystems on water resources: quantity versus quality. Water Resources Research 43:W03437. (i)

Schilling, K., and J. Kiniry. 2007. Estimation of evapotranspiration by Reed Canarygrass using field observations and model simulations. Journal of Hydrology 337:356-363. (i)

Schlosser, I.J. 1991. Stream fish ecology: a landscape perspective. BioScience 41:704-712. (i)

Schlosser, I.J. 1995. Critical landscape attributes that influence fish population dynamics in headwater streams. Hydrobiologia 303:71-81. (i)

Schumm, S.A. 1977. The fluvial system. Wiley, New York. (i)

Schumm, S.A. 1979. Geomorphic thresholds: the concept and its applications. Transactions of the Institute of British Geographers 4:485-515. (i)

Sedell, J.R., J.E. Richey, and F.J. Swanson. 1989. The river continuum concept: a basis for the expected ecosystem behavior of very large rivers? Pages 49-55 *in* D.P. Dodge, editor. Proceedings of the international large river symposium. Department of Fisheries and Oceans, Ottawa, Canada. (i)

Selby, M.J. 1993. Hillslope forms and processes, 2nd edition. Oxford University Press, United Kingdom. (i)

Shankman, D. 1993. Channel migration and vegetation patterns in the Southeastern Coastal Plain. Conservation Biology 7:176-183. (i)

Simon, A., and A.J.C. Collison. 2002. Quantifying the mechanical and hydrologic effects of riparian vegetation on streambank stability. Earth Surface Processes and Landforms 27:527-546. (i)

Simon, A., A. Curini, S.E. Darby, and E.J. Langendoen. 2000. Bank and near-bank processes in an incised channel. Geomorphology 35:193-217. (i)

Simon, A., N. Pollen, and E. Langendoen. 2006. Influence of two woody riparian species on critical conditions for streambank stability: upper Truckee River, California. Journal of the American Water Resources Association 42:99-113. (i)

Sklar, L., and W.E. Dietrich. 1998. River longitudinal profiles and bedrock incision models: stream power and the influence of sediment supply. Geophysical Monograph Series 107:237-260. (i)

Smith, J.H.G. 1964. Root spread can be estimated from crown width of Douglas-fir, Lodgepole Pine, and other British Columbia tree species. Forestry Chronicle 40:456-473. (i)

Smith, B., P. Warkeand, and W. Whalley. 2002. Landscape development, collective amnesia and the need for integration in geomorphological research. Area 34:409-418. (i)

Smock, L.A., J.E. Gladden, J.L. Riekenberg, L.C. Smith, and C.R. Black. 1992. Lotic macroinvertebrate production in three dimensions: channel surface, hyporheic, and floodplain environments. Ecology 73:876-886. (i)

Stallins, J.A. 2006. Geomorphology and ecology: unifying themes for complex systems in biogeomorphology. Geomorphology 77:207-216. (i)

Stanford, J.A., and J.V. Ward. 1988. The hyporheic habitat of river ecosystems. Nature 335:64-66. (i)

Stanford, J.A., and J.V. Ward. 2001. Revisiting the serial-discontinuity concept. Regulated Rivers: Research & Management 17:303-310. (i)

Swanson, F.J., R.L. Fredriksen, and R.M. McCorison. 1982. Material transfer in a western Oregon forested watershed. Pages 233-266 *in* R.L. Edmonds, editor. Analysis of coniferous forest ecosystems in the western United States. Hutchinson Ross, Stroudsburg, Pennsylvania. (viii)

Swanson, F.J., S.L. Johnson, S.V. Gregory, and S.A. Acker. 1998. Flood disturbance in a forested mountain landscape. BioScience 48:681-689. (i)

Swanston, D.N. 1991. Natural Processes. Pages 139-179 *in* W. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Bethesda, Maryland. (i)

Sweeney, B.W., T.L. Bott, J.K. Jackson, L.A. Kaplan, J.D. Newbold, L.J. Standley, W.C. Hession, and R.J. Horwitz. 2004. Riparian deforestation, stream narrowing, and loss of stream ecosystem services. Proceedings of the National Academy of Sciences101:14132-14137. (i)

Tabacchi, E., L. Lambs, H. Guilloy, A.M. Planty-Tabacchi, E. Muller, and H. Decamps. 2000. Impacts of riparian vegetation on hydrological processes. Hydrological Processes 14:2959-2976. (i)

Tal, M., K. Gran, A.B. Murray, C. Paola, and D.M Hicks. 2004. Riparian vegetation as a primary control on channel characteristics in multi-thread rivers. Pages 43-58 *in* A.J. Bennet and A. Simon, editors. Riparian vegetation and fluvial geomorphology. American Geophysical Union, Washington, D.C. (i)

Tal, M., and C. Paola. 2007. Dynamic single-thread channels maintained by the interaction of flow and vegetation. Geology 35:347-350. (i)

Thorn, C.E., and M.R. Welford. 1994. The equilibrium concept in geomorphology. Annals of the Association of American Geographers 84:666-696. (i)

Tooth, S., H. Rodnight, G.A. Duller, T.S. McCarthy, P.M. Marren, and D. Brandt. 2007. Chronology and controls of avulsion along a mixed bedrock-alluvial river. Geological Society of America Bulletin 119:452-461. (i)

Torgersen, C., E., C.V. Baxter, and H.W. Li. 2006. Landscape influences on longitudinal patterns of river fishes: spatially continuous analysis of fish-habitat relationships. American Fisheries Society Symposium 48:473-492. (i)

Trimble, S.W., and A.C. Mendel. 1995. The cow as a geomorphic agent—a critical review. Geomorphology 13:233-253. (i)

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893-901. (i)

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137. (i)

Ward J.V. 1998. Riverine landscapes: biodiversity patterns, disturbance regimes, and aquatic conservation. Biological Conservation 83:269-278. (i)

Wells, R.R., C.V. Alonso, and S.J. Bennett. 2009. Morphodynamics of headcut development and soil erosion in upland concentrated flows. Soil Science Society of America Journal 73:521-530. (i)

Wemple, B.C., J.A. Jones, and G.E. Grant. 1996. Channel network extension by logging roads in two basins, western Cascade, Oregon. Journal of the American Water Resources Association 32:1195-1207. (i)

Whitaker, A., Y. Alila, J. Beckers, and D. Toews. 2002. Evaluating peak flow sensitivity to clear-cutting in different elevation bands of a snowmelt-dominated mountainous catchment. Water Resources Research 38:1172. (i)



School of Bull Trout Salvelinus confluentus/*William Meyer, WDFW*

Williams, G.P., and M.G. Wolman. 1985. Effects of dams and reservoirs on surface-water hydrology – changes in rivers downstream from dams. U.S. Geological Survey, Washington, D.C. (i)

Wohl, E. 2013. Mountain rivers revisited. American Geophysical Union, Washington, D.C. (i)

Wohl, E. 2014. Rivers in the landscape: science and management. Wiley, Hoboken, New Jersey (i)

Wohl, E., D. Cooper, L. Poff, F. Rahel, D. Staley, and D. Winters. 2007. Assessment of stream ecosystem function and sensitivity in the Bighorn National Forest, Wyoming. Environmental Management 40:284-302. (i)

Wolman, M.G. 1959. Factors influencing erosion of cohesive river banks. American Journal of Science 25:204-216. (i)

Wolman, M.G. 1967. A cycle of sedimentation and erosion in urban river channels. Geografiska Annaler 49A:385-395. (i)

Wright H.A., and A.W. Bailey. 1982. Fire ecology: United States and southern Canada. Wiley, New York. (i)

Ziemer, R.R., and T.E. Lisle. 1998. Hydrology. Pages 43-68 *in* R.J. Naiman and R.E. Bilby, editors. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. (i)

Chapter 3. Wood

By: George F. Wilhere and Anne Marshall

3.1. Introduction

The scientific study of wood in rivers and streams began about 50 years ago (Gregory 2003) and the vital ecological role of instream wood has been known for at least 40 years (Swanson et al. 1976). Over that 50 year period, the substantial quantity of research on instream wood has motivated numerous authoritative reviews of the scientific literature, such as Bisson et al. (1987), Maser et al. (1988), Gurnell et al. (1995), Bilby and Bisson (1998), Gurnell et al. (2002), Naiman et al. (2002a), and Hassan et al. (2005). A comprehensive, in-depth review of the ecology of wood in aquatic ecosystems is provided by Gregory et al. (2003). Although we have a solid understanding of wood's role in aquatic ecosystems and the pathways through which wood enters and moves through a stream network, some important questions remained unanswered.



Wood, rocks, and roots – roughness elements that enhance habitat diversity by increasing hydraulic complexity/Jane Atha, WDFW

This chapter focuses on the roles and recruitment of wood in aquatic ecosystems. It does not cover stream restoration using large wood. For information on that, see Dominguez and Cederholm (2000), Reich et al. (2003), Bisson et al. (2003), Carah et al. (2014), and Roni et al. (2014). For information on riparian forest management see Boyer et al. (2003) and Spies et al. (2013).

3.2. The Ecological Role of Instream Wood

Wood plays critical roles in the composition, structure, and function of riparian and aquatic ecosystems. In forested regions, wood is an important determinant of channel form and dynamics, especially in small streams (Montgomery and Buffington 1997; Bilby and Bisson 1998). However, the importance of wood's effects differs with channel dimensions, slope, sediment supply, and stream discharge (Gurnell et al. 1995). Large wood causes widening and narrowing, deepening and shallowing, stabilization and destabilization at different points along a stream or river channel (Swanson et al. 1976). The many effects of large wood create a variety of channel morphologies–dam pools, plunge pools, riffles, glides, undercut banks, and side channels–which provide a diversity of aquatic habitats. Pools are deposition sites for sediment and fine organic matter. Sediment is essential substrate for salmonid spawning, and stored sediments become mobilized over time to replenish downstream spawning areas.

Sediment and fine organic matter deposits are productive areas for invertebrates and are important food production sites for juvenile salmonids (Bisson et al. 1987). Pools provide rearing habitats and essential refuge from high flows for fish and other aquatic fauna. Instream large wood provides fish with cover from predators, and by increasing a water body's effective space, wood structures may increase fish densities (Bisson et al. 1987).

3.2.1. Small Wood

Wood is often divided into large and small size categories. Large wood is usually defined as having diameter greater than 4 in (10 cm) and length greater than 6 ft (≈2 m) (Bilby and Ward 1991; Schuett-Hames et al. 1999).[1] Small wood[2] consists of branches and other woody material not classified as large wood. Small wood plays essential and unique roles in lotic ecosystems. For instance, accumulations of small wood enhance a stream's retention of leaves and particulate organic matter (Gregory et al. 1991), which are vital food sources for many aquatic invertebrates. Small wood also effects channel morphology. Plunge and dammed pools are often associated with accumulations of small wood, and large wood with dense accumulations of small wood retain sediment significantly more frequently than large wood with sparse small wood accumulations (Bilby and Ward 1991).

Small wood exerts tremendous effects on hydrology and channel morphology through actions of the American Beaver *Castor canadensis* (Naiman et al. 1988). Beaver dams can store large quantities of sediment, reduce channel incision, remove excess nutrients from water, increase water retention and base flows, reduce peak flows, and by spreading flow events over longer periods, increase groundwater recharge, and increase the salmonid habitat capacity of small streams (Pollock et al. 2015). Beaver dams consist mainly of mud and small wood. Published information on small wood sizes in dams of Beaver is lacking. However, Beaver most often forage on trees ranging from 1.2 - 3.2 in (3 - 8 cm) in diameter (Collen and Gibson 2001), and a large proportion of woody stems used as food are also used in dam construction (Barnes and Mallik 1996). In Maryland, Blersch and Kangas (2014) found that 98% of sticks (i.e., small wood) in a Beaver dam were less than 4 in (10 cm) in diameter and that 46% of those sticks were probably placed in the dam by Beaver. The other 54% of sticks in the dam were due to passive capture of transported wood. For more information on the role of Beaver and Beaver dams in aquatic ecosystems, see Pollock et al. (2015).

3.2.2. Roles of Instream Large Wood

The main role of large wood in aquatic ecosystems is large roughness elements (Bisson et al. 1987) (Figure 3.1). Roughness elements are obstacles in a channel that deflect flow and change its velocity. The size, shape, and strength of large wood make it very effective at redirecting hydraulic forces and the flow of materials (Figure 3.2), such as sediment and fine organic matter. Instream large wood increases hydraulic complexity, i.e., creates a wider range of flow velocities, which causes pool formation, streambed scour, sediment deposition, and channel migration. The net result is a diversity of aquatic habitats.

[1] Large wood is also known as large woody debris (LWD) or coarse woody debris. There is no universal definition of LWD. Another definition is greater than 4 in (10 cm) in diameter and greater than 3 ft (≈1 m) in length. The system of measurement used effects the size of large wood. The definition using English units (4 in wide and 6 ft long) results in a piece of smaller volume than the definition using metric units (10 cm wide and 2 m long).
[2] Small wood is also known as small woody debris or fine woody debris

The influences of instream large wood on aquatic ecosystems are a function of wood size relative to channel size. For instance, as much as 80% of pools in small streams can be associated with wood (Montgomery et al. 1995); however, the frequency of wood-associated pools decreases with increasing stream size (Bilby and Ward 1989, 1991; Montgomery et al. 1995). The latter relationship is due to the increased capacity of larger streams to transport large wood downstream.

In low order streams, "key pieces" of large wood affect channel morphology. Key pieces are defined as large wood that is independently stable within the bankfull channel (i.e., not held or trapped by other material) and have the potential to retain other pieces of large wood (WFPB 2011). Key piece size increases as channel width increases (Table 3.1). In large rivers, wood influences channel morphology through tangled accumulations of wood known as woody debris jams.

Stable structural features can promote channel stability (Sullivan et al. 1987). In large rivers, for instance, woody debris jams contribute to floodplain stabilization by initiating the formation of mid-channel bars that eventually become forested islands (Fetherston et al. 1995; Abbe and Montgomery 1996). In small streams, persistent large wood structures trap sizable amounts of sediment thereby increasing channel stability (Figure 3.3). Of all structures capable of storing sediment (i.e., wood, boulders) in small non-fish-bearing streams of northwest Washington, 93% were composed of large wood (Grizzel and Wolff 1998). Thirty to 80% of a stream's drop in elevation can be influenced by large wood (Keller and Swanson 1979), and log steps can reduce average channel gradients by 8 to 22% (Heede 1972). Reducing channel gradient dissipates stream power which mobilizes less sediment and increases sediment storage which can subsequently increase channel stability.

Table 3.1. Minimum volume of large wood key pieces for different channel widths. Example dimensions for key piece length and diameter yield minimum volume. Diameter is measured at piece midpoint. One meter is approximately 3.3 ft.

		Example dimensions (m)	
Bankfull width (m)	Minimum volume (m^3)	Length	Diameter
0-5[a]	1	2.5	0.71
5-10[a]	2.5	7.5	0.65
10-15[a]	6	12.5	0.78
15-20[a]	9	17.5	0.81
20-30[b]	9.75	17.5	0.84
30-50[bc]	10.5	17.5	0.87
50-100[bc]	10.75	17.5	0.88

[a] WFPB (2011), [b] Fox and Bolton (2007), [c] Must have an attached root wad.

Studies where wood has been experimentally removed from streams further reveal the significant role of large wood for storing sediment. For instance, Bilby (1981) measured a 72% reduction in sediment storage following removal of large wood from 575 ft (175 m) of streambed. Beschta (1979) observed a similar effect after woody debris dams were removed from a moderate gradient headwater stream in western Oregon where 6,500 yd^3 (5,000 m^3) of sediment was lost from 820 ft (250 m) of streambed over a period of about 10 months.

Large wood can also cause transient channel instability. Keller and Swanson (1979) and Nakamura and Swanson (1993) describe stream reaches where large wood caused local erosion that increased channel width by more than 50%. In one case a woody debris jam increased channel width by 230%. These two studies also describe reaches where large wood caused lateral migration of the main channel and formation of side

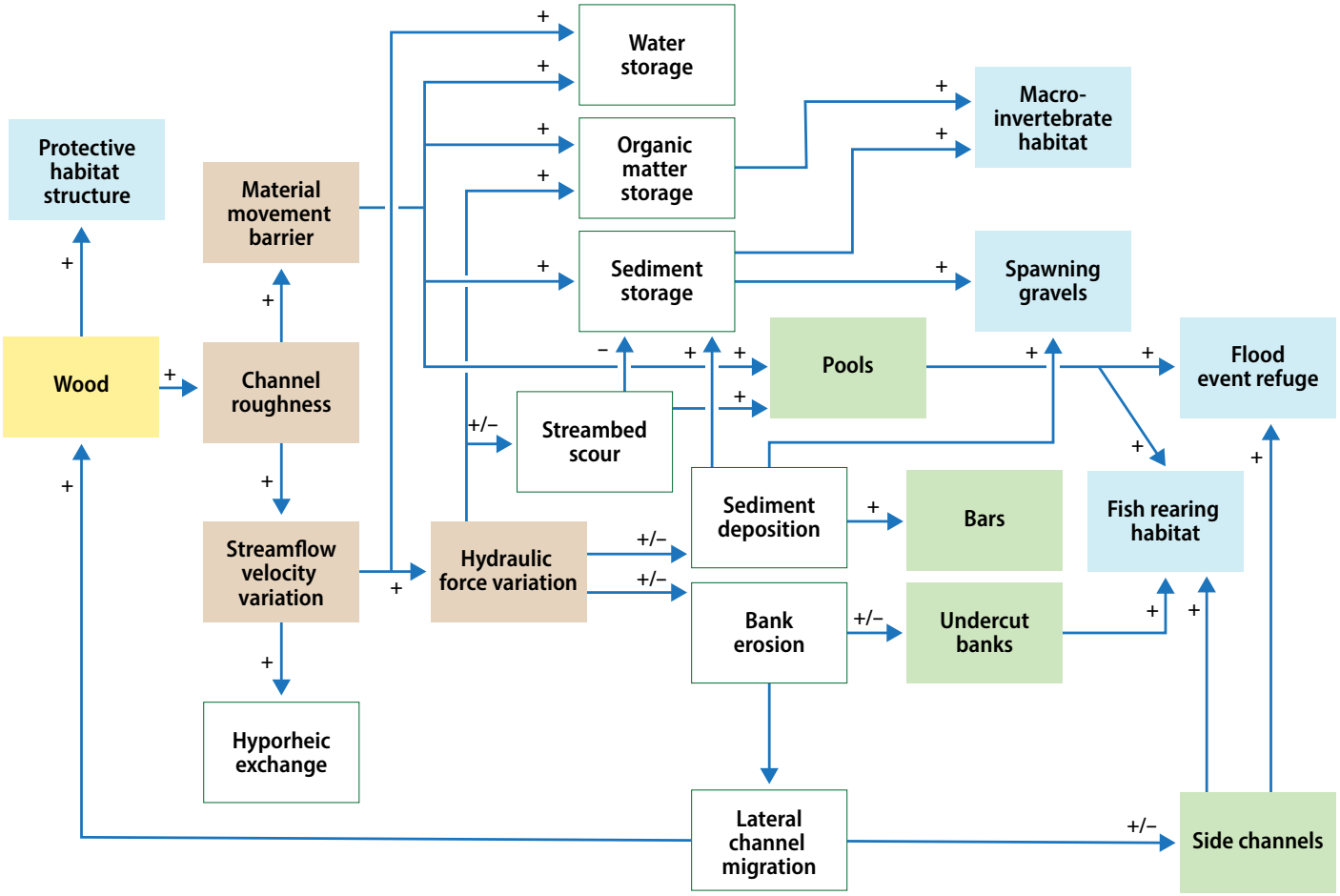


Figure 3.1. Conceptual model depicting the effects of wood on fluvial systems and fish habitats. Arrows indicate the hypothesized directions of causal relationships; pluses and minuses indicate the hypothesized slope of each relationship. Brown boxes represent direct effects of wood on fluvial processes. White boxes are secondary processes. Green boxes depict channel structures. Blue boxes are habitat features. Diagram does not include most feedback loops.

channels. Over time, these types of disturbances create a shifting mosaic of aquatic and riparian habitats.

Wood influences nutrient dynamics in two major ways: wood contains nutrients that are released through decomposition, and large wood influences the rate and timing of organic materials transport (Bilby 2003). The latter is the more important effect. Instream large wood traps and retains organic matter, such as leaves and other plant detritus, which are essential to the aquatic food web. Trapped organic materials are food sources for aquatic microorganisms, such as bacteria and certain fungi, and invertebrates, such as insects, crustaceans, and mollusks.



Figure 3.2. Sediment and nutrient storage and gravel bar formation behind large wood/Jane Atha, WDFW



Figure 3.3. Large wood altering channel morphology by creating dam pool, step drop, and plunge pool/Jane Atha, WDFW

The relationship between instream large wood and nutrient storage is well established. Larger quantities of wood per unit area in small streams lead to higher rates of storage of fine organic matter (Bilby and Likens 1980; Bilby and Bisson 1998; Brookshire and Dwire 2003). The mass of coarse particulate organic matter in streams in the McKenzie River watershed of Oregon was positively related to amounts of instream wood (Naiman and Sedell 1979). Bilby (1981) reported dramatic increases in downstream export of fine particulates during periods of high discharge following woody debris removal.

Carcasses of adult anadromous salmon provide nutrients to aquatic ecosystems (Cederholm et al. 1989; Reimchen et al. 2003). On the Olympic Peninsula, a positive correlation was observed between the number of Coho Salmon *Oncorhynchus kisutch* carcasses retained in streams and the amount of large wood in the stream (Cederholm and Peterson 1985).

By creating dams, instream large wood regulates water flow and storage. For example, surface water volume increased by 168%, five years after restoration of instream large wood in a coastal Oregon stream (Crispin et al. 1993), and third-order streams in Indiana with woody debris dams held surface water 1.5 to 1.7 times longer than those with minimal large wood (Ehrman and Lamberti 1992, cited by Gurnell et al. 1995). Hydrological effects such as these may alter high flow events by reducing peak discharge and increasing the event's duration (Gurnell et al. 1995). Pools created by woody debris dams raise the water table in adjacent streambanks (Gurnell et al. 1995), and that affects riparian vegetation composition. For instance, at some sites, wet riparian soils may be maintained through seepage from pools, and wet soils are more suitable for Red Alder *Alnus rubra,* Red Ceder *Thuja plicata,* and Alaska Yellow Ceder *Chamaecyparis nootkatensis* than other tree species. Red Alder is known to contribute enormous amounts of beneficial nitrogen to soils and streams (Naiman et al. 2002b).

The hyporheic zone is the saturated sediment beneath stream channels and riparian areas where groundwater and instream water mix. Large wood diverts surface water flow into the hyporheic zone, and by trapping and storing sediments, large wood increases the volume of the hyporheic zone (Naiman et al. 2000). Greater hyporheic exchange can also reduce a streams thermal sensitivity (Chapter 4).

3.3. Recruitment of Instream Large Wood

The quantity of instream large wood is determined by the processes of wood recruitment, decomposition, and transport (Figure 3.4). "Recruitment" refers to the process of wood moving from the terrestrial environment to the stream channel. "Transport" refers to wood import to, movement within, and export from stream reaches. For comprehensive reviews of the dynamics of instream large wood, including decomposition and transport, see Benda et al. (2003), Bilby (2003), Gurnell (2003), and Piegay (2003).

3.3.1. Wood Recruitment Mechanisms

Large wood recruitment is often caused by bank erosion, windthrow, landslides, debris flows, snow avalanches, and tree mortality due to fire, ice storms, insects, and disease (Swanson et al. 1976; Maser et al. 1988). At any given site, more than one mechanism may contribute to recruitment. However, the dominant mechanism is determined by channel morphology, slope steepness, slope stability, forest composition and structure, and local wind patterns (Murphy and Koski 1989; McDade et al. 1990; May and Gresswell 2003; Johnston et al. 2011; Benda and Bigelow 2014). In large low-gradient rivers, for instance, wood is commonly recruited via bank erosion. Steep-sloped riparian forests along confined streams can recruit instream large wood via several mechanisms; however, landslides and windthrow are the dominant recruitment mechanisms in such settings (Nakamura and Swanson 1993; May and Gresswell 2003). Fox (2001) reported that smaller channels are likely to obtain a significant proportion of instream large wood by stem breakage and individual tree mortality due to insects or disease because smaller streams recruit less wood through lateral bank avulsion. Beaver recruit small wood to small, low-gradient streams (Pollock et al. 2003).

Instream wood originating from bank erosion increases as channel confinement decreases (Murphy and Koski 1989; Nakamura and Swanson 1993; Martin and Benda 2001; Johnston et al. 2011). In relatively unconfined third-order channels surrounded by mature and old-growth forests in British Columbia, bank erosion was the dominant route of large wood delivery, especially in wider channels (Johnston et al. 2011). Along Alaska's southeastern coast, bank erosion dominated large wood recruitment in alluvial channels, while windthrow was dominant in bedrock channels (Murphy and Koski 1989). Over a 63 year period, the Queets River (bankfull width = 420 ft [128 m]) recruited 95% of wood pieces ≥ 3 ft (1 m) in diameter through bank erosion that occurred as its channel meandered across its wide floodplain (Latterell and Naiman 2007).

The relative importance of each instream wood recruitment mechanism is highly variable (Table 3.2). Johnston et al. (2011) found tree mortality was the most common recruitment mechanism followed by (in descending order) bank erosion, windthrow, and landslides. In contrast, Murphy and Koski (1989) found that tree mortality was the third most common mechanism, and their rank ordering was bank erosion, windthrow, tree mortality, and landslides. Johnston et al. (2011) found that windthrow contributed 4% of instream large wood, but May and Gresswell (2003) found windthrow contributed 59%, on average. Benda et al. (2003) found that landslides contributed, on average, 17% of instream wood volume, but at the site-level, the contribution from landslides ranged from 0 to 66%. In the Oregon Coast Range, 65% of instream pieces of large wood and 46% of wood volume in a fourth order stream were delivered by landslide or debris flow (Reeves et al. 2003).



Large wood suspended over water creates a refuge for fish from avian predators/Jane Atha, WDFW

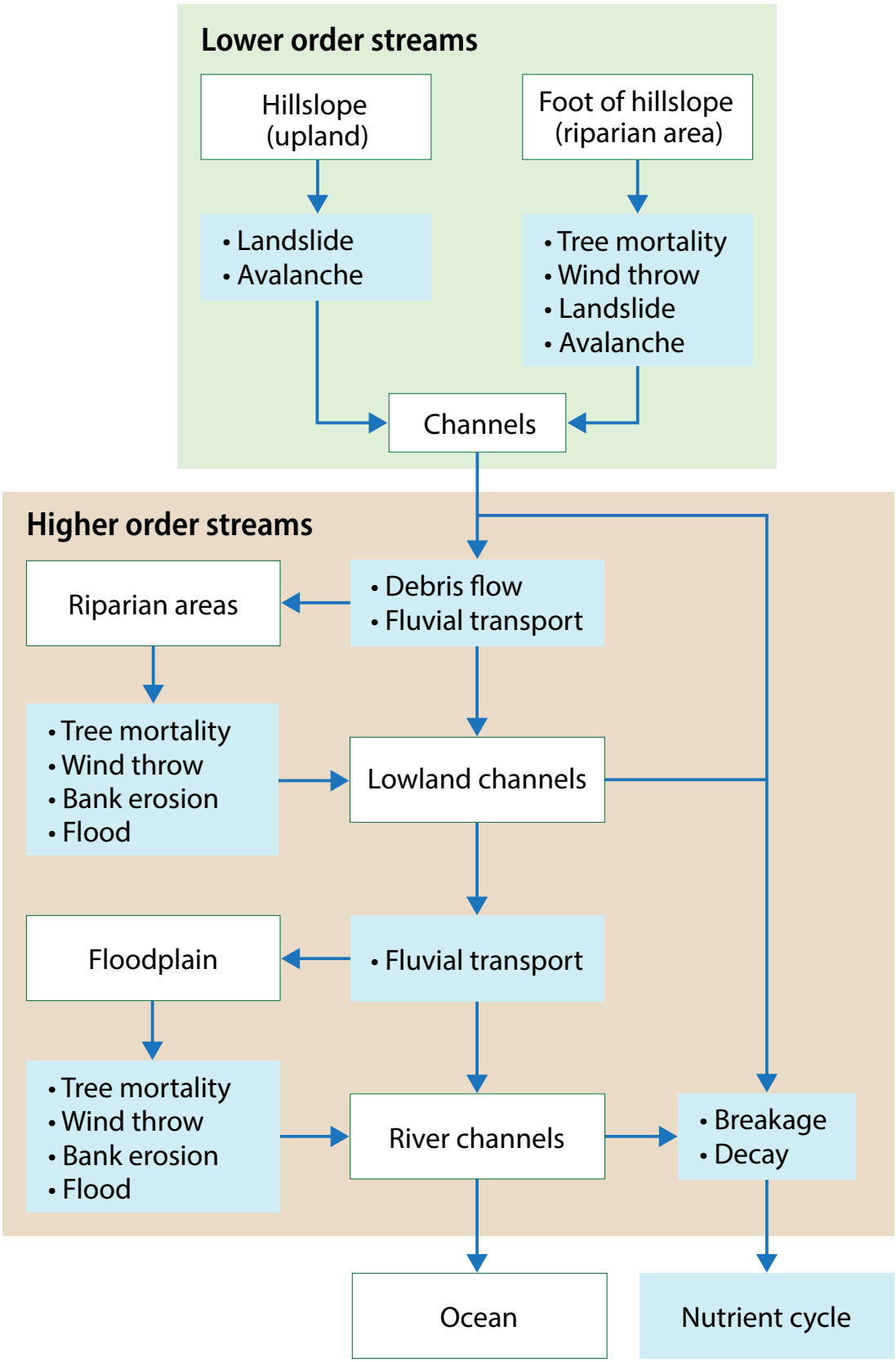


Figure 3.4. Wood recruitment mechanisms and wood transport pathways (adapted from Hassan et al. 2005). Lower order streams are first and second order headwaters. White and blue boxes are ecosystem structures and processes, respectively.

Table 3.2. Mean percentage of instream large wood contributed by various recruitment mechanisms in unmanaged old-growth conifer forests. For Johnston et al. (2011), stem breakage could be lumped with the windthrow or tree mortality categories. One meter is approximately 3.3 feet.

		Southeast Alaska[1]	South & Central British Columbia[2]	Coast Range Oregon[3]	Northern California[4]
	Stream length (m)	10,280	8,129	3,220	4,470
	Wood units	% of wood pieces	% of wood pieces	% of wood pieces	% of wood volume
Recruitment mechanism	bank erosion	42	18	6	29
	windthrow	33	4	59	--
	tree mortality	22	65	6	53
	stem break	--	12	--	--
	landslide	3	1	29	17

1 = Murphy and Koski 1989, 2 = Johnston et al. 2011, 3 = May and Gresswell 2003, 4 = Benda et al. 2003

A site's recruitment mechanisms determine the magnitude and timing of wood recruitment events. Recruitment can be continual or episodic. In large, meandering rivers wood may be recruited through continual bank erosion. Soil creep along the eroding base of a hillslope may also contribute to continual wood recruitment. However, most wood recruitment occurs through episodic events such as floods, landslides, debris flow, or windstorms. For example, if a 100-year flood causes a river to migrate across its floodplain, then a huge volume of wood that would have taken decades to be recruited under smaller flows could be recruited overnight. In smaller confined streams, the main recruitment mechanism may be windthrow, which can recruit wood incrementally (single tree per event) or catastrophically (100s of trees per event).

3.3.2. Recruitment Distances

Forests adjacent to streams provide the majority of large wood delivered to stream channels (Murphy and Koski 1989; McDade et al. 1990), however, trees far removed from riparian areas may also be delivered via landslides (Reeves et al. 2003) or channel migration (Latterell and Naiman 2007). Johnston et al. (2011) found that mean recruitment distances were greatest for wood entering by way of landslides, followed by (in descending order by distance) windthrow, stem breakage, falling of dead trees, and bank erosion.

Source distances are affected by channel geomorphology. The source distance of instream large wood differed significantly ($P < 0.05$) when comparing alluvial streams to colluvial channels draining steep hillslopes in Oregon's Coast Range (May and Gresswell 2003). In this study, 80% of wood pieces and total wood volume originated from forests within 160 ft (50 m) of colluvial channels confined by steep hillslopes, whereas in unconfined alluvial channels, 80% of instream large wood originated from within 98 ft (30 m) of the channel (May and Gresswell 2003). Along steep second growth redwood forests in northern California, landslides resulted in recruitment distances extending over 197 ft (60 m) (Benda et al. 2002). In the Oregon Coast Range, large wood from pristine steeply sloped conifer-deciduous forest was delivered to a fourth order stream by landslide or debris flow from distances of more than 295 ft (90 m) upslope of the channel (Reeves et al. 2003).

Table 3.3. Recruitment distances of instream large wood from unmanaged old-growth conifer riparian forests.

Location	Stream order or width	Maximum recruitment distance	Dominant recruitment process	Recruitment from intermediate distances	Source*
Southeast Alaska	second- to fifth-order	> 100 ft > 30 m	bank erosion	99% of pieces from < 100 ft (30 m). 45% of pieces from within 3 ft (1 m) of streambank. Average tree height = 130 ft (40 m)‡.	1
Western Oregon & Washington	first- to third-order	180 ft 55 m	not reported	50% of pieces from within 33 ft (10 m) of streambank; 85% from within 100 ft (30 m); 90% from within 128 ft (39 m), horizontal distance. Average tree height = 189 ft (57.6 m).	2
Northern California	45-55 ft 14-17 m	180 ft 55 m	variable	90% of wood from < 100 ft (30 m), slope distance. Longer recruitment distances due to landsliding.	3
Coast Range Oregon	second- and third-order	230 < d < 262 ft 70 < d < 80 m	windthrow	In alluvial stream 80% of pieces from ≤ 100 ft (30 m). In colluvial streams ≈50% of pieces from ≤ 100 ft (30 m). For both types ≈75% of volume from ≤ 165 ft (50 m).	4
Coast Range Oregon	fourth-order	> 300 ft > 90 m	landslide & debris flow	About 65% of pieces and 46% of wood volume were from upslope sources by landslides or debris flows.	5
Olympic Peninsula	sixth-order	> 1,475 ft > 450 m	channel migration	95% of wood from < 870 ft (265 m). 50% of pieces from within 300 ft (92 m).	6
Southeast Alaska	16-94 ft 5-30 m	115 < d < 130 ft 35 < d < 40 m	variable	96% of all large wood from within 65 ft (20 m) and 89% of from within 33 ft (10 m). Average tree height = 74 ft (22.6 m).	7
South & Central British Columbia	3-55 ft 1-17 m	425 ft 65 m	tree mortality	90% of large wood pieces and volume delivered to stream channels from within 33 and 30 ft (10 and 9 m), respectively. Average tree height = 120 ft (37 m).	8

* 1 = Murphy and Koski 1989, 2 = McDade et al. 1990, 3 = Benda et al. 2002; 4 = May and Gresswell 2003; 5 = Reeves et al. 2003, 6 - Latterell and Naiman 2007, 7 - Martin and Grotefendt 2007, 8 - Johnston et al. 2011.

‡ Tree height from Spence et al. (1996).

Source distances are affected by tree size. In one study, source distances for approximately 90% of instream large wood from mature and old-growth conifer riparian forest in western Washington and Oregon were within 85 and 130 ft (26 m and 40 m) of the streambank, respectively (McDade et al. 1990). The difference in source distances was largely attributed to taller trees in old-growth riparian forest (mean height = 189 ft [58 m]) compared to trees in mature riparian forest (mean height = 157 ft [48 m]). Likewise, recruitment distances measured in Alaska (e.g., Murphy and Koski 1989; Martin and Grotefendt 2007) are generally shorter than those measured in Oregon (e.g., McDade et al. 1990; May and Gresswell 2003) because trees of the same species are generally shorter in Alaska than in Oregon (Table 3.3). Johnston et al. (2011) also found that large wood source distances increased with increasing tree height. For a more thorough discussion of factors affecting source distances see Benda and Bigelow (2014).

The stereotypic recruitment function describing the amount of instream wood versus recruitment distance is nonlinear (Figure 3.5). That is, areas closer to the

stream channel provide relatively more wood than areas farther from the stream channel. In southeast Alaska, for instance, 100% of large wood was recruited from within 98 ft (30 m) of the streambank, but 45% of large wood originated from within 3.3 ft (1 m) (Murphy and Koski 1989). Likewise, in a study from Oregon and Washington, 100% of large wood with an identified source was recruited from within 180 ft (55 m), but 50% of large wood with an identified source originated from 33 ft (10 m; McDade et al. 1990) (Table 3.3). The shape of the wood recruitment function, and in particular, the shape under different watershed and site-level conditions, is an important question for riparian forest management.

Although most wood is recruited from areas close to a stream (Table 3.2), areas farther from a stream cannot be discounted, especially along larger alluvial streams. Along a fourth order stream in Oregon, the sources for 65% of large wood originated on hillslopes prone to landslides and lay beyond 295 ft (90 m) from the stream channel (Reeves et al. 2003). In Washington, 50% of large wood in a fifth-order river was recruited by lateral channel migration from forests on floodplains and fluvial terraces that lay beyond 300 ft (92 m) from the riverbank (Latterell and Naiman 2007).

3.3.3. Wood Recruitment in Intensively Managed Forests

An important question for riparian area management is how does wood recruitment in second-growth or intensively managed forests differ from recruitment in unmanaged, "natural" riparian forests? The answer to this question is essential for understanding the effects of contemporary forest management on fish habitats, however, useful answers are difficult to obtain because forest practices today are much different from those of the past.

The current conditions of instream wood and riparian areas in second-growth forests are the result of past management, and over the past 100 years management practices have changed dramatically. In the early 20th century splash dams were built on small streams to sluice logs downstream (Bisson et al. 1987), a practice that flushed naturally occurring large wood from the channel. During the 1950s and 1960s wood was routinely removed from streams to "improve" fish passage (Sedell et al. 1988), and this practice continued until the 1980s (Bilby 1984). Until the 1970s, logging to the streambank was common in Oregon

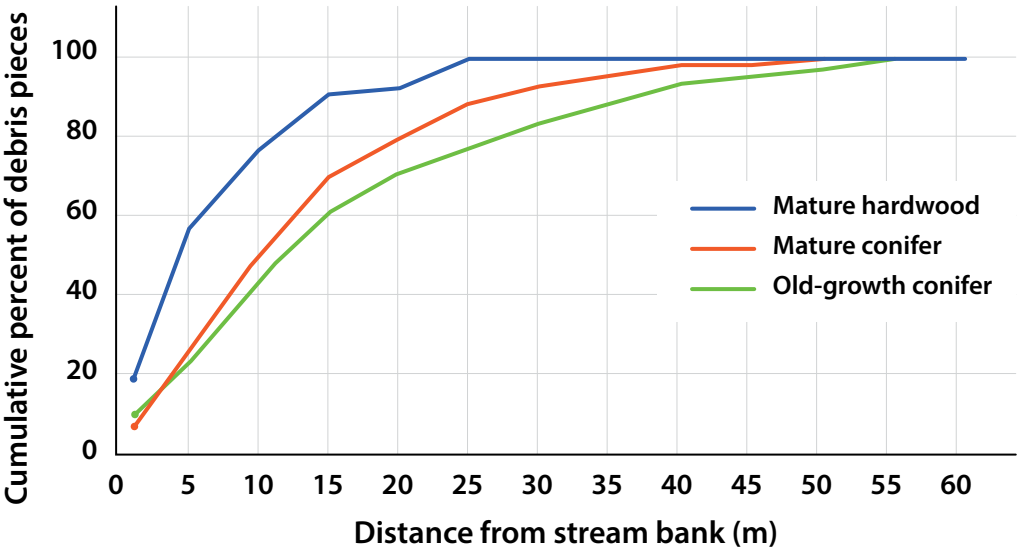


Figure 3.5. Distribution of source distances from tree origin to streambank. Empirically derived curves for old-growth conifer, mature conifer, and mature hardwood stands in western Oregon and Washington (from McDade et al. 1990). Empirically derived curves based on large wood with an identified source. One meter is equivalent to 3.3 feet.

and Washington; a practice that changed shortly after passage of the Clean Water Act of 1972. From 1987 to 2000, the Washington Forest Practices Rules required 23 to 65 trees per acre in riparian areas (WFPB 1987). In contrast, old-growth riparian areas may have 160 or more trees per acre (Acker et al. 2003). The current forest practices rule (WDNR 2005) require much wider stream-side buffers with much higher tree densities in riparian areas than pervious rules. The current regulations should result in a stand basal area equal to that of a mature conifer forest when the riparian stand is 140 years old. In short, over the past 100 years, riparian areas in intensively managed forests of Washington have been subjected to many different types of management, and over the next 100 years these same riparian areas will change dramatically.

Past forest practices are known to have severely degraded instream wood (Bilby and Ward 1991; Ralph et al. 1994), but current forest practice regulations are expected to improve instream wood (WDNR 2005). Whether current regulations will result in enough instream wood to create fish habitats that meet policy goals is unknown, and resolving that issue will be difficult until riparian areas attain their desired future conditions a century or more from now. Nevertheless, theoretical and empirical evidence suggest two main differences in large wood recruitment between second-growth, intensively managed forests and unmanaged mature and old-growth riparian forests.

Past forest practices are known to have severely degraded instream wood, but current forest practice regulations are expected to improve instream wood. Whether current regulations will result in enough instream wood to create fish habitats that meet policy goals is unknown.

First, the size of wood recruited from intensively managed forests is smaller than wood recruited from old-growth forests. Benda et al. (2002) found that the diameter of wood recruited from old-growth sites was, on average, up to twice the diameter of wood found in 50-year-old second-growth sites. Czarnomski et al. (2008) found significantly higher numbers of large wood pieces in stream segments adjacent to unmanaged mature and old-growth sites than in segments adjacent to 30- to 50-year-old intensively managed sites. From a theoretical perspective, these results are unsurprising—the dominant trees in a 200-year-old stand are much larger than the dominant trees in a 50-year-old stand. A similar relationship was also reported by McDade at al. (1990) who found that the size, both length and diameter, of instream large wood was related to forest age—wood was significantly smaller in younger forests (i.e., unmanaged mature forest versus old-growth forest).

Second, both theoretical models and empirical evidence show that maximum wood recruitment distances for intensively managed forest are less than the maximum recruitment distance for old-growth forests (McDade at al. 1990; Robison and Beschta 1990; Benda and Bigelow 2014). Again, these results are due to relative tree sizes—taller trees can contribute large wood from longer distances. The models show that the maximum recruitment distance for large wood is slightly less than the height of dominant trees; however, these models do not incorporate the recruitment processes of landslides and lateral channel migration which could substantially lengthen the maximum recruitment distance. For instance, in Benda et al. (2002) the theoretical maximum recruitment distance for their sixteen 50-year-old second-growth sites was about 98 ft (30 m), but due to landslides two sites had large wood recruited from beyond that distance—105 ft (32 m) and 210 ft (65 m). The results of Benda et al. (2002) and Benda and



Bank erosion recruits large wood into stream/Ned Pittman, WDFW

Bigelow (2014) also show that regardless of stand age or management, recruitment distances are primarily determined by recruitment processes. Riparian areas where bank erosion is the dominant process will, on average, have shorter recruitment distances, riparian areas where landslides dominate will have longer recruitment distances, and areas where other forms of tree mortality (e.g., windthrow, suppression, disease) dominate will have intermediate recruitment distances. In short, spatial variability in large wood recruitment is a function of many factors, including stream size and channel morphology, forest management, and natural disturbances such as landslides, floods, and windthrow.

3.4. Abundance of Instream Wood

3.4.1. Forested Regions of Washington

The abundance of instream large wood was much greater historically than it is today, especially in large rivers. One hundred fifty years ago, some woody debris jams on large rivers were nearly 1-mile-long (Sedell and Luchessa 1981), but

these impressive natural structures were cleared for purposes of river navigation. For instance, during the latter part of the 19th century, over 5,500 pieces of wood between 5 and 9 ft (1.5 and 2.7 m) in diameter were pulled from a 50-mile (80-km) section of the Willamette River (Sedell and Luchessa 1981). Collins et al. (2002) estimated that wood in some lowland Puget Sound rivers was 10 to 100 times greater prior to European settlement.

In contrast to large rivers, the abundance of large wood in small streams of unmanaged watersheds may still be representative of historical conditions. Fox and Bolton (2007) studied the quantities of instream large wood in natural, unmanaged forested watersheds in Washington. Ninety-six percent of their 150 sites had a stand age between 200 and 800 years (Fox 2001). In these watersheds, the processes of recruitment, decomposition, and transport were presumably undisturbed by human activities. Their findings, which are presented for forest zones and channel widths, could serve as reference or target conditions for instream large wood (Table 3.4).

3.4.2. Non-forested Regions of Washington

Fox and Bolton (2007) studied forested watersheds in forested regions (sensu Franklin and Dryness 1988), and, in fact, nearly all we know about instream wood is based on studies conducted in forested watersheds. This is unfortunate because our knowledge of instream wood for non-forested regions of Washington, such as semi-arid grasslands (i.e., steppe or Palouse) and shrub-steppe, is limited. Nevertheless, instream wood was likely to have been more abundant than it is today for two reasons.

First, in basins with headwaters in forested regions, such as the Yakima, Wenatchee, and Walla Walla basins, wood was transported downstream to shrub-steppe and grassland streams. This process is known to have occurred in other semi-arid and arid regions of the United States. Minckley and Rinne (1985) present historical evidence for the movement of large wood in rivers of the desert southwest: wood originated in forested headwaters, moved sporadically through desert riparian areas during flood events, and was ultimately deposited at the mouth of the Colorado River in Mexico. Minckley and Rinne (1985) identify interception of large wood by dams as a major cause of large wood reduction in semi-arid and arid river basins. At artificial reservoirs in eastern Washington, such as Keechelus, Kachess, Cle Elum, Bumping, Clear, and Rimrock lakes, large wood that could potentially interfere with dam operations is removed and burned (W. Meyer and B. Renfrow, Washington Department of Fish and Wildlife, personal communications). Some small water diversion dams do the same with large wood. This practice diminishes the quantity and quality of fish habitat in the Yakima and Tieton rivers, especially in their semi-arid shrub-steppe sections.

Second, riparian areas in grassland and shrub-steppe regions are inhabited by a wide variety of woody plants—Black Cottonwood *Populus balsamorhiza*, Quaking Aspen *Populus tremuloides*, White Alder *Alnus rhombifolia*, Thinleaf Alder *Alnus incana*, Water Birch *Betula occidentalis*, Black Hawthorne *Crataegus douglasii*, and Yellow Willow *Salix lutea* (Crawford 2003), and the historical abundance of woody plants in riparian areas is thought to have been much greater than it is today (Wissmar et al. 1994; Kauffman et al. 1997; Wissmar 2004). Reductions in woody plant abundance are mainly due to hydrological changes caused by water diversions for irrigation (Jamieson and Braatne 2001) and livestock grazing. Restoration projects can indicate the density of woody plants that historically existed in riparian areas prior to intensive livestock grazing. Only two years after the cessation of grazing within riparian areas in northeastern Oregon, the mean crown volume of willows and Thinleaf Alder tripled in size and that of Black Cottonwood increased 9-fold (Case and Kauffman

1997). Furthermore, shrub density increased by 50%. One possible reason for the severe impacts of grazing is that riparian vegetation in the semi-arid grassland and shrub-steppe regions of Washington evolved with little grazing by large herbivores (Mack and Thompson 1982).

With the exception of Black Cottonwood, woody plants in grassland and shrub-steppe regions do not contribute key pieces of large wood to stream channels (Table 3.1). Historically, much wood in stream channels of semi-arid regions was likely to have been small wood, and much of that small wood may have been recruited to and stored in the channel through Beaver activity. Prior to 1864, Beaver are known to have been abundant in the shrub-steppe region of central Oregon, and the eradication of Beaver from central Oregon is thought to have caused a cascade of effects: gradual disintegration of Beaver dams led to incision of streambeds, lowering of water

Table 3.4. Distributions of large wood per 100 m of stream channel by forest regions in Washington State and by bankfull width (BFW) class (Fox and Bolton 2007). Large wood was defined as pieces exceeding 10 cm (4 in) in diameter and 2 m (≈6 ft) in length. Key piece sizes are defined in Table 3.1. One meter is approximately 3.3 feet.

Forest zones	BFW Class (m)	75th Percentile	Median	25th Percentile
		Number of pieces per 100 m		
Sitka Spruce *Picea sitchensis*, Western Hemlock *Tsuga heterophylla*, Silver Fir *Abies alba*, and Mountain Hemlock *T. mertensiana*	0-6	> 38	29	< 26
	> 6-30	> 63	52	< 29
	> 30-100	> 208	106	< 57
Subalpine Fir *Abies lasiocarpa* and Grand Fir *A. grandis*	0-3	> 28	22	< 15
	> 3-30	> 56	35	< 25
	> 30-50	> 63	34	< 22
Douglas-fir *Pseudotsuga menziesii* and Ponderosa Pine *Pinus ponderosa*	0-6	> 29	15	< 5
	> 6-30	> 35	17	< 5
		Number of key pieces per 100 m		
Sitka Spruce, Western Hemlock, Silver Fir, and Mountain Hemlock	0-30	> 11	6	< 4
	> 30-100	> 4	1.3	< 1
Subalpine Fir and Grand Fir	0-15	> 4	2	< 0.5
	>15-50	> 1	0.3	< 0.5
Douglas-fir and Ponderosa Pine	0-30	> 2	0.4	< 0.5
		Volume (m^3) per 100 m		
Sitka Spruce, Western Hemlock, Silver Fir, and Mountain Hemlock	0-30	> 99	51	< 28
	> 30-100	> 317	93	< 44
Subalpine Fir and Grand Fir	0-3	> 10	8	< 3
	> 3-50	> 30	18	< 11
Douglas-fir and Ponderosa Pine	0-30	> 15	7	< 2



Wood jams are habitat features and are less common now than they were historically/Ned Pittman, WDFW

tables, loss of riparian vegetation, and subsequently deeper incision of channels (Buckley 1993). According to Pollock et al. (2007), the exact mechanism that caused widespread incision of streambeds remains uncertain, however, incision almost invariably coincided with widespread trapping of Beaver and the onset of intensive livestock grazing.

For the semi-arid grassland and shrub-steppe regions of Washington, we currently lack data with which to describe reference conditions for instream wood and for riparian plant communities. Historical reconstruction using General Land Office survey notes and historical photos is one way to develop qualitative descriptions of riparian plant communities (McAllister 2008); however, more quantitative descriptions would benefit development of management objectives. Much remains unknown about historical conditions of riparian areas in non-forested regions.

3.5. Fish, Wildlife, and Instream Wood

Authoritative reviews of the scientific literature regarding relationships between instream wood and fish or wildlife species have been written by Bisson et al. (1987), Benke and Wallace (2003), Dolloff and Warren (2003), Zalewski et al. (2003), Steel et al. (2003), and Wondzell and Bisson (2003). Certain small mammal and bird species are known to be associated with wood in stream channels (Steel et al. 2003). However, we discuss only fish, amphibians, reptiles, and invertebrates; taxonomic groups known to have strong associations with instream wood.

3.5.1. Fish

For salmonids, especially juvenile Coho Salmon, there is no more important structural component than instream wood (Bisson et al. 1987). In Puget Sound lowland streams, measures of salmonid rearing habitat were strongly linked to instream large wood abundance (May et al. 1997). In headwater streams, step pools formed by large wood were important for Dolly Varden *Salvelinus malma,* juvenile Coho Salmon, steelhead, and Cutthroat Trout *Oncorhynchus clarkii* in reaches with gradients less than 4% to greater than 10% (Bryant et al. 2007). Adult spawning Sockeye Salmon *Oncorhynchus nerka* densities were positively correlated with cover provided by large wood and undercut banks, pool area, and large wood (Braun and Reynolds 2011). The instream abundance of juvenile salmonids often is directly related to the amount of large wood (Murphy et al. 1986; Bisson et al. 1987). Stream reaches where large wood was artificially added were used by higher densities of juvenile Coho Salmon in summer and winter, and Cutthroat Trout and steelhead in winter in 30 western Oregon and Washington streams when compared to reaches where large wood was not enhanced (Roni and Quinn 2001). Spawning Coho Salmon abundance increased after instream wood structures were restored (Crispin et al. 1993). A study in British Columbia found that the biomass of yearling and older salmonids was positively correlated with stream pool volume (R^2 = 0.92) and that over 70% of pool volume was formed by large wood (Fausch and Northcote 1992).

Large wood provides both direct and indirect benefits to fish (Bisson et al. 1987). Indirect benefits are related to wood's role as a roughness element, and this role is especially obvious in smaller streams where wood

can bridge much of a channel (Zalewski et al. 2003). Large wood within a small channel dissipates flow velocity, which reduces the energy fish expend as they move upstream (Zalewski et al. 2003). Bisson et al. (1987) state that sediment storage by large wood benefits fish primarily by buffering the stream network against rapid changes in sediment load that would degrade habitats, such as rapid sediment increases due to landslides. Wood also benefits fish by increasing habitat diversity. In seeking a path around large wood obstructions, water creates complex hydraulic patterns that carve pools and side channels, form falls, and enhance channel sinuosity, imposing numerous variations in a stream's hydrology and geomorphology. Another indirect benefit of instream large wood is its influences on the availability of prey for fish in the form of macroinvertebrates. Large wood provides habitat for invertebrates, which then supplies fish with a source of food (Bisson et al. 1987).

The direct benefits of instream large wood to fish are also important. Large pieces of instream wood provide fish with refuge from high velocity flows during floods and provide hiding cover from predators (Sedell et al. 1985; Bisson et al. 1987; Braun and Reynolds 2011). Upturned tree roots and logs were the most common type of cover used by juvenile Coho Salmon and steelhead in an unlogged, west coast Vancouver Island stream (Bustard and Narver 1975). The deep pools often formed around these features made for good cover, particularly for older juveniles (Bustard and Narver 1975). After logging, almost all Coho Salmon that remained in channels over the winter sheltered in stream segments jammed with logs, with undercut banks, and in pools filled with upturned tree roots and other forest debris (Tschaplinski and Harman 1983). Hartman (1965) also found overwintering Coho Salmon fry preferring cover near logs, roots, and banks in streams in coastal British Columbia. Large wood increases fish density by visually isolating individual fish, which reduces inter- and intra-species competition (Dolloff and Reeves 1990; Crook and Robertson 1999).

3.5.2. Amphibians and Reptiles

Amphibians can be a dominant biotic component in Pacific Northwest streams (Olson et al. 2007), but in contrast to fishes and invertebrates, studies that characterize the importance of instream large wood for amphibians are sparse (Wondzell and Bisson 2003). However, diverse sources of data on stream-associated amphibian species life histories indicate that instream wood contributes to the creation and maintenance of breeding, rearing, and foraging habitats, and likely overwintering habitats as well. In particular, large wood can serve as the instream substrate for amphibian oviposition (Henry and Twitty 1940; Jones et al. 1990). Wood also forms steps in streams that promote sediment wedges (May and Gresswell 2003) that serve as variable but often extensive habitat matrices for oviposition and rearing (Nussbaum 1969; Wilkins and Peterson 2000). Moreover, wood-formed steps often create dam and plunge pools that are important for amphibian foraging or refuge (Wilkins and Peterson 2000; Welsh and Lind 2002). The basis of the former is that many aquatic invertebrates eaten by stream-associated amphibians occur in the habitat matrices created by wood-formed steps (Parker 1994; Steele and Brammer 2006; see next section). In coastal Washington headwater streams, the density of stream-associated amphibians



Van Dyke's Salamander Plethodon vandykei *use large wood for cover/ Eric Lund, WDFW*

was positively correlated with the amount of functional large wood (R^2 = 0.50), and torrent salamander (family Rhyacotritonidae) densities were positively correlated with the percentage of pools, indicating the importance of habitat complexity that large wood creates (Jackson et al. 2007). In Olympic National Park, large wood was a significant variable in explaining the densities of all three stream-associated amphibian species that were present, but its relative importance varied between species and was less important than one or more of aspect, gradient, and substrate in habitat use models for tailed frogs (family Ascaphidae) and torrent salamanders (Adams and Bury 2002).

Instream large wood is especially important for one Pacific Northwest reptile order: turtles. In the Northwest, water temperatures, even in the lowland stillwater habitats in which our two native turtle species occur, is often limiting (Holland 1994). Hence, the ability to bask securely (i.e., in a relatively predator-free environment) at temperatures that exceed those of water is critical to the normal processes of digestion and for female turtles, successfully yolking up eggs. Large floating or anchored-downed logs with enough area extending above the water surface are the key structures on which basking can occur (Holland 1994). Such structures are especially important in stillwater side- and off-channel habitats of large streams.

3.5.3. Aquatic Invertebrates

The distribution and abundance of aquatic invertebrates are influenced by instream wood and certain taxa are dependent on instream wood. In streams of all sizes, areas of wood accumulation are often also invertebrate biodiversity hot spots (Benke and Wallace 2003; Wondzell and Bisson 2003). Many aquatic invertebrates use the numerous grooves, splits, and fissures in large wood as refuges from predators and harsh environments. Other invertebrate uses of wood include



Large wood in Deschutes River/Noll Steinweg, WDFW

oviposition, case making, and emergence, especially when submerged pieces are decayed rather than firm (Harmon et al. 1986). Several families of caddisfly use wood for case construction. Of ninety-two case-making caddisfly genera reviewed by Wiggins (1977), roughly a quarter exploit bark or wood to varying degrees for case construction. Instream wood also is used as sites for oviposition above and below the water line. Many caddisflies in the family Limnephilidae deposit their egg masses on moist wood. In the Coast Range of Oregon, Wisseman and Anderson (1984) found oviposition by a number of caddisfly taxa on overhanging logs. The surfaces of instream wood also are used as nursery areas for early instars, and for resting, molting, and pupation (Anderson et al. 1978).

Large wood is especially important as substrate for invertebrates to attach to in rivers with limited sources of stable substrate (Benke and Wallace 2003). Trees that have fallen into the main channels of low-gradient rivers frequently are the only stable habitat (Benke and Wallace 2003). In these streams, wood can be especially important for periphyton and macroinvertebrate taxa to attach themselves (Benke and Wallace 2003). In contrast to smaller rivers, instream large wood shifts to channel margins and floodplains of larger rivers (Bisson et al. 1987), and hence, in these main-stem locations invertebrate densities peak (Ward et al. 1982). In headwater streams, large wood and gravel habitats supported higher densities and biomass of benthic invertebrates than cobble habitats (Hernandez et al. 2005). Coe et al. (2009) saw significantly higher densities of invertebrates in Pacific Northwest streams where engineered logjams were added. They attributed this to increased overall habitat surface area, and thereby the potential for increased productivity relative to reaches with low levels of wood. Instream large wood also supported a richer and more diverse invertebrate fauna than either cobble or gravel substrates.

Wood provides invertebrates with access to a wide variety of food sources. Large wood traps and stores



Large wood on Cedar River/Hal Beecher, WDFW

organic matter, and wood can be directly consumed by some invertebrates (Benke and Wallace 2003). Trapped organic materials are food sources for bacteria, fungi, mollusks, insects, and crustaceans. Although only a small fraction of aquatic insect taxa exploit woody debris as a source of food (Harmon et al. 1986), direct wood consumption by aquatic invertebrates in the Pacific Northwest has been observed in some species of caddisfly, mayfly, beetles, and snails (Anderson et al. 1978; Dudley and Anderson 1982; Pereira and Anderson 1982; Pereira et al. 1982). Submerged large wood may also support surface films of micro-organisms (e.g., diatoms, bacteria, fungi) that efficiently take up instream nitrogen and form a food web base for aquatic invertebrates (Dudley and Anderson 1982; Johnson et al. 2003), that in turn support vertebrate species (Ashkenas et al. 2004). By moderating pulses of fine sediment (Entrekin et al. 2009), instream large wood also acts to reduce the accumulation of sediment on algae (Richardson 2008), which is an important food to many macroinvertebrate taxa.

3.5.4. Fish and Wildlife Summary

The vital ecological role of instream wood has been known for at least 40 years (Swanson et al. 1976). Relationships between high quality salmonid habitats and instream large wood are well established (Bisson et al. 1987; Dollof and Warren 2003). Invertebrate taxa,

such as aquatic insects, are also known to rely on large wood as a habitat substrate and food source. Juvenile salmonids prey on aquatic insects. Amphibians and turtles also depend on the channel morphology and wood structure created by instream large wood.

3.6. Land Use Effects

The major human land uses in Washington–urban/suburban, agriculture, and forestry–have altered or removed extensive areas of riparian forest and have adversely impacted instream wood size, abundance, and distribution, and left many streams with a chronic deficiency of instream large wood compared to historical conditions (Maser et al. 1988; Bilby and Ward 1991; Stouder et al. 1997; May et al. 1997).

In general, the three major land uses impact instream large wood in similar ways–they diminish the amount of instream wood by reducing the number and size of trees in riparian areas. Furthermore, large wood is often purposefully removed from rivers and streams because it can block culverts or damage other human-made structures such as bridges, dams, or levees; cause streambank erosion that destroys private property; and present hazards to navigation or recreation. Culverts and dams also disrupt the transport of wood through a stream network and reduce the amount of wood in higher order streams and rivers.



Juvenile fish use large wood for shelter/WDFW

Most research on instream wood and riparian forests has occurred in unmanaged and managed forests, but much of the knowledge gained in forests–such as the functions of instream wood, natural amounts of instream wood, and recruitment mechanisms–is applicable to riparian areas in urban/suburban and agricultural settings as well, especially in forested ecoregions.

3.6.1. Forestry

Because mature conifer trees in the Pacific Northwest have large-diameter, decay-resistant boles, streams in this region have naturally high volumes of large wood compared to other parts of North America (Harmon et al. 1986). Nevertheless, harvest in and around riparian areas can result in immediate and long-term changes to the volume of instream wood. Czarnomski et al. (2008) found that instream wood volume and abundance varied significantly relative to timber harvest and adjacent tree stand age. They found instream wood volume and abundance were significantly higher in streams adjacent to unmanaged, mature and old-growth stands compared to streams along 30- to 50-year-old plantations, and significantly less in streams adjacent to 30- to 50-year-old plantations compared to those adjacent to 20- to 30-year-old plantations or mature and old-growth forest. Beechie et al. (2000) estimated that if a riparian buffer was established today in a 50-year-old stand of Douglas-fir, recovery of pool-forming large wood might take less than 100 years in small channels (e.g., ≤ 66 ft [20 m] wide), but could take as much as 200 years in larger channels.

The impacts of logging on instream large wood and aquatic habitats may not be realized for many decades after logging. In interior British Columbia, Chen et al. (2005) found that in the short term, instream large wood volume and biomass increased after logging. However, they concluded that in the long term, abundance of instream large wood may be greatly reduced as a

result of increased rates of decay, transport, and reduced recruitment from the adjacent riparian forest. With instream wood residence times averaging about 30 years, Hyatt and Naiman (2001) estimated that harvesting large riparian conifers would adversely impact aquatic habitats of large streams in about three to five decades. Murphy and Koski (1989) showed a 70% reduction of instream large wood 90 years after clearcutting without a riparian buffer. They also estimated a 250-year recovery time to pre-harvest levels.



Harvest near riparian areas can impact aquatic habitats/Marc Hayes, WDFW

The loss of riparian trees can come with long-term repercussions to functional aquatic habitat. Where riparian trees are absent, Beechie et al. (2000) predicted a lag of 7-49 and 15-91 years before pool-forming large wood could be recruited from Red Alder and Douglas-fir forests, respectively. The lag time for a given stream depends on multiple factors including channel width and the minimum size of pool-forming wood. In Alberta, instream large wood generated from stand-replacing fires was depleted within 100 years of the event but once the forests reestablished, new large wood recruitment was delayed by roughly 40 years (Powell et al. 2009).

A riparian management zone (RMZ) adjacent to logging differs in its ability to supply instream wood compared to riparian areas adjacent to unlogged uplands. On average, tree mortality was 50% greater in RMZs compared to riparian areas in unlogged landscapes, 3 to 15 years post-harvest (Martin and Grotefendt 2007). Differences in stand mortality between logged and unlogged tracts were primarily due to greater windthrow at a small proportion of RMZs in logged tracts. Additionally, downed tree recruitment from RMZ outer zones was more than double that of trees recruited in unlogged tracts. Consequently, wood recruitment increased by an average of 2 trees per 330 ft (100 m) in the buffered versus unlogged forested tracts (Martin and Grotefendt 2007).

Trees in RMZs with adjacent clear-cuts may be more susceptible to windthrow. Windthrow in RMZs (85 ft [26 m] wide on both side of streams) increased instream large wood by 34% within one to three years after logging in small streams (Grizzel and Wolff 1998). The authors of that study suggested that the RMZs adjacent to clearcuts served as a long-term source of large wood. They added that over a 10-year period, windthrow could add an average of 1.9 trees per 984 ft (300 m) of stream. Along second to fifth order streams, windthrow in RMZs was 26 times greater up to three years post-harvest compared to estimated mortality rates of trees in riparian stands in unlogged tracts (Liquori 2006). Post-harvest windthrow may reduce tree density in RMZs enough to significantly reduce competition-induced tree mortality, which in turn may lead to substantially different wood recruitment dynamics in buffers compared to unlogged forests (Liquori 2006).

3.6.2. Urban/Suburban

Very few studies have examined the impacts of development on instream large wood dynamics. In their analysis of the effects of urbanization, May et al. (1997) noted that as a basin's urbanization increased the quantity of large wood declined, as did related measures of habitat quality, namely loss of riparian forest area, reduced pool area, and decreased habitat complexity. Urban streams greater than 2% gradient and lacking large wood were found to be more susceptible to scour than less developed counterparts. Other than restoration sites where instream large wood had been replaced, high quantities of instream large wood were only found in undeveloped watersheds.

An analysis of relationships of channel characteristics, land ownership, land use, and land cover to instream large wood abundance in western Oregon showed that the most important predictor for large wood volume was land ownership, followed by stream gradient (Wing and Skaugset 2002). They also observed fewer large wood pieces in streams near rural residential areas compared to managed forests. In a study outside the Pacific Northwest, researchers in the Piedmont region of Georgia found that the absence of forest cover in catchments in suburban Atlanta corresponded to a decrease of instream large wood biomass (Roy et al. 2005).



Agricultural area in western Washington/Marlin Greene, One Earth Images

3.6.3. Agriculture

Many types of agriculture remove riparian forest, and consequently, reduce the recruitment of large wood to fish-bearing rivers and streams. Within the Nooksack River basin of northwest Washington, riparian forest along reaches accessible to anadromous fish were evaluated based on their ability to contribute instream wood large enough to form pools (Hyatt et al. 2004). Seventy-four percent of this basin's riparian forests that failed to meet this criterion were found in lowland rural-agricultural areas. In contrast, only 20% of the stands that failed to meet this threshold were in federal and commercial forestlands. This contrast is notable given that agricultural and rural areas comprised only about 22% of Nooksack basin (Hyatt et al. 2004). Similar results were observed in an analysis relating land use and land cover to instream wood abundance in western Oregon (Wing and Skaugset 2002). In this study, they found fewer pieces of large wood in streams near agricultural land uses compared to that of managed forestlands.

In shrub-steppe and grassland ecoregions of eastern Washington, livestock grazing in riparian areas significantly reduces the amount of woody vegetation. Significant reductions in woody vegetation lead to numerous adverse impacts to aquatic habitats: increased streambank erosion, increased overland flow and erosion within riparian areas, increased turbidity, reduced shade, higher water temperatures, loss of cover for fish due to reductions in overhanging vegetation and undercut banks, reduction in the amount of instream small wood, changes to channel morphology such as fewer pools, fewer meanders, and channel incision, lowering the water table, and reduction in essential nutrients derived from detritus (Belsky et al. 1999).

3.6.4. Land Use Effects Summary

Land uses that affect riparian forest also affect instream large wood. Of the three major land uses, contemporary forestry has the least effect on instream large wood. However, for all three land uses, the severity of effects depends largely on how riparian areas are managed.

3.7. Conclusions

Many effects of wood on aquatic ecosystems are well understood and not subtle, and therefore, ecologists are very confident about the critical role of wood in fish habitats. Ecologists are also confident about the role of riparian forests in supplying large wood to aquatic systems. Successful conservation of fish habitats and fish species in the forested regions of Washington depends on riparian forest management that delivers adequate wood to aquatic ecosystems. From a management perspective, the main scientific uncertainties are: 1) the shape of the wood recruitment function (e.g., Figure 3.5), especially the shape under different watershed and site-level conditions; and 2) the potential contributions from recruitment mechanisms outside the riparian forest, such as landslides, debris flows, or extreme channel migration. Addressing these uncertainties through research could lead to more ecologically effective and economically efficient management of riparian areas.

To maintain or restore 100% of a site's large wood recruitment potential, the site's composition and structure should be similar to that of an unmanaged riparian forest. Given current uncertainties, re-establishing riparian forest similar to unmanaged, mature or old-growth forests should be the most reliable way to provide instream large wood sizes and abundance that are similar to historical levels.

An important management question is: what are source distances for large wood recruitment from riparian areas to aquatic ecosystems? We know that source distances for wood in riparian areas are a function of tree height—source distances are longer for riparian forests with taller trees. We also know that tree heights for old-growth conifer forests can exceed 200 ft (60 m). In Washington State, Fox (2003) found that mean heights of canopy trees in old-growth riparian areas (i.e., stand age > 200 years old) ranged from 100 to 240 ft (30 to 73 m). Height variation among riparian areas was largely explained by forest zone and site productivity class. If large wood has a minimum diameter of 4 in (10 cm), then only that portion of a tree's stem greater than 4 in (10 cm) in diameter is large wood. From tree taper equations for Douglas-fir (Biging 1984), we know that for trees between 100 to 240 ft (30 and 73 m) tall about 15 to 3 percent of the stem is not large wood, respectively.[3] In other words, for the purpose of large wood recruitment, the "effective" tree height (*sensu* Robison and Beschta. 1990; Van Sickle and Gregory 1990) ranges from 85 to 230 ft (26 to 70 m), depending on site productivity class. Therefore, in forested ecoregions, 100% of a site's large wood recruitment potential, is located about 85 to 230 ft (26 to 70 m) from the stream channel, depending on site productivity class. These source distances only account for trees recruited via bank erosion, windthrow, or tree mortality. It does not account for large wood recruited to the stream channel through landslides or debris flows, nor does it account for recruitment through extreme channel migration in large river floodplains. In addition, this does not account for source distances of small wood. Source distances for small wood equal a full tree height from the stream channel.

Ecologists are confident about the critical role of wood in creating fish habitat and the role of riparian forests in supplying large wood to aquatic systems.

[3] Effective tree height calculations were done in Microsoft Excel with equations from Robison and Beschta (1990) and Biging (1984).

3.8. Literature Cited[4]

Abbe, T.B., and D.R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers: Research & Management 12:201-221. (i)

Acker, S.A., S.V. Gregory, G. Lienkaemper, W.A. McKee, F.J. Swanson, and S.D. Miler. 2003. Composition, complexity, and tree mortality in riparian forests in the central western Cascades of Oregon. Forest Ecology and Management 173:293-308. (i)

Adams, M. J., and R. B. Bury. 2002. The endemic headwater stream amphibians of the American Northwest: associations with environmental gradients in a large forested preserve. Global Ecology & Biogeography 11:169-178. (i)

Anderson, N.H., J.R. Sedell, L.M. Roberts, and F.J. Triska. 1978. The role of aquatic invertebrates in processing of wood debris in coniferous forest streams. The American Midland Naturalist 100:64–82. (i)

Barnes, D.M., and A.U. Mallik. 1996. Use of woody plants in construction of Beaver dams in northern Ontario. Canadian Journal of Zoology 74:1781-1786. (i)

Beechie, T.J., G. Pess; P. Kennard, R.E. Bilby, and S. Bolton. 2000. Modeling recovery rates and pathways for woody debris recruitment in northwestern Washington streams. North American Journal of Fisheries Management 20:436-452. (i)

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54:419-431. (i)

Benda, L., and P. Bigelow. 2014. On the patterns and processes of wood in northern California streams. Geomorphology 209:79-97. (i)

Benda, L.E., P. Bigelow, and T.M. Worsley. 2002. Recruitment of wood to streams in old-growth and second-growth redwood forests, northern California, U.S.A. Canadian Journal of Forest Research 32:1460-1477. (i)

Benda, L., D. Miller, J. Sias, D. Martin, R. Bilby, C. Veldhuisen, and T. Dunne. 2003. Wood recruitment processes and wood budgeting. Pages 49-74 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Benke, A.C., and J.B. Wallace. 2003. Influence of wood on invertebrate communities in streams and rivers. Pages 149-178 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Beschta, R.L. 1979. Debris removal and its effects on sedimentation in an Oregon Coast Range stream. Northwest Science 53:71-77. (i)

Biging, G.S. 1984. Taper equations for second-growth mixed conifers of northern California. Forest Science 30:1103-1117. (i)

Bilby, R.E. 1981. Role of organic debris dams in regulating the export of dissolved and particulate matter from a forested watershed. Ecology 62:1234-1243. (i)

Bilby, R.E. 1984. Removal of woody debris may affect stream channel stability. Journal of Forestry 82:609-613. (i)

Bilby, R.E. 2003. Decomposition and nutrient dynamics of wood in streams and rivers. Pages 135-148 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Bilby, R.E., and P.A. Bisson. 1998. Function and distribution of large woody debris. Pages 324-346 *in* R.J. Naiman and R.E. Bilby, editors. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. (i)

Bilby, R.E., and G.E. Likens. 1980. Importance of organic debris dams in the structure and function of stream ecosystems. Ecology 61:1107-1113. (i)

4 References are classified according to RCW 34.05.271 (see Appendix 1) denoted by a lower case roman numeral (i – viii) in parentheses at the end of the citation.

Bilby, R.E., and J.W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society 118:368-378. (i)

Bilby, R.E., and J.W. Ward. 1991. Characteristics and function of large woody debris in streams draining old-growth, clear-cut, and second-growth forests in southwestern Washington. Canadian Journal of Fisheries and Aquatic Sciences 48:2499-2508. (i)

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dollof, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, and future. Pages 143-190 *in* E.O. Salo, and T.W. Cundy, editors. Streamside management: forestry and fishery interactions. Contribution No. 57. Institute of Forest Resources, University of Washington, Seattle. (viii)

Bisson, P.A., S.M. Wondzell, G.H. Reeves, and S.V. Gregory. 2003. Trends in using wood to restore aquatic habitats and fish communities in western North America. Pages 391-406 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Blersch, D.M., and P.C. Kangas. 2014. Signatures of self-assembly in size distributions of wood members in dam structures of *Castor canadensis.* Global Ecology and Conservation 2:204-213. (i)

Boyer, K.L., D.R. Berg and S.V. Gregory. 2003. Riparian management for wood in rivers. Pages 407-420 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Brookshire, E.N.J., and K.A. Dwire. 2003. Controls on patterns of coarse organic particle retention in headwater streams. Journal of the North American Benthological Society 22:17-34. (i)

Braun, D.C., and J.D. Reynolds. 2011. Relationships between habitat characteristics and breeding population densities in Sockeye Salmon. Canadian Journal of Fisheries and Aquatic Sciences 68:758-767. (i)

Bryant, M.D., T. Gomi, and J.J. Piccolo. 2007. Structures linking physical and biological processes in headwater streams of the Maybeso Watershed, southeast Alaska. Forest Science 53:371-383. (i)

Buckley, G.L. 1993. Desertification of the Camp Creek Drainage in central Oregon. Yearbook of the Association of Pacific Coast Geographers 55:91-126. (i)

Bustard, D.R., and D.W. Narver. 1975. Aspects of the winter ecology of juvenile Coho Salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 32:667-680. (i)

Carah, J.K., C.C. Blencowe, D.W. Wright, and L.A. Bolton. 2014. Low-cost restoration techniques for rapidly increasing wood cover in coastal Coho Salmon streams. North American Journal of Fisheries Management 34(5):1003-1013. (i)

Case, T.L., and J.B. Kauffman. 1997. Wild ungulate influence on the recovery of willows, Black Cottonwood, and Thin-leaf Alder following cessation of cattle grazing in northeastern Oregon. Northwest Science 71:115-126. (i)

Cederholm, C.J., D.B. Houston, D.L. Cole, and W.J. Scarlett. 1989. Fate of Coho Salmon (*Oncorhynchus kisutch*) carcasses in spawning streams. Canadian Journal of Fisheries and Aquatic Sciences 46:1347-1355. (i)

Cederholm, C.J., and N.P. Peterson. 1985. The retention of Coho Salmon (*Oncorhynchus kisutch*) carcasses by organic debris in small streams. Canadian Journal of Fisheries and Aquatic Sciences 42:1222-1225. (i)

Chen, X., X. Wei, and R. Scherer. 2005. Influence of wildfire and harvest on biomass, carbon pool, and decomposition of large woody debris in forested streams of southern interior British Columbia. Forest Ecology and Management 208:101-114. (i)

Coe, H.J., P.M. Kiffney, G.R. Pess, K.K. Kloehn, and M.L. McHenry. 2009. Periphyton and invertebrate response to wood placement in large Pacific coastal rivers. River Research and Applications 25:1025-1035. (i)

Collen, P., and R.J. Gibson. 2001. The general ecology of Beavers (*Castor* spp.), as related to their influence in stream ecosystems and riparian habitats, and the subsequent effects on fish—a review. Reviews in Fish Biology and Fisheries 10:439-461. (i)

Collins, B.D., D.R. Montgomery, and A.D. Haas 2002. Historical changes in the distribution and functions of large wood in Puget lowland rivers. Canadian Journal of Fisheries and Aquatic Sciences 59:66-76. (i)

Crawford, R.C. 2003. Riparian vegetation classification of the Columbia Basin, Washington. Natural Heritage Program Report 2003-03. Washington Department Natural Resources. Olympia, Washington. (viii)

Crispin, V., R. House, and D. Roberts. 1993. Changes in instream habitat, large woody debris, and salmon habitat after the restructuring of a coastal Oregon stream. North American Journal of Fisheries Management 13:96-102. (i)

Crook, D A., and A.I. Robertson. 1999. Relationship between riverine fish and woody debris: implications for lowland rivers. Marine and Freshwater Research 50:941-953. (i)

Czarnomski, N.M., D.M. David, K.U. Snyder, J.A. Jones, and F.J. Swanson. 2008. Dynamics of wood in stream networks of the western Cascades Range, Oregon. Canadian Journal of Forest Research 38:2236-2248. (i)

Dolloff, C.A., and C.H. Reeves. 1990. Microhabitat partitioning among stream-dwelling juvenile Coho Salmon, *Oncorhynchus kisutch,* and Dolly Varden, *Salvelinus malma.* Canadian Journal of Fisheries and Aquatic Sciences 47:2297-2306. (i)

Dolloff, C.A., and M.L. Warren. 2003. Fish relationships with large wood in small streams. Pages 179-194 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Dominguez, L.G., and C.J. Cederholm. 2000. Rehabilitating stream channels using large woody debris with considerations for salmonid life history and fluvial geomorphic processes. Pages 545-563 *in* E.E. Knudsen, C.R. Steward, D.D. MacDonald, J.E. Williams, and D.W. Reiser, editors. Sustainable fisheries management: Pacific salmon. Lewis Publishers, New York. (i)

Dudley T., and N.H. Anderson. 1982. A survey of invertebrates associated with wood debris in aquatic habitats. Melanderia 39:1-21. (i)

Entrekin, S.A., J.L. Tank, E.J. Rso-Marshall, T.J. Hoellein, and G.A. Lamberti. 2009. Response of secondary production by macroinvertebrates to large wood addition in three Michigan streams. Freshwater Biology 54:1741-1758. (i)

Ehrman, T.P., and G.A. Lamberti. 1992. Hydraulic and particulate matter retention in a 3rd-order Indiana stream. Journal of the North American Benthological Society 11:341-349. (i)

Fausch, K.D., and T. G. Northcote. 1992. Large woody debris and salmonid habitat in a small coastal British Columbia stream. Canadian Journal of Fisheries and Aquatic Sciences 49:682-693. (i)

Fetherston, K.L., R.J. Naiman, and R.E. Bilby. 1995. Large woody debris, physical process, and riparian forest development in montane river networks of the Pacific Northwest. Geomorphology 13:133-144. (i)

Fox, M.J. 2001. A new look at the quantities and volumes of instream wood in forested basins within Washington State. Master's thesis. University of Washington, Seattle. (i)

Fox, M.J. 2003. Spatial organization, position, and source characteristics of large woody debris in natural systems. Doctoral dissertation. University of Washington, Seattle. (i)

Fox, M., and S. Bolton. 2007. A regional and geomorphic reference for quantities and volumes of instream wood in unmanaged forested basins of Washington State. North American Journal of Fisheries Management 27:342-359. (i)

Franklin, J.F., and C.T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University press, Corvallis, Oregon. (i)

Gregory, K.J. 2003. The limits of wood in world rivers: present, past, and future. Pages 1-19 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Gregory, S.V., K.L. Boyer, and A.M. Gurnell, editors. 2003. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones: focus on links between land and water. Bioscience 41:540-551. (i)

Grizzel, J.D., and N. Wolff. 1998. Occurrence of windthrow in forest buffer strips and its effect on small streams in northwest Washington. Northwest Science 72: 214-223. (i)

Gurnell, A.M. 2003. Wood storage and mobility. Pages 75-92 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Gurnell, A.M., K.J. Gregory, and G.E. Petts. 1995. The role of coarse woody debris in forest aquatic habitats: implications for management. Aquatic Conservation: Marine and Freshwater Ecosystems 5:143-166. (i)

Gurnell, A.M., H. Piégay, F.J. Swanson, and S.V. Gregory. 2002. Large wood and fluvial processes. Freshwater Biology 47:601-619. (i)

Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkaemper, K. Cromack, and K.W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. Advances in Ecological Research 15:133–302. (i)

Hartman, G.F. 1965. The role of behavior in the ecology and interaction of underyearling Coho Salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Board of Canada 22:1035-1081. (i)

Hassan, M.A., D.L. Hogan, S.A. Bird, C.L. May, T. Gomi, and D. Campbell. 2005. Spatial and temporal dynamics of wood in headwater streams of the Pacific Northwest. Journal of the American Water Resources Association 41:899-919. (i)

Henry, W.V., and V.C. Twitty. 1940. Contributions to the life histories of *Dicamptodon ensatus* and *Ambystoma gracile*. Copeia 1940:247-250. (i)

Heede, B.H. 1972. Influences of a forest on the hydraulic geometry of two mountain streams. Water Resources Bulletin 8:523-530. (i)

Hernandez, O., R.W. Merritt, and M.S. Wipfli. 2005. Benthic invertebrate community structure is influenced by forest succession after clearcut logging in southeastern Alaska. Hydrobiologia 533:45-59. (i)

Holland D.C. 1994. The Western Pond Turtle: habitat and history. Bonneville Power Administration, Wildlife Diversity Program, BP-62137-1, unpublished report, Portland, Oregon. (viii)

Hyatt, T.L., and R.J. Naiman. 2001. The residence time of large woody debris in the Queets River, Washington, USA. Ecological Applications 11:191-202. (i)

Hyatt, T.L., T.Z. Waldo, and T.J. Beechie. 2004. A watershed scale assessment of riparian forests, with implications for restoration. Restoration Ecology 12:175-175. (i)

Jackson, C.R., D.P. Batzer, S.S. Cross, S.M. Haggerty, and C.A. Sturm. 2007. Headwater streams and timber harvest: channel, macroinvertebrate, and amphibian response and recovery. Forest Science 53:356-370. (i)

Jamieson, B., and J. Braatne. 2001. Riparian cottonwood ecosystems and regulated flows in Kootenai and Yakima subbasins: impacts of flow regulation on riparian cottonwood forests of the Yakima River. BPA Report DOE/BP-00000005-3. Bonneville Power Administration, Portland, Oregon. (viii)

Johnson, L. B., D.H. Breneman, and C. Richards. 2003. Macroinvertebrate community structure and function associated with large wood in low gradient streams. River Research and Applications 19:199-218. (i)

Johnston, N.T., S.A. Bird, D.L. Hogan, and E.A. MacIsaac. 2011. Mechanisms and source distances for the input of large woody debris to forested streams in British Columbia, Canada. Canadian Journal of Forest Research 41:2231-2246. (i)

Jones, L.L.C., R.B. Bury, and P.S. Corn. 1990. Field observation on the development of a clutch of Pacific Giant Salamander (*Dicamptodon tenebrosus*) eggs. Northwestern Naturalist 71:93-94. (i)

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries 22:12-24. (i)

Keller, E.A., and F.J. Swanson. 1979. Effects of large organic material on channel form and fluvial processes. Earth Surface Processes 4:361-380. (i)

Latterell, J.J., and R.J. Naiman. 2007. Sources and dynamics of large logs in a temperate floodplain river. Ecological Applications 17:1127-1141. (i)

Liquori, M.K. 2006. Post-harvest riparian buffer response: implications for wood recruitment modeling and buffer design. Journal of the American Water Resources Association 42:177-189. (i)

Mack, R.N., and J.N. Thompson 1982. Evolution in steppe with few large, hooved mammals. American Naturalist 119:757-773. (i)

Martin, D.J., and L.E. Benda. 2001. Patterns of instream wood recruitment and transport at the watershed scale. Transactions of the American Fisheries Society 130:940-958. (i)

Martin, D.J., and R.A. Grotefendt. 2007. Stand mortality in buffer strips and the supply of woody debris to streams in Southeast Alaska. Canadian Journal of Forest Research 37:36-49. (i)

Maser, C.M., R.F. Tarrant, J.M. Trappe, and J.F. Franklin, editors. 1988. From the forest to the sea: a story of fallen trees. PNW-GTR-229. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

May, C.L., and R.E. Gresswell. 2003. Large wood recruitment and redistribution in headwater streams in the southern Oregon Coast Range, USA. Canadian Journal of Forest Research 33:1352-1362. (i)

May, C.W., R.R. Horner, J.R. Karr, B.W. Mar, and E.B. Welch. 1997. Effects of urbanization on small streams in the Puget Sound Lowland Ecoregion. Watershed Protection Techniques 2(4):485-494. (i)

McAllister, L.S. 2008. Reconstructing historical riparian conditions for two river basins in eastern Oregon, USA. Environmental Management 42:412-425. (i)

McDade, M.H., F.J. Swanson, W.A. McKee, J.F. Franklin, and J.V. Sickle. 1990. Source distances for coarse woody debris entering small streams in western Oregon and Washington. Canadian Journal of Forest Research 20:326-330. (i)

Minckley, W.L., and J.N. Rune. 1985. Large woody debris in hot-desert streams: an historical overview. Desert Plants 7(3):142-153. (i)

Montgomery, D.R., and J.M. Buffington. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin 109:596–611. (i)

Montgomery, D.R., J.M. Buffington, R.D. Smith, K.M. Schmidt, and G. Pess. 1995. Pool spacing in forest channels. Water Resources Research 31:1097-1105. (i)

Murphy, M.L., J. Heifetz, S.W. Johnson, K.V. Koski, and J.F. Thedinga. 1986. Effects of clear-cut logging with and without buffer strips on juvenile salmonids in Alaskan streams. Canadian Journal of Fisheries and Aquatic Sciences 43:1521-1533. (i)

Murphy, M.L., and K.V. Koski. 1989. Input and depletion of woody debris in Alaska streams and implications for streamside management. North American Journal of Fisheries Management 9:427-436. (i)

Naiman, R.J., E.V. Balian, K.K. Bartz, R.E. Bilby, and J.J. Latterell. 2002a. Dead wood dynamics in stream ecosystems. Pages 23-47 *in* W.F. Laudenslayer, P.J. Shea, B.E. Valentine, C.P Weatherspoon, and T.E. Lisle, technical coordinators. Proceedings of the symposium on the ecology and management of dead wood in western forests. PSW-GTR-181. U.S. Forest Service, Pacific Southwest Research Station, Portland, Oregon. (viii)

Naiman, R.J., R.E. Bilby, and P.A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. BioScience 50:996-1011. (i)

Naiman, R.J., R.E. Bilby, D.E. Schindler, and J.M. Helfield. 2002b. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. Ecosystems 5:399–417. (i)

Naiman, R.J., C.A. Johnston, and J.C. Kelley. 1988. Alteration of North American streams by Beaver. BioScience 38:753-762. (i)

Naiman, R.J., and J.R. Sedell. 1979. Characterization of particulate organic matter transported by some Cascade Mountain streams. Journal of the Fisheries Research Board of Canada 36:17-31. (i)

Nakamura, F., and F.J. Swanson. 1993. Effects of coarse woody debris on morphology and sediment storage of a mountain stream system in western Oregon. Earth Surface Processes and Landforms 18:43-61. (i)

Nussbaum, R.A. 1969. Nests and eggs of the Pacific Giant Salamander, *Dicamptodon ensatus* (Eschsacholtz). Herpetologica 25:257–262. (i)

Olson, D.H., P.D. Anderson, C.A. Frissell, H.H. Welsh Jr., and D.F. Bradford. 2007. Biodiversity management approaches for stream–riparian areas: perspectives for Pacific Northwest headwater forests, microclimates, and amphibians. Forest Ecology and Management 246: 81-107. (i)

Parker, M.S. 1994. Feeding ecology of stream-dwelling Pacific Giant Salamander larvae (*Dicamptodon tenebrosus*). Copeia 1994:705-718. (i)

Pereira, C.R.D., and N.H. Anderson. 1982. Observations on the life history and feeding of *Cinygma integrum* (Eaton) and *Ironodes nitidus* (Eaton) (*Ephemeroptera: Heptageniidae*). Melanderia 39:35-45. (i)

Pereira, C.R.D., N.H. Anderson, and T. Dudley. 1982. Gut content analysis of aquatic insects from wood substrates. Melanderia 39:23-33. (i)

Piégay, H. 2003. Dynamics of wood in large rivers. Pages 109-134 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Pollock, M.M., T.J. Beechie, and C.E. Jordan. 2007. Geomorphic changes upstream of Beaver dams in Bridge Creek, an incised stream channel in the interior Columbia River basin, eastern Oregon. Earth Surface Processes and Landforms 32:1174-1185. (i)

Pollock, M.M., M. Heim, and D. Werner. 2003. Hydrological and geomorphic effects of Beaver dams and their influence on fishes. Pages 213-233 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Pollock, M.M., G. Lewallen, K. Woodruff, C.E. Jordan, and J.M. Castro, editors. 2015. The Beaver restoration guidebook: working with Beaver to restore streams, wetlands, and floodplains. Version 1.02. U.S. Fish and Wildlife Service, Portland, Oregon. (viii)

Powell, S.R., L.D. Daniels, and T.A. Jones. 2009. Temporal dynamics of large woody debris in small streams of the Alberta foothills, Canada. Canadian Journal of Forest Research 39:1159-1170. (i)

Ralph, S.C., G.C. Poole, L.L. Conquest, and R.J. Naiman. 1994. Stream channel morphology and woody debris in logged and unlogged basins of western Washington. Canadian Journal of Fisheries and Aquatic Sciences 51:37-51. (i)

Reeves, G.H., K.M. Burnett, and E.V. McGarry. 2003. Sources of large wood in the main stem of a fourth-order watershed in coastal Oregon. Canadian Journal of Forest Research 33:1363-1370. (i)

Reich, M., J.L. Kershner, and R.C. Wildman. 2003. Restoring streams with large wood: a synthesis. Pages 355-366 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Reimchen T.E., D. Mathewson, M.D. Hocking, J. Moran, and D. Harris. 2003. Isotopic evidence for enrichment of salmon-derived nutrients in vegetation, soil, and insects in riparian zones in coastal British Columbia. Pages 59-69 *in* J. Stockner, editor. Nutrients in salmonid ecosystems: sustaining production and

biodiversity. American Fisheries Society, Symposium 34, Bethesda, Maryland. (i)

Rhoads, B.L. 1988. Mutual adjustments between process and form in a desert mountain fluvial system. Annals of the Association of American Geographers 78:271-287. (i)

Richardson, J.S. 2008. Aquatic arthropods and forestry: effects of large-scale land use on aquatic systems in Nearctic temperate regions. The Canadian Entomologist 140:495-509. (i)

Robison, E.G., and R.L. Beschta. 1990. Identifying trees in riparian areas that can provide coarse woody debris. Forest Science 36:790-801. (i)

Roni, P., T.J. Beechie, G.R. Pess, and K.M. Hanson. 2014. Wood placement in river restoration: fact, fiction and future direction. Canadian Journal of Fisheries and Aquatic Sciences 72(3):466-478. (i)

Roni, P., and T.P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. Canadian Journal of Fisheries and Aquatic Sciences 58:282–292. (i)

Roy, A.H., C.L. Faust, M.C. Freeman, and J.L. Meyer. 2005. Reach-scale effects of riparian forest cover on urban stream ecosystems. Canadian Journal of Fisheries and Aquatic Sciences 62:2312-2329. (i)

Schuett-Hames, D., A.E. Pleus, J. Ward, M. Fox, and J. Light. 1999. Method manual for the large woody debris survey. TFW-AM9-99-004. Forest Practices Division, Washington Department of Natural Resources, Olympia, Washington. (viii)

Sedell, J.R., P.A. Bisson, F.J. Swanson, and S.V. Gregory. 1988. What we know about large trees that fall into stream and rivers. Pages 47-80 *in* C.M. Maser, R.F. Tarrant, J.M. Trappe, and J.F. Franklin, editors. From the forest to the sea: a story of fallen trees. PNW-GTR-229. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

Sedell, J.R., and K.J. Luchessa. 1981. Using the historical record as an aid to salmonid habitat enhancement. Pages 210-233 *in* N.B. Arementrout, editor. Acquisition and utilization of aquatic habitat inventory information. American Fisheries Society, Bethesda, Maryland. (i)

Sedell, J.R., F.J. Swanson, and S.V. Gregory. 1985. Evaluating fish response to woody debris. Pages 222-245 *in* T.J. Hassler, editor. Pacific Northwest stream habitat management workshop. Humboldt State University, Arcata, California. (viii)

Spence, B.C., G.A., Lomnicky, R.M. Hughes, and R.P Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corporation, Corvallis, Oregon. (viii)

Spies, T., M. Pollock, G. Reeves, and T. Beechie. 2013. Effects of riparian thinning on wood recruitment: a scientific synthesis. Science Review Team Wood Recruitment Subgroup, Forest Science Laboratory, Corvallis, Oregon. (viii)

Steel, E.A., W.H. Richards, and K.A. Kelsay. 2003. Wood and wildlife: benefits of river wood to terrestrial and aquatic vertebrates. Pages 235-248 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Steele, C.A., and C. Brammer. 2006. Dietary overlap in giant salamanders (*Dicamptodon*): applying null models to resource partitioning. Western North American Naturalist 66:115-120. (i)

Stouder, D.J., P.A. Bisson, and R.J. Naiman, editors. 1997. Pacific salmon and their ecosystems: status and future options. Chapman & Hall, New York. (i)

Sullivan, K, T.E. Lisle, C.A. Dolloff, G.E. Grant, and L.M. Reid. 1987. Stream channels: the link between forests and fishes. Pages 30-97 *in* E.O. Salo and T.W. Cundy, editors. Streamside management: forestry and fishery interactions. Contribution No. 57. Institute of Forest Resources, University of Washington, Seattle. (viii)

Swanson, F.J., G.W. Lienkaemper, and J.R. Sedell. 1976. History, physical effects, and management implications of large organic debris in western Oregon streams. PNW-GTR-56. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

Tschaplinski, P.J., and G.F. Hartman. 1983. Winter distribution of juvenile Coho Salmon (*Oncorhynchus kisutch*) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Canadian Journal of Fisheries and Aquatic Sciences 40:452-461. (i)

Van Sickle, J., and S.V. Gregory. 1990. Modeling inputs of large woody debris from falling trees. Canadian Journal Forest Research 20:1593-1601. (i)

Ward, G.H., K.W. Cummins, R.W. Speaker, A.K. Ward, S.V. Gregory, and T.L. Dudley. 1982. Habitat and food resources for invertebrate communities in South Fork Hoh River, Olympic National Park. Pages 9-14 *in* E.E. Starkey, J.F. Franklin, and J.W. Matthews, editors. Ecological research in national parks of the Pacific Northwest. Forest Research Laboratory, Oregon State University, Corvallis, Oregon. (viii)

WDNR (Washington Department of Natural Resources). 2005. Forest practices habitat conservation plan. Forest Practices Division, Washington Department of Natural Resources, Olympia, Washington. (v)

Welsh, H.H., Jr., and A.J. Lind. 2002. Multiscale habitat relationships of stream amphibians in the Klamath-Siskiyou Region of California and Oregon. Journal of Wildlife Management 66:581-602. (i)

WFPB (Washington Forest Practices Board). 1987. Proposed forest practices rule and regulations: final environmental impact statement. Washington Forest Practices Board, Washington Department of Natural Resources, Olympia, Washington. (v)

WFPB (Washington Forest Practices Board). 2011. Board manual: standard methodology for conducting watershed analysis. Version 5.0. Appendix F: Fish habitat module. Washington Forest Practices Board, Washington Department of Natural Resources, Olympia, Washington. (v)

Wiggins, G.B. 1977. Larvae of North American Caddisfly Genera (Trichoptera). 1st Edition. University of Toronto Press, Ontario, Canada. (i)

Wilkins, R.P., and N.P. Peterson. 2000. Factors related to amphibian occurrence and abundance in headwater streams draining second-growth Douglas-fir forests in southwestern Washington. Forest Ecology and Management 139:79-79. (i)

Wing, M.G., and A. Skaugset. 2002. Relationships of channel characteristics, land ownership, and land use patterns to large woody debris in western Oregon streams. Canadian Journal of Fisheries and Aquatic Sciences 59:796-807. (i)

Wisseman, R.W., and N.H. Anderson. 1984. Mortality factors affecting trichoptera eggs and pupae in an Oregon coast range watershed. Pages 455-460 *in* J.C. Morse, editor. Proceedings of the 4th International Symposium on Trichoptera. Dr W. Junk Publishers, The Hague, Netherlands. (viii)

Wissmar, R.C. 2004. Riparian corridors of eastern Oregon and Washington: functions and sustainability along lowland-arid to mountain gradients. Aquatic Sciences 66:373-387. (i)

Wissmar, R.C., J.E. Smith, B.A. McIntosh, H.W. Li, and G.H. Reeves. 1994. A history of resource use and disturbance in riverine basins of eastern Oregon and Washington (early 1800s-1990s). Northwest Science 68 (special issue):1-35. (i)

Wondzell, S.M., and P.A. Bisson. 2003. Influence of wood on aquatic biodiversity. Pages 249-264 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Zalewski, M., M. Lapinska, and P.B. Bayley. 2003. Fish relationships with wood in large rivers. Pages 194-212 *in* S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Symposium 37, Bethesda, Maryland. (i)

Chapter 4. Stream Temperature

By: Kirk L. Krueger, Daniel J. Isaak, and Marc P. Hayes

4.1. Introduction

The great diversity of Washington's landscapes creates equally diverse stream thermal conditions (Figure 4.1). Broad ranges in elevation (0 -14,000 ft, 0 - 4,300 m), precipitation, stream size, topography, and other factors contribute to some streams having average summer temperatures as low as 39°F (4°C); whereas others only a few miles away may exceed 68°F (20°C). Much of that thermal heterogeneity is dictated by effectively immutable geomorphic attributes of landscapes (e.g., elevation, aspect, topographic slope), which affect the potential amount of solar radiation available at a given location (Boyd and Kasper 2003). However, the types of riparian vegetation and their condition also play important roles in determining the amount of solar radiation that reaches a stream's surface. Through management of riparian ecosystem conditions, especially vegetation, the spatiotemporal distribution of stream temperatures (i.e., thermal regime) (Boyd and Kasper 2003; Caissie 2006) can be affected, which in turn, directly and indirectly affect the survival and productivity of aquatic species (Beschta et al. 1987; McCullough 1999) including salmon.

Shade can substantially reduce the amount of direct (shortwave) solar radiation, usually the main cause of heating, that reaches a stream (Poole and Berman 2001). Indirect effects of riparian vegetation include, but are not limited to, maintenance of channel form and



Pink Salmon Oncorhynchus gorbuscha *moving upstream to spawn/Ned Pittman, WDFW*

hyporheic connectivity (Gregory et al. 1991; Stanford 1998; Poole and Berman 2001) that also affect stream temperatures (Boyd and Kasper 2003; Webb et al. 2008). Maintaining and restoring riparian ecosystem functions and the thermal regimes of aquatic systems is increasingly important in light of climate change and as land use intensifies. Land use can strongly influence the intensity, timing, duration, and geographic distributions (i.e., structure) of stream temperatures (NRC 2002).

In this chapter we briefly summarize the results of our literature review, and present a simple conceptual model that identifies components (environmental factors) and structures (relations of components) that affect stream temperatures, to facilitate understanding of potential effects of different management alternatives. We also briefly discuss considerations of the effects of riparian management on stream thermal regime within a watershed or stream network context, the sensitivity of some priority species to changes in stream thermal regime, and applications of current scientific information to riparian management for suitable thermal regimes for aquatic species. Much of the literature describing the effects of human activity on stream temperature has focused on summer maximum water temperatures. Increasingly, scientists are focusing on better understanding stream thermal regimes, which describe how the temperature of streams varies through time and throughout stream networks. This shift recognizes two important ideas: 1) fish and other aquatic organism use different stream habitats, defined in part by specific water temperature ranges, to complete their life cycle, and 2) heat energy inputs into streams are variable in space and time and heat energy is often carried downstream of the reach from which it was gained.

Our review of the scientific literature on the effects of riparian conditions on stream temperatures was extensive; including more than 6,000 articles relevant to riparian ecosystem research, of which more than 700 referenced stream temperatures and over 100 that referred to or reported measured effects of riparian ecosystem conditions on stream temperatures. Our work also identifies research to inform management recommendations that are applicable across a wide range of environmental conditions (e.g., various latitudes, topographies, and land uses). Further, we wanted to address the broad range of thermal conditions that are important to aquatic species (e.g., frequency, duration, intensity, and predictability of summer high temperatures and temperatures during incubation (Lytle and Poff 2004); and the geographic distribution of stream temperatures (Torgersen et al. 1999; Poole et al. 2001; Ebersole et al. 2003a). Therefore, we reference additional scientific information to provide the context that allows for better understanding and application of riparian ecosystem-specific information. Several reviews were particularly valuable in directing our efforts (e.g., Elmore and Kauffman 1994; May 2003; Moore et al. 2005; Sather and May 2007; Bowler et al. 2012; Czarnomski and Hale 2013).

Scientists are focusing on better understanding stream thermal regimes, which describe how the temperature of streams varies through time and throughout stream networks.

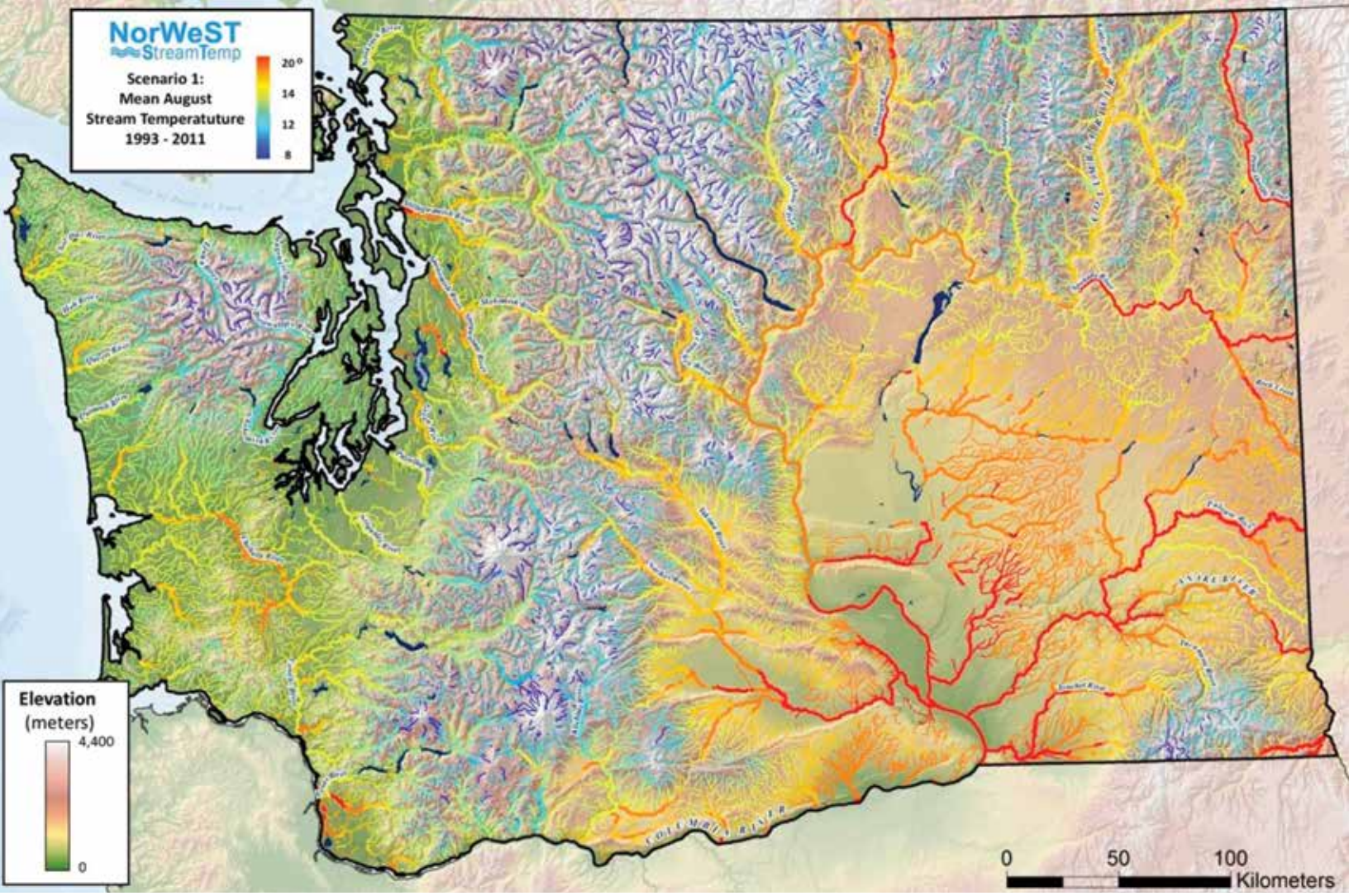


Figure 4.1. Stream thermalscape showing mean August temperatures for 66,236 kilometers (41,157 miles) of streams across Washington that was developed in the NorWeST project (poster available here: http://www.fs.fed .us/rm/boise/AWAE/projects/stream_temp/downloads/14NorWeST_WashingtonStreamTemperatureMap.pdf). Topographic and geomorphic complexity across the state creates significant thermal heterogeneity that is moderated locally by riparian conditions.

4.1.1. State of the Science

The scientific literature establishes a clear expectation that reduction of stream shade, especially due to vegetation removal, will result in warmer summer stream temperatures (e.g., Sridhar et al. 2004; Allen et al. 2007). The literature, derived primarily from descriptive (e.g., case study) and occasionally statistically predictive (e.g., generalization across many case studies) studies, demonstrates that riparian management can affect shade and in turn stream temperatures (Johnson 2004; Moore et al. 2005). The vast majority of those studies document an increase in a temperature statistic, often mean daily maximum temperature during summer, associated with a loss of shade (Johnson 2004; Moore et al. 2005; Bowler et al. 2012), but a few studies have shown mixed results (Johnson 2004; Moore et al. 2005; Janisch et al. 2012; Kibler et al. 2013).

Variability in stream temperatures among locations (Figure 4.1) and among some study results is due to both temporally constant attributes of landscapes (e.g., elevation, topographic slope, drainage area) and temporally variable attributes (e.g., stream wetted width, stream flow) that affect the potential amount of solar radiation available at a given location (Boyd and Kasper 2003) and the thermal sensitivity of the stream, respectively. The amount of solar radiation available is often referred to as thermal loading potential or

potential solar load. At a given thermal input or load, the temperature change responsiveness of a stream is often referred to as "thermal sensitivity" (Beschta et al. 1987; Moore et al. 2005). Thermal sensitivity is influenced by many physical factors. Streams with higher flows of surface and groundwater, and hyporheic exchange rates (Cristea and Burges 2010; Arismendi et al. 2012) tend to be relatively thermally insensitive. Wood loading, channel complexity and depth can also affect thermal load and sensitivity. The potential solar load in combination with thermal sensitivity (discussed in detail below) of locations across a stream network and through time largely determine a stream thermal regime.

In addition to solar radiation, other microclimate variables - such as air temperature, wind speed, and humidity - may affect instream water temperatures. Microclimate conditions interact with energy exchanges at the air-water interface (Figure 4.2) and can thereby affect stream thermal regimes (Moore et al. 2005; Benyahya et al. 2010), especially in small streams (Caissie 2016). However, we believe the effects of microclimate on the thermal regime of streams with fully functioning riparian ecosystems are minor for two reasons: 1) microclimate effects (e.g., changes in air temperature and humidity) at forest edges rarely extend farther than one tree height into mature riparian forest (Moore et al. 2005; Rykken et al. 2007; Reeves at al. 2018), and 2) sensible heat exchanges comprise only a small portion of total heat flux in streams (Johnson 2004; Moore et al. 2005). In fact, net solar radiation effects on stream temperatures are generally about an order of magnitude greater than sensible and latent heat exchanges at the air-water interface (Moore et al. 2005; D. Caissie, Fisheries and Oceans Canada, personal communication). However, we also agree with Reeves et al. (2018), who note that the range of effects measured in different studies suggests substantial uncertainties regarding riparian ecosystem management with respect to microclimate.

Riparian ecosystem-stream temperature research appears to be transitioning from largely local, descriptive (e.g., case study and generalizations of case studies) to predictive, mechanistic, and deterministic modeling across larger areas (e.g., Boyd and Kasper 2003; Allen et al. 2007). Mechanistic models attempt to include most of the factors that affect stream temperatures (Figure 4.2) in a given area and thus do not rely on statistical extrapolation from other locations. These types of models can provide relatively accurate and precise temperature predictions at various spatial and temporal scales (Leinenbach et al. 2013). Further, they can provide useful information on systems and processes that are not readily estimated through statistical approaches used in case studies. However, collecting the environmental data necessary for accurate prediction of the effects of riparian management actions on stream thermal regimes via mechanistic models is difficult and often prohibitively expensive (Allen et al. 2007). For example, studies on the effects of riparian ecosystem or land cover management on stream temperatures at large spatial extents (e.g., watersheds of large streams or rivers) and cumulative effects are very rare. Watershed-scale studies (e.g., Janisch et al. 2012; Kibler et al. 2013) are often limited to relatively small watersheds (e.g., 2 to 1,000 ha) and second order streams.

New types of statistical models for stream network data (Ver Hoef et al. 2006; Isaak et al. 2014) have been applied to large stream temperature databases (Isaak et al. 2017a) and these have enabled relatively accurate predictions (R^2 = 0.90; RMSE = 1.8°F or 1.0°C) and mapping of summer thermal conditions across all Washington streams (Figure 4.1). Those statistical approaches use predictor variables derived from broad geospatial and remotely sensed datasets (e.g., elevation, stream slope, riparian density from the National Land Cover Database) so they do not provide insights to local temperature anomalies that could be associated with alterations of riparian or channel conditions. However,

these statistical models do provide accurate thermal status maps that could be used with mechanistic models or field measurements to better ascertain the influence of riparian conditions on stream temperatures.

Scientific knowledge of the importance of stream temperatures on aquatic species has also advanced since the publication of Knutson and Naef in 1997; especially by better describing the importance of thermal regimes (rather than only extreme high temperatures) on fish survival, growth, and productivity (Ward and Stanford 1982; McCullough 1999; Caissie 2006; McCullough et al. 2009; Hinch et al. 2012). For example, the collapse of the Fraser River Sockeye Salmon *Oncorhynchus nerka* spawning run in 2009 was largely attributed to thermal exposure due to early migration, which resulted in indirect, but often fatal, effects (Hinch et al. 2012). Following Olden and Naiman (2010), we suggest that thermal regimes can be described by their rates of change, magnitude, frequency, timing, and duration, and also their spatial distribution in a stream. The timing and duration of thermal exposure, in addition to exposure to extreme temperatures, affects the survival and productivity of many aquatic species (Caissie 2006).

Importantly, studies such as those of Murphy and Hall (1981), Murphy et al. (1981), Hawkins et al. (1983), and Bilby and Bisson (1987) that demonstrated apparent beneficial effects of reduced riparian shade on an aquatic species, such as increased salmonid growth or abundance, can now be considered in a broader ecological context. It should be noted that in these studies observed temperature increases were small and apparent beneficial effects were attributed to increased solar radiation, primary production, and consequent bottom-up stimulation of the food web. These findings are consistent with the idea that oftentimes the biological effects of altered temperatures differ among locations (Li et al. 1994; Farrell et al. 2008), and that such differences in effects may be attributed to the difference between local temperature and the thermal niche of a species. For example, in reaches where temperatures are near a species' thermal maxima, additional warming will cause the habitat to become unsuitable. However, in streams that are too cold for a species, warmer temperatures may increase habitat suitability (Isaak and Hubert 2004; Isaak et al. 2017b). In addition to direct stream temperature changes on a single species, changes may affect ecological trade-offs between species. Rezende et al. (2014) showed that faster growth might also be associated with increased competition with non-native species (Lawrence et al. 2014).

Widespread alterations of upland and riparian conditions and subsequent changes in stream composition and structure have likely already impacted thermal conditions in many streams (Poole and Berman 2001) and such impacts will be further exacerbated by the ongoing effects of climate change (Isaak et al. 2012; Holsinger et al. 2014). Streams with degraded riparian conditions, however, also offer opportunities where restoration actions could mitigate future warming and improve ecological resilience by enhancing the survival and productivity of the populations and assemblages that use those systems.

4.2. Conceptual Model

We provide a conceptual model to help describe the important components, structures, and processes that affect stream temperatures and that can result in different effects of riparian management actions on stream temperatures among locations (Figure 4.2). Our conceptual model is largely a simplification of the model "Heat Source" in Boyd (1996) and Boyd and Kasper (2003) and developed based on the preponderance of scientific evidence. Heat Source is a deterministic, mechanistic model developed to predict dynamic open channel heat and mass transfer. As such, it includes parameters for all variables that are known

to significantly affect stream temperatures. Our simplified conceptual model describes components and parameters that can have a large effect on stream temperatures or that are affected by riparian ecosystem management. We provide this model in an attempt to improve basic understanding of stream thermal processes and to identify important composition, structure, and functions that are subject to management and that affect stream temperatures. Additional information based on the models of Poole and Berman (2001), Moore et al. (2005), and Leinenbach et al. (2013) are included to more clearly identify factors that affect thermal loading potential and stream thermal sensitivity via riparian management.

Scientific understanding of the environmental factors and their relations that affect stream thermal regimes is well developed, as demonstrated by the development of deterministic, mechanistic models (e.g., Boyd and Kasper 2003) that can provide accurate temperature predictions when sufficient data are available to run the model and when the stream system remains relatively stable. Such models have been applied successfully at the spatial extent of individual stream reaches (Cristea and Janisch 2007; Cole and Newton 2013) and watersheds (Coffin et al. 2011; Bisson et al. 2013; Booth et al. 2014), suggesting that our understanding of the composition, structure, and functions that affect stream temperatures are well understood and can be

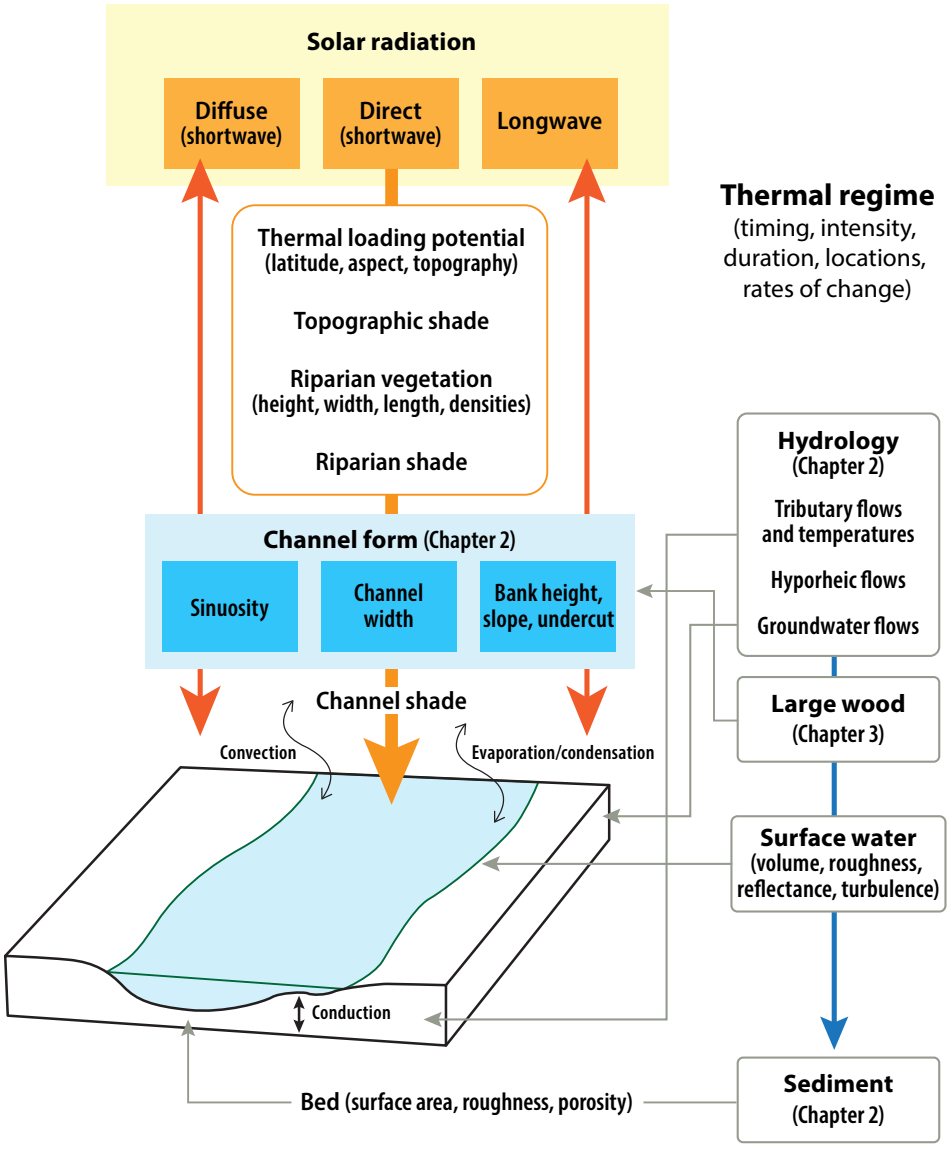


Figure 4.2. Conceptual model that identifies some factors that affect the thermal regime of stream networks. Relative importance is noted by line weight and arrows indicate directions of flows. Note that most of the elements in the model are influenced by human activities and that many components and structures are not presented here. See Boyd and Kasper (2003) for a more thorough review.



Dense tree canopies rarely provide 100% shade/Ned Pittman, WDFW

reliably applied to management problems. Rates of direct (shortwave) solar radiation reaching the stream surface and the volumes and temperatures of water are consistently identified as the dominant processes affecting the thermal regime of streams (Sinokrot and Stefan 1993; Johnson 2004). At many locations these two dominant processes are subject to management: direct solar radiation reaching a stream via vegetation management and water flows via water diversion, storage, and return (Olden and Naiman 2010).

The thermal loading potential of a stream reach is controlled in part by temporally constant and largely independent factors such as latitude, aspect, elevation, and topographic shading (Figure 4.2, Boyd and Kasper 2003; Janisch et al. 2012). Streams at high latitudes are less exposed to solar radiation, the ultimate source of heat energy to streams, than streams at low latitudes. Stream aspect affects stream temperatures because a stream's orientation relative to the path of the sun (which differs seasonally) determines the amount of direct solar radiation that a stream receives (Johnson 1971). Elevation affects the ambient air temperatures that streams are exposed to, as well as the dominant form and amount of precipitation (i.e., snow or rain). For these reasons, higher elevation streams are usually colder and commonly, although not always, less thermally sensitive than lower elevation streams (Luce et al. 2014). Topography can shade a stream from direct solar radiation and the effects of topography and aspect can interact. The effects of these four geographic factors can be difficult to detect (Isaak and Hubert 2001) and are likely responsible for some of the variability of the results of case studies that measured the effects of riparian management on stream temperatures. Note that some of these attributes (e.g., elevation) also affect the composition and structure of riparian vegetation. Stream thermal loading is not only controlled by independent factors such as latitude, aspect, elevation, and topographic shading. The scientific literature clearly identifies shade from riparian vegetation as important to stream temperatures, especially for small (narrow) streams (e.g., Beschta 1987; Poole and Berman 2001; Johnson 2004; Sridhar et al. 2004; Moore et al. 2005; Caissie 2006; Allen et al. 2007; Bowler et al. 2012; Garner et al. 2014). The effects of altered stream shading on temperatures is complex because thermal loading potential and thermal sensitivity of streams differ among locations. Some attributes, such as water volume, wetted width, and width-depth ratio can affect both thermal loading potential and thermal sensitivity (Cristea and Janisch 2007; DeWalle 2010). For a given volume of water, wider channels of the same length have a greater surface area that can intercept more direct solar radiation (Boyd and Kasper 2003) and also exchange more heat through atmospheric conduction. The width of a stream also affects the amount of shade that can be provided by topography and riparian vegetation (Cristea and Janisch 2007; DeWalle 2010). That is, riparian vegetation of given height, density, and width might shade a larger proportion of a narrow channel for a longer period than for a wide channel. Stream widths, especially wetted channel widths, are often much less temporally stable than the other factors that control thermal loading potential. Management actions that result in changes in stream width (e.g., over-grazing [Belsky et al. 1999; Chapter 2] and maintenance of wide forested riparian areas that can result in wide channels [Sweeney and Newbold 2014]) can increase thermal loading potential and thermal sensitivity.

While shortwave radiation input and water volume and temperature largely control temperature regime, longitudinal channel form (stream reach and cross section) can also affect stream temperature, for example, via high sinuosity and the presence of undercut banks (Frissell et al. 1986; Bisson et al. 2006). Channel form and features that increase stream roughness can store gravel (Buffington et al. 2004) and increase hyporheic exchange (Wondzell and Gooseff 2013) that, in turn, can affect stream temperatures by storing and releasing heat (Burkholder et al. 2008). Large wood can also store large amounts of gravel in some streams (Buffington et al. 2004) and affect channel form (Chapter 3; Keller and Swanson 1979; Abbe and Montgomery 1996; Konrad et al. 2005) which might subsequently affect stream temperatures. For example, sediment deposition due to instream large wood might increase hyporheic flow and stream width, which can subsequently effect stream temperatures. Steep or undercut banks can also provide shade (Boyd and Kasper 2003) which, in some locations (Ebersole et al. 2003b), can lower water temperatures at small spatial extents (e.g., individual pools; Ebersole et al. 2003a), even in large streams and rivers. Unfortunately, relatively few studies quantify the effects of channel form on thermal sensitivity and stream temperatures, which likely adds variability among stream temperature case studies and limits our ability to predict their relative importance at specific locations. Groundwater and tributary flows also affect stream temperatures (Malard et al. 2002) in two ways, 1) by adding volume and increasing flow velocity that can make streams less sensitive to thermal change (i.e., increasing thermal capacity), and 2) by adding water that is at a different temperature than receiving waters (Boyd and Kasper 2003; Story et al. 2003). However, the effects of groundwater flows can be difficult to detect due to spatiotemporal lags (Alvarez et al. 2004; Arrigoni et al. 2008) and difficult to apply to management due to the paucity of information describing groundwater flows. Additionally, side channels and wetlands can provide large volumes of water at different temperatures to receiving stream water (Bobba et al. 2010). Streambed attributes, such as porosity and surface area, are largely controlled by the flows of water and available sediment (see Chapter 2). Streambed attributes can affect the thermal regime of a reach by affecting heat conduction (Sinokrot and Stefan 1993), by regulating the amount and velocity of water flow through the streambed, and by controlling the rates and locations of groundwater flows (Malcolm et al. 2002). The effects of these processes on stream temperatures can be spatially and temporally discontinuous and dynamic, especially in systems where stream form is heterogeneous and dynamic (Wright et al. 2005; Wondzell 2012). Hyporheic flows often have little effect on average stream surface water temperatures except for small streams at low flows but can create discrete locations of cool water (Wondzell 2012) that may serve as important refugia for salmon. Hyporheic flows can be influenced by flow regulation (e.g., dams), which can reduce variation in both flows and temperatures that reduces the potential for hyporheic exchange to act as a thermal buffer (Ward and Stanford 1995; Poole and Berman 2001; Nyberg et al. 2008).



Juvenile salmon/Portia Leigh, WDFW

The interaction of complex in- and near-stream riparian ecosystem processes can lead to a cascade of events (i.e., a series of related events triggered by single event) and new system states (Pringle and Triska 2000; Allan 2004). These cascading events are almost impossible to predict. For example, the removal of riparian trees typically reduces shading and increases solar radiation to the stream. Even when reductions in shade have a small direct effect on stream temperatures, the loss of trees can increase bank susceptibility to erosion (Chapters 2 and 3; Micheli and Kirchner 2002; Gomi et al. 2004) resulting in a wider stream that increases thermal loading and thermally sensitivity of the stream. Similarly, channel incision resulting from riparian management, may increase local topographic shading to the stream, but lower streambed and water elevations that can shift the riparian vegetation composition and structure. This shift in riparian vegetation can result in less stable streambanks and less riparian shade that ultimately offsets any benefits of topographical shading on water temperature (Toledo and Kauffman 2001). The results of such interactions are difficult to predict because they rely on accurate predictions of changes to stream morphology, vegetation composition and structure (which interact and have non-linear responses), and water and sediment flows (which can be stochastic).

The processes that affect the timing, duration, and geographic distribution of stream temperatures are complex due to the variability of the environment in which these processes occur (Figure 4.2). The relative importance of these ecological processes differs among locations and through time (Poole and Berman 2001; Webb et al. 2008). Scientific literature is clear about the expected effect of reducing stream shading, especially during summer; water gets warmer, particularly peak temperatures. Science is less able to provide accurate and precise predictions of the effects of specific riparian management measures. For example, the studies presented in Figure 4.3 represent statistical models relating changes in riparian buffer width to changes in stream temperature. Data in Figure 4.3 are collected by measuring stream temperature before and after a reduction in the width of a forested riparian buffer which in turn decreases shade to the stream. Model output (prediction) is change in temperature related to specific buffer widths. The models tell us that reducing shade usually increases stream temperatures (following the shape of the dotted line connecting points), but they cannot predict exactly how much shade reduction will result in a specific temperature increase. A manager attempting to use the statistical model in Figure 4.3 to predict how a reduction from a fully forested site to a 30-foot wide buffer might affect summer stream temperatures is confronted with a range of possible answers. Those answers fall within the 90% credible intervals for one study representing a change between 1.25 and 2.25°C (2.25 and 4.05°F), and for another study between -0.5 to nearly 5.0°C (-0.9 to nearly 9.0°F). Uncertainty in this case describes our inability to accurately predict exact outcomes. While rarely applied due to their expense, mechanistic models and attendant data (e.g., hyporheic flows and temperatures) provide the best approach for predicting accurate site-specific outcomes from management.

Fortunately, the literature is very clear that solar radiation is often the dominant factor affecting stream heat budgets during all seasons except winter (Webb et al. 2008). Results of case studies can prove very useful by clearly describing the expected direction and shape of the relations between attributes of riparian ecosystems (e.g., width of vegetation) and stream shade and temperature. Importantly, riparian shade is often directly amenable to management and in many locations riparian vegetation height and density may be more closely associated with shade than width of riparian vegetation per se (DeWalle 2010). In any case, the literature is very clear about the importance of riparian vegetation for providing shade to streams (Figure 4.3a).

4.3. Species Sensitivity

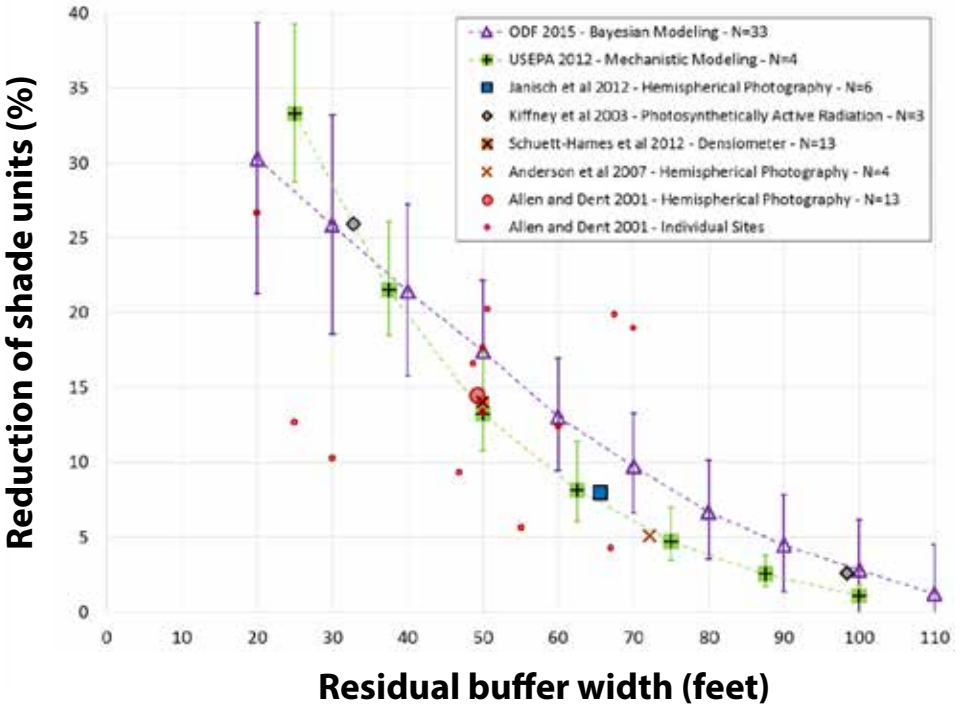
4.3.1. Fish

The scientific literature describing the importance of temperature, especially high temperatures, to fish is extensive (e.g., Brett 1952, 1971; Brett et al. 1969; Richter and Kolmes 2005). As aquatic ectotherms, the physiology of fish are strongly affected by water temperatures (McCullough et al. 2001; Welsh et al. 2001). Studies have frequently found associations between temperature and the geographic distribution (Welsh et al. 2001), spawn timing (Hodgson and Quinn 2002), growth rates, egg development and survival, competitive interactions, life stage survival, and behavior of fish (McCullough 1999; McCullough et al. 2009). Salmonids have frequently been studied because of their cultural and economic importance and their relative sensitivity to high temperatures, narrow thermal tolerance, and narrow aerobic scope (Farrell et al. 2008; Eliason et al. 2011; Ayllon et al. 2013). Summer temperature information is useful for identifying acute problems, but may be insufficient for ensuring population resilience because indirect effects and exposure to altered thermal regimes, not just extreme summer temperatures, can affect fish survival and productivity (McCullough 1999).

Recent research has increasingly focused on the effects of water temperatures and thermal regimes for fishes that have narrow thermal tolerance (i.e., range of suitable temperatures) or aerobic scope (Farrell et al. 2008; Eliason et al. 2011; Ayllon et al. 2013). This work is particularly relevant to salmonids in the Pacific Northwest that have life histories adapted to historical, location-specific thermal regimes (Brannon et al. 2004; Farrell et al. 2008; Eliason et al. 2011). Much of this research is related to the increasing threats posed by climate change, and some studies have already found evidence of existing, detrimental effects of increased stream temperatures on fish. For example, Isaak et al.



Juvenile anadromous salmon can spend up to 3 years in streams depending on the species/Ned Pittman, WDFW



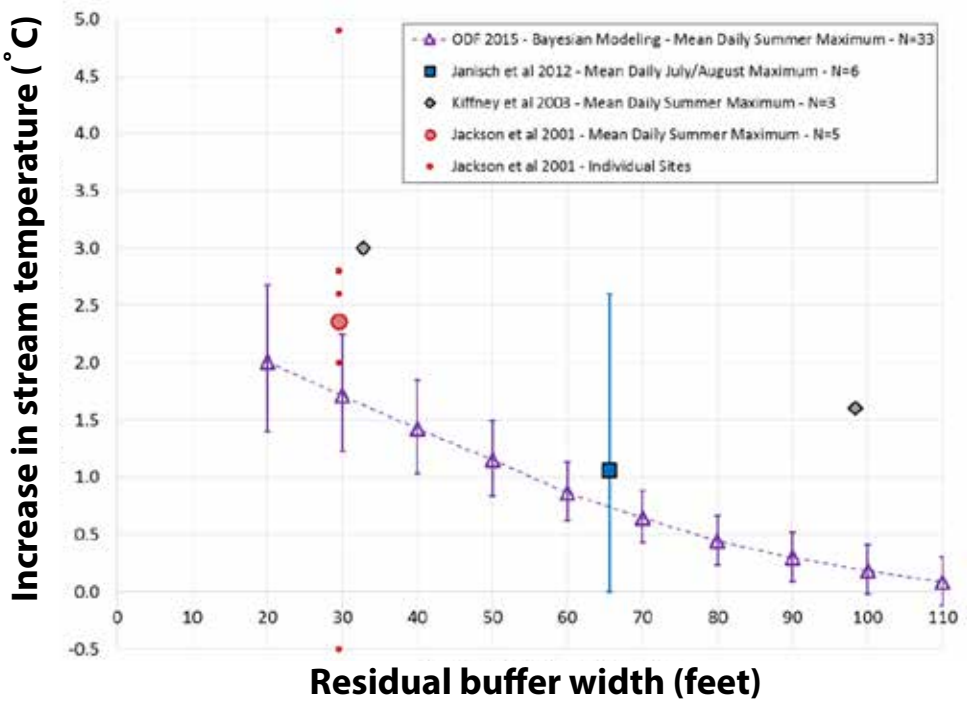


Figure 4.3. Observed shade (a: top panel) and temperature response (b: bottom panel) associated with "no-cut" riparian buffers with adjacent clearcut harvest. Only studies that employed a Before-After-Control-Impact design and conducted in Pacific Northwest forests are included. Shade unit is percent from completely shaded. Bayesian modeling results (and 90% credible intervals) were derived from data collected as part of Groom et al. (2011). Analyses provided by P. Leinenbach, USEPA Region 10.



Chum Salmon Oncorhynchus keta *in spawning colors/Ned Pittman, WDFW*

(2010, 2015) found increases in stream temperatures would result in losses of Bull Trout *Salvelinus confluentus* and Cutthroat Trout *Oncorhynchus clarkii* habitats, but also that especially cold streams could serve as climate refugia during the 21st century. Additionally, a number of recent studies have described some complex effects of altered thermal regimes to the productivity and survival of fish at different life stages and dramatic differences in thermal tolerance and aerobic scope among populations and species. For example, Hinch et al. (2012) describe complex links between the physiology, behavior, environment, disease exposure, and the effect of thermal exposure, on the population-specific survival of migrating Sockeye Salmon. Hodgson and Quinn (2002), Keefer et al. (2007), Strange (2010) and others have documented that high temperatures and previous thermal exposure can inhibit fish migration, and Marsh (1985) and Kappenman et al. (2013) have documented that high and low temperatures can impede spawning and embryo development and that optimal temperatures for embryo survival and development differ among species. Steel et al. (2012) found that thermal variability (without changing mean temperature) can affect the emergence timing and development of Chinook Salmon *Oncorhynchus tshawytscha*.

The literature is conclusive about the importance of stream thermal regimes to fish survival and productivity and also demonstrates wide variability in sensitivity to altered thermal regimes among species and among populations within species (Steel et al. 2012). More research would help us fill the sizeable gap in our understanding of the risk posed by altered thermal regimes on the survival and productivity of populations of salmonids or non-salmonid fishes, and on the ecological interactions that affect survival, productivity and population viability. For example, the time of hatching (i.e., duration of incubation) of salmonid eggs is largely determined by their thermal exposure during incubation. Relatively small changes in temperature can advance or delay maturation and subsequently hatching date (Groot and Margolis 2010) and effects of temperature can differ among closely related populations of the same species that spawn in different habitats (Hendry et al. 1998). Regardless of the ultimate cause, changes in thermal regimes can, for example, uncouple trophic interactions due to temporal mismatches, such as fry emerging when their preferred food is not available to them (Winder and Schindler 2004; Post et al. 2008). Altered thermal regimes can also affect other life stages by altering the timing of parr-smolt transformation (Zaugg and Wagner 1973), the duration of freshwater rearing (Sauter et al. 2001) which can affect ocean survival (Weitkamp et al. 2015), and the timing and success of spawning migration (Crossin et al. 2008). Altered thermal regimes can also affect ecological interactions. For example,

Wise management of riparian and aquatic systems would ideally consider the distribution and dynamics of stream temperatures in space and time and at scales that are relevant to the species in the region.

Lawrence et al. (2014) demonstrated that higher stream temperatures can expand the geographic distribution of non-native Smallmouth Bass *Micropterus dolomieu* and increase their predation on salmon. These results are complicated by the fact that effects of altered thermal regimes often differ among populations and life stages of a species, and among species (Brett 1971; Zaugg and Wagner 1973) which makes prediction of the exact effects of any riparian shade reduction and subsequent effects on stream thermal regime on fish survival and productivity uncertain. This uncertainty is compounded by fish behavioral responses, such as daily and seasonal movement among locations where thermal conditions differ (Torgersen et al. 2001).

Our understanding of the importance of altered thermal regimes on fish has improved substantially since the publication of Knutson and Naef (1997). Discussion of stream temperature by Knutson and Naef (1997) focused mostly on summer high temperatures and their effects on fish, but did not identify many components and structures of ecosystems that can affect stream temperatures or the importance of thermal regimes to fish. In particular, more recent studies are able to measure thermal exposure of fish through time, occasionally in field conditions, and estimate physiological attributes such as growth rate (Sauter and Connolly 2010).

Most studies calculate a single statistic that describes an important attribute of a stream's thermal regime (e.g., mean maximum daily summer temperature) and identify species, population, or life stage attributes that are correlated with that statistic, such as a critical thermal limit. These studies have been useful for demonstrating the importance of temperature and for setting some management objectives. However, they are insufficient for effective, long-term management of perturbed systems because changes in temperature means (i.e., chronic exposure) or extremes (i.e., acute exposure) can result in different selective pressures and evolutionary responses (Rezende et al. 2014) and because life stages, populations, and species differ widely in their sensitivity to altered thermal regimes (Farrell et al. 2008; Hinch et al. 2012). Further, we now better understand that many individual fish and especially populations use (and perhaps are dependent on) a dynamic mosaic of habitats (Fausch et al. 2002; Ward et al. 2002; Wiens 2002); that is, they move between discrete locations with different temperatures (Torgersen et al. 1999). Such movement among "patches" can be important to individual survival and population persistence because thermal conditions at discrete locations can be highly temporally variable (Dugdale et al. 2013) and spatially complex (Fullerton et al. 2015). Management of stream thermal regimes should carefully consider the spatiotemporal distribution and dynamics of thermal conditions at scales that are relevant to the species in the region (Fausch et al. 2002) at durations that are relevant to the rates of system change and recovery from disturbance.

4.3.2. Amphibians and Reptiles

Few studies address the effects of altered thermal regimes on stream-associated amphibians and reptiles, which currently limits the level of specificity to which reliable management recommendations can be made. However, some important insights are possible and these are best discussed in the context of breeding habitat: 1) amphibians that breed in the flowing portions of stream networks, and 2) amphibians and reptiles that breed in or use off-channel stillwater habitats associated with stream networks.

Instream-breeding amphibians (giant salamanders, *Dicamptodon* spp.; tailed frogs, *Ascaphus* spp.; and torrent salamanders, *Rhyacotriton* spp.) are generally described as having low thermal requirements (Bury 2008). However, those requirements are often characterized solely in terms of critical thermal maxima (Brattstrom 1963; Claussen 1973; Brown 1975; Bury



*Giant salamanders (*Dicamptodon *spp.) can be found in small western Washington streams/Eric Lund, WDFW*

2008), while stream temperatures in which these species are found are considerably lower than those maxima (invariably ≤61°F [16°C]; e.g., Brattstrom 1963; Welsh 1990; Welsh and Lind 1996; Pollett et al. 2010). Moreover, water temperatures at which these species first become stressed are entirely unknown. Several studies demonstrate higher density or relative abundances (Stoddard and Hayes 2005; Pollett et al. 2010) of amphibians at the margin of their temperature maxima although the mechanism responsible for this effect is unclear. Similar to fish, identifying critical effects of temperatures on amphibians is complicated by a host of potential variables, e.g., younger life stages frequently have cooler temperature requirements (de Vlaming and Bury 1970; Brown 1975) than older life stages. Importantly, very little research has been conducted on the effects of altered thermal regimes on the timing of life history events, such as the time of hatching, and indirect effects, such as possible ecological temporal mismatches, altered predator-prey relations, and disease frequency and effect (e.g., Hari et al. 2006), that would be useful for identifying important conservation and management actions.

Amphibians and reptiles that breed or utilize riverine off-channel stillwater habitats (e.g., oxbow lakes and permanent and seasonally flooded riverine wetlands) associated with stream networks generally have warmer thermal requirements than instream breeding amphibians. For stillwater-breeding amphibians, thermal requirements vary as a function of the thermal tolerance limits of a specific life stage (often eggs and embryos), which determine the seasonal interval in which they lay eggs. For example, Northern Red-legged Frog *Rana aurora* embryos have the lowest critical thermal maximum of any North American frog (about 68°F or 20°C) (Licht 1971), and they oviposit in late winter, at which time surface water temperatures of stillwater habitats rarely if ever put its embryos at risk. Except for our two turtle species (Western Pond Turtle *Actinemys marmorata* and Western Painted Turtle *Chryemys picta*) and selected garter snake species *Thamnophis*, especially the Common Garter Snake *T. sirtalis* and the Western Terrestrial Garter Snake *T. elegans,* few reptiles utilize aquatic habitats in the Pacific Northwest. These reptiles have



Riparian corridor/Ned Pittman, WDFW

thermal requirements that are more elevated than the temperatures generally found in stillwater habitats except during the warmest part of summer. For this reason, aerial basking (basking out of water) at daytime temperatures that are warmer than water temperature can be critical for these species for effective digestion of food or production of eggs. This pattern is especially important for turtles that need aquatic aerial basking sites isolated from predators, which in most stillwater habitats are provided by large downed wood with relatively level accessible surfaces above the water line (Holland 1994).

4.3.3. Invertebrates

Few studies have examined the effects of altered thermal regimes on stream-associated invertebrates in the Pacific Northwest. However, broad relationships between the geographic distributions of invertebrates and their thermal tolerance have been reported (Beschta et al. 1987; Moulton et al. 1993) as have changes in emergence timing and asynchronous emergence among sexes due to small increases in summer temperatures (Li et al. 2011), demonstrating the importance of temperature to invertebrates. Stream temperature can affect invertebrate density, growth, size at maturation, and sex ratios and the effects often differ among species (Hogg and Williams 1996). Altered stream thermal regimes appear to have important effects on many invertebrates and, subsequently, on stream food webs. Indirect effects such as altered predator-prey relations and disease frequency may also be important but have not been well studied. Riparian ecosystem management for aquatic invertebrates is also constrained by a general lack of information on their geographic distribution.

4.3.4. Species Sensitivity Summary

Management of vegetation in riparian ecosystems can affect stream temperatures and, subsequently, fish, amphibian, and invertebrate abundance and survival. Stream temperature influences important food web and energetic interactions between fish, amphibians, and invertebrates in multiple direct ways and likely in more subtle but relatively unstudied indirect ways (Baxter et al. 2005). The effects of thermal regime has received little study for amphibians and invertebrates. Fortunately, our understanding of the mechanisms that affect stream thermal regime can provide useful guidance in the absence of better information.

4.4. Land Use Effects

4.4.1. Urbanization

There have been very few studies specifically relating urbanization to riparian ecosystem function and subsequent effects on stream thermal regimes (Paul and Meyer 2001). Clearly, urbanization related changes to riparian areas can be similar to riparian changes associated with agriculture and forestry as far as stream temperature is concerned, e.g., removal of shade, reduction in large wood inputs. Urban areas have additional issues that can affect stream temperatures including heat island

effects, and inputs of wastewater and runoff from impervious surfaces (Kinouchi et al. 2006; Hester and Doyle 2011). Some of these complicating factors may contribute to the absence of detectable effects on stream temperatures studies in some comparative studies (Wahl et al. 2013). Nonetheless, urbanization is considered to have adverse effects on stream temperatures (LeBlanc et al. 1997; Finkenbine 1998), especially when riparian functions are affected (Booth et al. 2001). To protect stream thermal regimes in urban settings, conservation efforts should focus on maintaining riparian functions, mitigating anthropogenic changes to hydrology, and preserving watershed connectivity (e.g., movement of water, sediment, wood, nutrients, and species).

4.4.2. Agriculture

In comparison to urbanization studies, studies of the effects of agricultural practices on riparian ecosystems or subsequent effects on stream thermal regimes are fairly abundant, especially for grazing lands (e.g., Li et al. 1994; Tait et al. 1994; Maloney et al. 1999; Zoellick 2004) and crop lands (e.g., Waite and Carpenter 2000). Studies examining the effects of agriculture, particularly livestock grazing, generally find stream temperature increases associated with disturbance of the riparian ecosystem (Zoellick 2004; Webb et al. 2008). Livestock use of streamside areas can increase a stream's exposure to direct sunlight by reducing shade from streamside vegetation (Li et al. 1994). Livestock can also reduce the amount of undercut banks and increase stream channel width through trampling and vegetation removal (Belsky et al. 1999; Chapter 2). Channel widening can also result in reduced depth, which can exacerbate warming (Poole and Berman 2001). However, results of observational studies are mixed, with occasional absences of predicted detectable increases in stream temperature due to changes in riparian ecosystems as a result of agriculture (e.g., Tait et al. 1994) and wide variation in effect on riparian vegetation among locations and types of agriculture (see Maloney et al. 1999). Importantly, Zoellick (2004) found that riparian vegetation can recover after removal of the disturbance agent (e.g., livestock). For crop lands, the importance of riparian ecosystem attributes, e.g., vegetation width, height and density, on stream temperatures have been documented (Waite and Carpenter 2000) and, similar to grazed lands, effects differ widely among locations (Benedict and Shaw 2012).

Studies of the effects of land management on riparian functions and stream temperatures confirm the importance of riparian ecosystems to stream thermal regimes.

4.4.3. Forestry

Relative to urbanization and agriculture, many studies in the Pacific Northwest have examined the effects of forest management on stream temperatures. Decades of research have frequently documented increased stream temperature due to forestry practices (Olson and Rugger 2007), and our understanding of the mechanisms by which forest practices affect stream temperatures is well developed (Beschta et al. 1987; Groom et al. 2011). Most studies find that forestry, especially when riparian vegetation is disturbed, results in higher stream temperatures than in less disturbed locations (Li et al. 1994), however, exceptions to this pattern are not uncommon. For example, Liquori and Jackson (2001) found stream temperatures 3 to 7°F (1.5 to 4°C) greater in stream reaches surrounded by dense riparian forests compared to downstream reaches

adjacent to scrub-shrub riparian communities.
Many of the studies of the effects of forestry on stream temperatures include consideration of some of the components and structures that affect stream thermal regimes identified by Boyd and Kasper (2003) and Poole and Berman (2001). For example, Liquori and Jackson (2001) suggest that their results are due to lower width-to-depth ratio, higher rates of hyporheic or groundwater exchange, and greater amounts of shade in shrub-scrub associated reaches. Maloney et al. (1999) found that much of the variation in their results (in mostly agricultural settings) was explained by reach length, shade, elevation, aspect, and especially by stream gradient and air temperature. Similarly, Kiffney et al. (2003) and Janisch et al. (2012) described the influence of groundwater and hyporheic exchange on their results.

4.4.4. Land Use Summary

Studies of the effects of land management, especially the many studies of forestry, on riparian functions and stream temperatures confirm the importance of riparian ecosystems to stream thermal regimes. Additionally, they emphasize the high degree of variability among locations of the functions that affect stream thermal regimes, even among adjacent stream reaches, that so often produce variable results. Unfortunately, studies that examined the effects of land management on the complete thermal regime of a stream are lacking. Such studies could be especially valuable because the cumulative effects of riparian ecosystem or upland management on stream temperatures can dominate local effects (Chapter 8). Further, most studies use only a few statistics that describe peak or average temperatures, usually during summer. Such statistics are useful, but have limited ability to address dynamic, water quality parameters including temperature (Poole et al. 2004) related to species needs. Thus, predicting the effects of land management on other thermal attributes (e.g., duration or frequency of stressful temperatures) or during other seasons when thermal exposure can significantly affect some species (e.g., overwinter incubation) is difficult. Similarly, even cumulatively, the relatively small number of studies and their skewed geographic distribution (i.e., most are on low-order streams in maritime regions) constrain our ability to provide broad and precise generalizations or make accurate predictions to other locations. Conservation efforts for maintaining stream thermal regimes must be based on our understanding of direct and indirect mechanisms of stream heating affected by human activities, wise use of statistical models relating shade and stream temperature across the watershed until mechanistic models become available, and preserving watershed connectivity (e.g., movement of water, sediment, wood, nutrients, and species).



Light through alder tree canopy/Ned Pittman, WDFW

4.5. Conclusions

Scientific understanding of the structure and function of streams and the importance of thermal regimes has improved substantially since the publication of Knutson and Naef (1997). This understanding underscores the need to consider temperature statistics other than the daily maximum temperature during summer. We now have mechanistic,



Giant salamander (Dicamptodon *spp.*) *egg cluster/Jack Armstrong, WDFW*

deterministic models that can accurately predict changes in stream temperatures for specific locations due to specific management actions in the riparian ecosystem. We are also better able to set directional or qualitative expectations for cumulative effects on temperatures at the spatial extent of watersheds. However, quantitative information needed to run mechanistic, deterministic models to make site-scale predictions (e.g., surface water and groundwater flows and temperatures) is expensive to collect and thus are rarely used in management settings. Further, even the most capable stream temperature predictive models are limited by the assumption that the channel structure remains relatively stable (e.g., cross-section shape will not change) even though there is strong evidence that riparian and some types of upslope management affects channel stability (Chapters 2 and 3) at least in some reach types.

Scientific models and most observational studies find that shade from riparian vegetation can affect stream thermal regimes, particularly by lowering peak temperatures during summer. Recent monitoring studies have found substantial variation in the thermal sensitivity of apparently similar stream reaches. The use of improved monitoring tools (e.g., digital temperature loggers), more robust study designs e.g., Before-After-Control-Impact designs (Eberhardt 1976; Stewart-Oaten et al. 1986), more powerful statistical analyses (Gomi et al. 2006; Isaak et al. 2014), and longer study durations have improved our ability to detect effects of riparian management actions on stream temperatures. Importantly, better understanding of the structure and function of streams, especially the importance of surface, ground, and hyporheic water flows on stream temperatures, has allowed scientists to identify likely causes for failures to detect effects of riparian shade reductions on stream temperatures.

Scientific understanding of the importance of stream temperatures on aquatic species has improved substantially over the past two decades, especially for salmonids. Most studies provide useful descriptions of some direct effects of exposure to high temperatures on specific life stages. Laboratory and field studies demonstrated the importance of temperature on fish survival and allowed for comparisons among species, populations, and life stages, and thus the identification of those that are likely most sensitive to heat stress. They have also demonstrated substantial differences in sensitivity among species, populations, and life stages which make developing simple thermal standards challenging and likely inadequate for management. Several recent studies have described effects of prolonged exposure to elevated, but non-lethal, temperatures and altered thermal regimes. These studies demonstrate some of the complexity of this management challenge. Even when altered thermal regimes do not have immediate lethal effects on species, there are costs or trade-offs, such as changes in growth, survival, productivity, and energetic requirements. Detecting such effects is beyond the scope of most studies and will often require long-term, comprehensive monitoring of populations through several life cycles. Such studies will likely need to be conducted at spatial



Salmon eggs in Morse Creek/Steve Boessow, WDFW

extents and durations that account for fish behavior, such as daily and seasonal movement among locations where temperature regimes differ.

Relatively few studies that describe the effects of temperatures or thermal regimes on reptiles, amphibians or invertebrates have been completed. Most studies of these taxonomic groups have simply identified seasonal thermal preferences in the field or the effects of acute temperature in laboratory settings. Such studies are valuable for identifying thermally sensitive species, but are insufficient for management. Further, we found no study that addressed ecological interactions that might be mediated by riparian condition on a stream's thermal regime.

Studies generally show that the effects of urbanization, agriculture, and forestry on watershed and riparian ecosystems result in warmer summer stream temperatures, an expectation consistent with the conceptual model. Importantly, these land uses often include surface water routing to streams (e.g., roads and ditches) that can change the timing, intensity, duration, and temperatures of stream flows. The changes in temperature detected differed among regions, land uses, and studies. The relatively low number of studies and high variability among study results limits our ability to accurately predict outcomes in unstudied locations and precludes us from reliably calculating a mean (i.e., expected) resulting temperature change, even for a specific temperature statistic. Of the studies we reviewed, most were designed to detect an effect using a specific stream temperature statistic (e.g., mean daily maximum summer temperature) rather than changes in the stream's thermal regime. This limits the inferences that can be made, especially from studies in which anticipated temperature changes were not detected, and to make reliable, precise generalizations from study results.

Although we have sound understanding of the composition, structure, and functions that affect stream thermal regimes, substantial uncertainty remains regarding the effects of any specific riparian management action on stream thermal regimes in most locations. That uncertainty is amplified by our relative lack of understanding at large spatial and long temporal extents for which few studies have been

completed. Recovery of stream temperatures due to shade from vegetation regrowth can occur in less than a decade following disturbance (D'Souza et al. 2011), but recovery rates differ widely among locations due to differences in stream size and components that control rates of vegetation re-establishment and growth (Gecy and Wilson 1990; D'Souza et al. 2011). Although scientists are very certain that temperatures and thermal regimes are important to many aquatic species, relatively little is known about ecological interactions (e.g., predator-prey relations), behaviors (e.g., movement among locations of different temperature), and indirect effects (e.g., effects on the rates and severity of disease). These interactions may be very important. For example, Lawrence et al. (2014) suggest that riparian restoration in some locations might prevent extirpation of Chinook Salmon and restrict the expansion of non-native fish in some locations by maintaining relatively cool stream temperatures. Such uncertainties often compound and should be addressed explicitly when making management decisions, especially when the decisions can have important, lasting effects (Harwood and Stokes 2003). Management of riparian ecosystem composition (e.g., vegetation species, side channels) and structure (e.g., longitudinal and lateral connectivity) can importantly benefit aquatic species. Management for such beneficial effects might prove especially important as our climate continues to change.

The state of the science regarding stream thermal regimes is uneven. On the one hand, we have a very good understanding of the physics of stream heating and cooling. We understand the relative magnitudes of direct and indirect effects of ecosystem changes on stream thermal regimes and have the ability to quantify these effects given enough time and resources. Shade provided by riparian vegetation is generally considered the single most important, albeit not the only, process of the system that humans can directly effect. These findings are undisputed. On the other hand, because thermal regimes are affected by a variety of factors and their interactions, stream temperatures are difficult to precisely predict on the basis on any single factor alone (e.g., shade). Thus, predicting stream temperature based solely on shade removal or buffer width will likely always suffer from imprecision. In addition to this prediction challenge, and despite the fact that we know suitable water temperatures are critical to the persistence of aquatic species, we are only now beginning to understand how aquatic organisms interact with and are impacted by changes in the stream thermal regime. The combination of what we know and do not know about how changes to stream thermal regimes affect aquatic species and how human activities can affect those regimes makes conservation in the face of a changing climate particularly challenging.

4.6. Literature Cited[1]

Abbe, T.B., and D.R. Montgomery. 1996. Large woody debris jams, channel hydraulics and habitat formation in large rivers. Regulated Rivers Research & Management 12:201-221. (i)

Allan, J.D. 2004. Landscapes and riverscapes: the influence of land use on stream ecosystems. Annual Review of Ecology and Systematics 35:257-284. (i)

Allen, M., and L. Dent. 2001. Shade conditions over forested streams in the Blue Mountain and Coast Range georegions of Oregon. ODF Technical Report #13. Oregon Department of Forestry.

Allen, D., W.E. Dietrich, P.F. Baker, F. Ligon, and B. Orr. 2007. Development of a mechanistically-based, basin-scale stream temperature model: applications to cumulative effects modeling. Pages 11-24 *in* R.B. Standiford, G.A. Giusti, Y. Valachovic, W.J. Zielinski, M.J. Furniss, technical editors. Proceedings of the Redwood Region forest science symposium: what does the future hold? PSW-GTR-194. U.S. Forest Service, Pacific Southwest Research Station, Albany, California. (viii)

Alvarez, S.M., J.K. Johnson, and R. Spafford. 2004. Reclamation project allows new phase for Moon

Creek. Land and Water 48:10-15. (i)
Anderson, P.D., D.J. Larson, and S.S. Chan. 2007. Riparian buffer and density management influences on microclimate of young headwater forests of western Oregon. Forest Science 53(2): 254-269.
Arismendi, I., S.L. Johnson, J.B. Dunham, R. Haggerty, and D. Hockman-Wert. 2012. The paradox of cooling streams in a warming world: regional climate trends do not parallel variable local trends in stream temperature in the Pacific Continental United States. Geophysical Research Letters 39:L10401. (i)
Arrigoni, A.S., G.C. Poole, L.A.K. Mertes, S.J. O'Daniel, W.W. Woessner, and S.A. Thomas. 2008. Buffered, lagged, or cooled? Disentangling hyporheic influences on temperature cycles in stream channels. Water Resources Research 44:W09418.
Ayllón D., G.G. Nicola, B. Elvira, I. Parra, and A. Almodóvar. 2013. Thermal carrying capacity for a thermally-sensitive species at the warmest edge of its range. PLoS One 8:e81354. (i)
Baxter, C.V., K.D. Fausch, and W.C. Saunders. 2005. Tangled webs: reciprocal flows of invertebrate prey link streams and riparian zones. Freshwater biology 50:201-220. (i)
Belsky, A. J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54:419–431. (i)
Benedict, C., and J. Shaw. 2012. Agricultural waterway buffer study. Washington State University Extension, Bellingham, Washington. (viii)
Benyahya L., D. Caissie, N. El-Jabi, and M.G. Satish. 2010. Comparison of microclimate vs. remote meteorological data and results applied to a water temperature model (Miramichi River, Canada). Journal of Hydrology 380:247–259. (i)
Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. Pages 191-232 *in* E.O. Salo and T.W. Cundy, editors. Streamside management: forestry and fishery interactions. Contribution No. 57. Institute of Forest Resources, University of Washington, Seattle. (viii)
Bilby, R.E., and P.A. Bisson. 1987. Emigration and production of hatchery Coho Salmon (*Oncorhynchus kisutch*) stocked in streams draining an old-growth and clear-cut watershed. Canadian Journal of Fisheries and Aquatic Sciences 44:1397-1407. (i)
Bisson, P.A., J.M. Buffington, and D.R. Montgomery. 2006. Valley segments, stream reaches, and channel units. Pages 23-49 *in* F.R. Hauer and G.A. Lamberti, editors. Methods in stream ecology. Elsevier, Burlington, Massachusetts. (i)
Bisson, P.A., S.M. Claeson, S.M. Wondzell, A.D. Foster, and A. Steel. 2013. Evaluating headwater stream buffers: lessons learned from watershed-scale experiments in southwest Washington. Pages 165-184 *in* P.D. Anderson and K.L. Ronnenberg, editors. Density management in the 21st Century: west side story. PNW-GTR-880. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)
Bobba, A.G., P.A. Chambers, and J. Spoelstra. 2010. Environmental impacts in arid and semiarid floodplains. Journal of Environmental Hydrology 18:1-15. (i)
Booth, D.B., J.R. Karr, S. Schauman, C.P. Konrad, S.A. Morley, M.G. Larson, P.C. Henshaw, E.J. Nelson, and S.J. Burges. 2001. Urban stream rehabilitation in the Pacific Northwest. Final report of EPA Grant Number R82-5284-010. University of Washington, Seattle (viii)
Booth, D.B., K.A. Kraseski, and C.R. Jackson. 2014. Local-scale and watershed-scale determinants of summertime urban stream temperatures. Hydrological Processes 28:2427-2438. (i)
Bowler, D.E., R. Mant, H. Orr, D.M. Hannah, and A.S. Pullin. 2012. What are the effects of wooded riparian zones on stream temperature? Environmental Evidence 2012:3-9. (i)
Boyd, M. 1996. Heat source: stream temperature prediction. Master's thesis. Oregon State University, Corvallis, Oregon. (i)
Boyd, M., and B. Kasper. 2003. Analytical methods for dynamic open channel heat and mass transfer:

[1] References are classified according to RCW 34.05.271 (see Appendix 1) denoted by a lower case roman numeral (i – viii) in parentheses at the end of the citation.

methodology for heat source model Version 7.0. Available: https://www.oregon.gov/deq/FilterDocs/heatsourcemanual.pdf. (January 2019). (viii)

Brannon, E.L., M.S. Powell, T.P. Quinn, and A. Talbot 2004. Population structure of Columbia River basin Chinook Salmon and steelhead trout. Reviews in Fisheries Science 12:99–232. (i)

Brattstrom, B.H. 1963. A preliminary review of the thermal requirements of amphibians. Ecology 44:238-255. (i)

Brett, J.R. 1952. Temperature tolerance in young Pacific salmon, genus *Oncorhynchus*. Journal of the Fisheries Research Board of Canada 9:265-323. (i)

Brett, J.R. 1971. Energetic responses of salmon to temperature. A study of some thermal relations in the physiology and freshwater ecology of Sockeye Salmon (*Oncorhynchus nerka*). American Zoologist 11:99–113. (i)

Brett, J.R., J.E. Shelbourn, and C.T. Shoop. 1969. Growth rate and body composition of fingerling Sockeye Salmon, *Oncorhynchus nerka,* in relation to temperature and ration size. Journal of the Fisheries Research Board of Canada 26:2363–2394. (i)

Brown, H.A. 1975. Temperature and the development of the Tailed Frog, *Ascaphus truei.* Comparative Biochemistry and Physiology 50A(2):397-405. (i)

Buffington, J.M., D.R. Montgomery, and H.M. Greenberg. 2004. Basin-scale availability of salmonid spawning gravel as influenced by channel type and hydraulic roughness in mountain catchments. Canadian Journal of Fisheries and Aquatic Sciences 61:2085-2096. (i)

Burkholder, B.K., G.E. Grant, R. Haggerty, T. Khangaonkar, and P.J. Wampler. 2008. Influence of hyporheic flow and geomorphology on temperature of a large, gravel-bed river, Clackamas River, Oregon, USA. Hydrological Processes 22:941-953. (i)

Bury, R.B. 2008. Low thermal tolerances of stream amphibians in the Pacific Northwest: implications for riparian and forest management. Applied Herpetology 5:63-74. (i)

Caissie, D. 2006. The thermal regime of rivers: a review. Freshwater Biology 51:1389–1406. (i)

Caissie, D. 2016. River evaporation, condensation and heat fluxes within a first order tributary of Catamaran Brook (New Brunswick, Canada). Hydrological Processes 30:1872–1883. (i)

Claussen, D.L. 1973. The thermal relations of the Tailed Frog, *Ascaphus truei,* and the Pacific Treefrog, *Hyla regilla*. Comparative Biochemistry and Physiology 44A(1):137-153. (i)

Coffin, C., S. Lee, and D. Garland. 2011. Bear-Evans Watershed temperature, dissolved oxygen and fecal coliform bacteria total maximum daily load: water quality implementation plan. Publication No.11-10-024. Washington Department of Ecology, Bellevue, Washington. (viii)

Cole, E., and M. Newton. 2013. Influence of streamside buffers on stream temperature response following clear-cut harvesting in western Oregon. Canadian Journal of Forest Research 43:993-1005. (i)

Cristea, N.C., and S.J. Burges. 2010. An assessment of the current and future thermal regimes of three streams located in the Wenatchee River basin, Washington State: some implications for regional river basin systems. Climatic Change 2010:493-520. (i)

Cristea, N., and J. Janisch. 2007. Modeling the effects of riparian buffer width on effective shade and stream temperature. Washington Department of Ecology, Olympia. (viii)

Crossin, G.T., S.G. Hinch, S.J. Cooke, D.W. Welch, D.A. Patterson, S.R.M. Jones, A.G. Lotto, R.A. Leggatt, M.T. Mathes, J.M. Shrimpton, G. Van Der Kraak, and A.P. Farrell. 2008. Exposure to high temperatures influences the behavior, physiology, and survival of Sockeye Salmon during spawning migration. Canadian Journal of Zoology 86:127-140. (i)

Czarnomski, N., C. Hale, W.T. Frueh, M. Allen, and J. Groom. 2013. Effectiveness of riparian buffers at protecting stream temperature and shade in Pacific Northwest forests: a systematic review. Final Report to the Forest Practices Monitoring Program. Oregon

Department of Forestry, Salem. (viii)
de Vlaming, V.L., and R.B. Bury. 1970. Thermal selection in tadpoles of the Tailed-Frog, *Ascaphus truei.* Journal of Herpetology 4:179-189. (i)
DeWalle, D.R. 2010. Modeling stream shade: riparian buffer height and density as important as buffer width. Journal of the American Water Resources Association 46:323-333. (i)
D'Souza, L.E., M. Reiter, L.J. Six, and R.E. Bilby. 2011. Response of vegetation, shade and stream temperature to debris torrents in two western Oregon watersheds. Forest Ecology and Management 261:2157-2167. (i)
Dugdale, S.J., N.E. Bergeron, and A. St-Hilaire. 2013. Temporal variability of thermal refuges and water temperature patterns in an Atlantic Salmon river. Remote Sensing of Environment 136:358-373. (i)
Eberhardt, L.L. 1976. Quantitative ecology and impact assessment. Journal of Environmental Management 4:27–70. (i)
Ebersole, J.L., W.J. Liss, and C.A. Frissell. 2003a. Thermal heterogeneity, stream channel morphology, and salmonid abundance in northeastern Oregon streams. Canadian Journal of Fisheries and Aquatic Sciences 60:1266-1280. (i)
Ebersole, J.L., W.J. Liss, and C.A. Frissell. 2003b. Cold water patches in warm streams: physicochemical characteristics and the influence of shading. Journal of the American Water Resources Association 39:355-368. (i)
Eliason, E.J., T.D. Clark, M.J. Hague, L.M. Hanson, Z.S. Gallagher, K.M. Jeffries, M.K. Gale, D.A. Patterson, S.G. Hinch, and A.P. Farrell. 2011. Differences in thermal tolerance among Sockeye Salmon populations. Science 332:109-112. (i)
Elmore, W., and J.B. Kauffman. 1994. Riparian and watershed systems: degradation and restoration. Pages 211-232 *in* M. Vavra, W.A. Laycock, and R.D. Piper, editors. Ecological implications of livestock herbivory in the West. Society of Range Management, Denver, Colorado. (viii)
Farrell, A.P., S.G. Hinch, S.J. Cooke, D.A. Patterson, G.T. Crossin, M. Lapointe, and M.T. Mathes. 2008. Pacific salmon in hot water: applying aerobic scope models and biotelemetry to predict the success of spawning migrations. Physiological and Biochemical Zoology 81:697-709. (i)
Fausch, K.D., C.E. Torgersen, C.V. Baxter, and H.W. Li. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. BioScience 52:1-16. (i)
Finkenbine, J.K., J.W. Atwater, and D.S. Mavinic. 2000. Stream health after urbanization. Journal of the American Water Resources Association 36:1149-1160. (i)
Frissell, C.A., W.J. Liss, C.E. Warren, and M.D. Hurley. 1986. A hierarchical framework for stream habitat classification: viewing streams in a watershed context. Environmental Management 10:199-214. (i)
Fullerton, A.H., C. Torgersen, J.J. Lawler, R.N. Faux, E.A. Steel, T.J. Beechie, J.L. Ebersole, and S.J. Leibowitz. 2015. Rethinking the longitudinal stream temperature paradigm—region-wide comparison of thermal infrared imagery reveals unexpected complexity of river temperatures. Hydrological Processes 29:4719-4737. (i)
Garner, G., I.A. Malcolm, J.P. Sadler, and D.M. Hannah. 2014. What causes cooling water temperature gradients in a forested stream reach? Hydrology and Earth System Sciences 18:5361-5376. (i)
Gecy, J.L., and M.V. Wilson. 1990. Initial establishment of riparian vegetation after disturbance by debris flows in Oregon. American Midland Naturalist 123:282-291. (i)
Gomi, T., R.D. Moore, and A.S. Dhakal. 2006. Headwater stream temperature response to clear-cut harvesting with different riparian treatments, coastal British Columbia, Canada. Water Resources Research

42: W08437.
Gomi, T., R.C. Sidle, and D.N. Swanston. 2004. Hydrogeomorphic linkages of sediment transport in headwater streams, Maybeso Experimental Forest, southeast Alaska. Hydrological Processes 18:667-667. (i)
Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience 41:540-551. (i)
Groom, J.D., L. Dent, and J. Madsen. 2011. Stream temperature change detection for state and private forests in the Oregon Coast Range. Water Resources Research 47:1-12. (i)
Groot, C., and L. Margolis. 2010. Pacific salmon life histories. University of Washington Press, Seattle. (i)
Hari, R.E., D.M. Livingston, R. Siber, P. Burkhardt-Holm, and H. Guttinger. 2006. Consequences of climate change for water temperature and brown trout populations in alpine rivers and streams. Global Change Biology 12:10-26. (i)
Harwood, J., and K. Stokes. 2003. Coping with uncertainty in ecological advice: lessons from fisheries. Trends in Ecology and Evolution 18:617–622. (i)
Hawkins, C.P., M.L. Murphy, N.H. Anderson, and M.A. Wilzbach. 1983. Density of fish and salamanders in relation to riparian canopy and physical habitat in streams of the northwestern United States. Canadian Journal of Fisheries and Aquatic Sciences 40:1173-1185. (i)
Hendry, A.P., J.E. Hensleigh, and R.R. Reisenbichler. 1998. Incubation temperature, developmental biology, and the divergence of Sockeye Salmon (*Oncorhynchus nerka*) within Lake Washington. Canadian Journal of Fisheries and Aquatic Sciences 55:1387–1394. (i)
Hester, E.T., and M.W. Doyle. 2011. Human impacts to river temperature and their effects on biological processes: a quantitative synthesis. Journal of the American Water Resources Association 47:571–587. (i)
Hinch, S.G., S.J. Cooke, A.P. Farrell, K.M. Miller, M. LaPointe, and D.A. Patterson. 2012. Dead fish swimming: a review of research on the early migration and high premature mortality in adult Fraser River Sockeye Salmon (*Oncorhynchus nerka*). Journal of Fish Biology 81:576-599. (i)
Hodgson, S., and T.P. Quinn. 2002. The timing of adult Sockeye Salmon migration into fresh water: adaptations by populations to prevailing thermal regimes. Canadian Journal of Zoology 80:542-555. (i)
Hogg, I.D., and D.D. Williams. 1996. Response of stream invertebrates to a global-warming thermal regime: an ecosystem-level manipulation. Ecology 77:395-407. (i)
Holland, D.C. 1994. The Western Pond Turtle: habitat and history. Unpublished final report, U. S. Dept. of Energy, Portland, Oregon. (viii)
Holsinger, L., R.E. Keane, D.J. Isaak, L. Eby, and M.K. Young. 2014. Relative effects of climate change and wildfires on stream temperatures: a simulation modeling approach in a Rocky Mountain watershed. Climate Change 124:191-206. (i)
Isaak, D.J., and W.A. Hubert. 2001. A hypothesis about factors that affect maximum summer stream temperatures across montane landscapes. Journal of the American Water Resources Association 37:351-366. (i)
Isaak, D.J., and W.A. Hubert. 2004. Nonlinear response of trout abundance to summer stream temperatures across a thermally diverse montane landscape. Transactions of the American Fisheries Society 133:1254-1259. (i)
Isaak, D.J., C.H. Luce, B.B. Rieman, D.E. Nagel, E.E. Peterson, D.L. Horan, S. Parkes, and G.L. Chandler. 2010. Effects of climate change and wildfire on stream temperatures and salmonid thermal habitat in a mountain river network. Ecological

Applications 20:1350-1371. (i)
Isaak, D.J., E.E. Peterson, J.M. Ver Hoef, S.J. Wenger, J.A. Falke, C. Torgersen, C. Sowder, E.A. Steel, M. Fortin, C.E. Jordan, A.S. Ruesch, N. Som, and P. Monestiez. 2014. Applications of spatial statistical network models to stream data. Wiley Interdisciplinary Reviews–Water 1:277-294. (i)
Isaak, D., S. Wenger, E. Peterson, J. Ver Hoef, D. Nagel, C. Luce, S. Hostetler, J. Dunham, B. Roper, S. Wollrab, G. Chandler, D. Horan, and S. Parkes-Payne. 2017a. The NorWeST summer stream temperature model and scenarios for the western U.S.: a crowd-sourced database and new geospatial tools foster a user community and predict broad climate warming of rivers and streams. Water Resources Research 53:9181-9205. (i)
Isaak, D.J., S.J. Wenger, and M.K. Young. 2017b. Big biology meets microclimatology: defining thermal niches of ectotherms at landscape scales for conservation planning. Ecological Applications 27:977–990. (i)
Isaak, D.J., S. Wollrab, D. Horan, and G. Chandler. 2012. Climate change effects on stream and river temperatures across the Northwest U.S. from 1980–2009 and implications for salmonid fishes. Climatic Change 113:499-524. (i)
Isaak, D.J., M.K. Young, D. Nagel, D. Horan, and M. Groce. 2015. The coldwater climate shield: delineating refugia to preserve salmonid fishes through the 21st Century. Global Change Biology 21:2540-2553. (i)
Jackson, C.R., C.A. Sturm, and J.M. Ward. 2001. Timber harvest impacts on small headwater stream channels in the coast ranges of Washington. Journal of the American Water Resources Association 37:1533–1549.
Janisch, J.E., S.M. Wondzell, and W. J. Ehinger. 2012. Headwater stream temperature: interpreting response after logging, with and without riparian buffers, Washington, USA. Forest Ecology and Management 270:302-313. (i)
Johnson, F.A. 1971. Stream temperatures in an alpine area. Journal of Hydrology 14:322-336. (i)
Johnson, S.L. 2004. Factors influencing stream temperatures in small streams: substrate effects and a shading experiment. Canadian Journal of Fisheries and Aquatic Sciences 61:913-923. (i)
Kappenman, K.M., M.A.H. Webb, and M. Greenwood. 2013. The effect of temperature on embryo survival and development in Pallid Sturgeon *Scaphirhynchus albus* (Forbes & Richardson 1905) and Shovelnose Sturgeon *S. platorynchus* (Rafinesque, 1820). Journal of Applied Ichthyology 29:1193-1203. (i)
Keefer, M.L., C.A. Peery, and M.J. Heinrich. 2008. Temperature-mediated en route migration mortality and travel rates of endangered Snake River Sockeye Salmon. Ecology of Freshwater Fish 17:136–145. (i)
Keller, E.A., and F.J. Swanson. 1979. Effects of large organic material on channel form and fluvial processes. Earth Surface Processes 4:361-380. (i)
Kibler, K.M., A. Skaugset, L.M. Ganio, and M.M. Huso. 2013. Effects of contemporary forest harvesting practices on headwater stream temperatures: initial response of the Hinkle Creek catchment, Pacific Northwest, USA. Forest Ecology and Management 310:680-691. (i)
Kiffney, P.M., J.S. Richardson, and J.P. Bull. 2003. Responses of periphyton and insect consumers to experimental manipulation of riparian buffer width along headwater streams. Journal of the American Water Resources Association 40:1060-1076. (i)
Kinouchi, T., H. Yagi, and M. Miyamoto. 2006. Increase in stream temperature related to anthropogenic heat input from urban wastewater. Journal of Hydrology 335:78–88. (i)
Knutson, K.L., and V.L. Naef. 1997. Management recommendations for Washington's priority habitats: riparian. Washington Department of Fish and Wildlife,

Olympia, Washington. (iii)
Konrad, C.P., D.B. Booth, and S.J. Burges. 2005. Effects of urban development in the Puget Lowland, Washington, on interannual streamflow patterns: consequences for channel form and streambed disturbance. Water Resources Research 41:W07009. (i)
Lawrence, D.J., B. Stewart-Koster, J.D. Olden, A.S. Ruesch, C.E. Torgersen, J.J. Lawler, D.P. Butcher, and J.K. Crown. 2014. The interactive effects of climate change, riparian management, and a nonnative predator on stream-rearing salmon. Ecological Applications 24:895-912. (i)
LeBlanc, R.T., R.D. Brown, and J.E. FitzGibbon. 1997. Modeling the effects of land use change on the water temperature in unregulated urban streams. Journal of Environmental Management 49:445–469. (i)
Leinenbach, P., G. McFadden, and C. Torgersen. 2013. Effects of riparian management strategies on stream temperature, Part II. Summary report of the Science Review Team submitted to the Interagency Coordinating Subcommittee. Bureau of Land Management, Portland, Oregon. (viii)
Li, H.W., G.A. Lamberti, T.N. Pearsons, C.K. Tait, and J.C. Buckhouse. 1994. Cumulative effects of riparian disturbances along high desert trout streams of the John Day Basin, Oregon. Transactions of the American Fisheries Society 123:627–640. (i)
Li, J.L., S.L. Johnson, and J.B. Sobota. 2011. Three responses to small changes in stream temperature by autumn-emerging aquatic insects. Journal of the North American Benthological Society 30:474-484. (i)
Licht, L.E. 1971. Breeding habits and embryonic thermal requirements of the frogs, *Rana aurora aurora* and *Rana pretiosa pretiosa*, in the Pacific Northwest. Ecology 52:116–124. (i)
Liquori, M., and C.R. Jackson. 2001. Channel response from shrub dominated riparian communities and associated effects on salmonid habitat. Journal of the American Water Resources Association 37:1639–1651. (i)
Luce, C.H., B.P. Staab, M.G. Kramer, S.J., D.J. Isaak, and C. McConnell. 2014. Sensitivity of summer stream temperatures to climate variability in the Pacific Northwest. Water Resources Research 50:1-16. (i)
Lytle, D.A., and N.L. Poff. 2004. Adaptation to natural flow regimes. Trends in Ecology and Evolution 19:94-100. (i)
Malard, F., K. Tockner, M. Dole-Olivier, and J.V. Ward. 2002. A landscape perspective of surface-subsurface hydrological exchanges in river corridors. Freshwater Biology 47:621-640. (i)
Malcolm, I.A., C. Soulsby, and A.F. Youngson. 2002. Thermal regime in the hyporheic zone of two contrasting salmonid spawning streams: ecological and hydrological implications. Fisheries Management and Ecology 9:1-10. (i)
Maloney, S.B., A.R. Tiedemann, D.A. Higgins, T.M. Quigley, and D.B. Marx. 1999. Influence of stream characteristics and grazing intensity on stream temperatures in eastern Oregon. PNW-GTR-459. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)
Marsh, P.C. 1985. Effect of incubation temperature on survival of embryos of native Colorado River fishes. The Southwestern Naturalist 30:129-140. (i)
May, C.W. 2003. Stream-riparian ecosystems in the Puget Sound lowland ecoregions: a review of best available science. Watershed Ecology, LLC, Poulsbo, Washington. (i)
McCullough, D.A. 1999. A review and synthesis of effects of alterations to the water temperature regime of freshwater life stages of salmonids, with special reference to Chinook Salmon. U.S. Environmental Protection Agency, Region 10, Seattle,

Washington. (viii)
McCullough, D.A., J.M. Bartholow, H.I. Jager, R.L. Beschta, E.F. Cheslak, M.L. Deas, J.L. Ebersole, J.S. Foote, S.L. Johnson, K.R. Marine, M.G. Mesa, J.H. Petersen, Y. Souchon, K.F. Tiffan, and D.A. Wurtsbaugh. 2009. Research in thermal biology: burning questions for coldwater stream fishes. Reviews in Fisheries Science 17:90-115. (i)
McCullough, D., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue Paper 5. Summary of technical literature examining the physiological effects of temperature on salmonids. EPA-910-D-01-005. U.S. Environmental Protection Agency, Region 10, Seattle, Washington. (viii)
Micheli, E.R., and J.W. Kirchner. 2002. Effects of wet meadow riparian vegetation on streambank erosion. 2. Measurements of vegetated bank strength and consequences for failure mechanics. Earth Surface Processes and Landforms 27:687-697. (i)
Moore, R.D., D.L. Spittlehouse, and A. Story. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. Journal of the American Water Resources Association 41:813-834. (i)
Moulton, S.R., T.L. Beitinger, K.W. Stewart, and R.J. Currie. 1993. Upper temperature tolerance of four species of caddisflies (Insecta: Trichoptera). Journal of Freshwater Ecology 8:193–198. (i)
Murphy, M.L., and J.D. Hall. 1981. Varied effects of clear-cut logging on predators and their habitat in small streams in the Cascade Mountains, Oregon. Canadian Journal of Fisheries and Aquatic Sciences 38:137-145. (i)
Murphy, M.L., C.P. Hawkins, and N.H. Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities. Transactions of the American Fisheries Society 110:469-478. (i)
NRC (National Research Council). 2002. Riparian areas: functions and strategies for management. National Academy Press, Washington, D.C. (i)
Nyberg, L., O. Calles, and L. Greenberg. 2008. Impact of short-term regulation on hyporheic water quality in a boreal river. River Research and Applications 24:407-419. (i)
Olden, J.D., and R.J. Naiman. 2010. Incorporating thermal regimes into environmental flows assessments: modifying dam operations to restore freshwater ecosystem integrity. Freshwater Biology 55:86-107. (i)
Olson, D.H., and C. Rugger. 2007. Preliminary study of the effects of headwater riparian reserves with upslope thinning on stream habitats and amphibians in western Oregon. Forest Science 53:331-342. (i)
Paul, M.J., and J.L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics 32:333–365. (i)
Pollett, K.L., J.G. MacCracken, and J.A. MacMahon. 2010. Stream buffers ameliorate the effects of timber harvest on amphibians in the Cascade Range of southern Washington, USA. Forest Ecology and Management 260:1083-1087. (i)
Poole, G.C., and C.H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27:787-802. (i)
Poole, G.C., J.B. Dunham, D.M. Keenan, S.T. Sauter, D.A. McCullough, C. Mebane, J.C. Lockwood, D.A. Essig, M.P. Hicks, D.J. Sturdevant, E.J. Materna, S.A. Spalding, J. Risley, and M. Deppman. 2004. The case for regime-based water quality standards. BioScience 54:155-161. (i)
Poole, G., J. Risley, and M. Hicks. 2001. Issue paper 3: spatial and temporal patterns of stream temperature (revised). EPA-910-D-01-003. U.S. Environmental Protection Agency, Region 10, Seattle, Washington. (viii)
Post, D.M., E.P. Palkovacs, E.G. Schielke, and S.I. Dodson. 2008. Interspecific variation in a predator affects community structure and cascading trophic interactions. Ecology 98:2019–2032. (i)
Pringle, C.M., and F.J. Triska. 2000. Emergent biological patterns in streams resulting from surface-subsurface water interactions at landscape scales. Pages 167-193 *in* J.B. Jones and P.J. Mulholland, editors. Streams and groundwaters. Elsevier, Burlington, Massachusetts. (i)

Reeves, G.H., D.H. Olson, S.M. Wondzell, P.A. Bisson, S. Gordon, S.A. Miller, J.W. Long, and M.J. Furniss. 2018. Chapter 7: The Aquatic Conservation Strategy of the Northwest Forest Plan–a review of the relevant science after 23 years. Pages 461-642 *in* T.A. Spies, P.A. Stine, R. Gravenmier, J.W. Long, and M.J. Reilly, technical coordinators. Synthesis of science to inform land management within the Northwest Forest Plan area. PNW-GTR-966. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

Rezende E.L., L.E. Castañeda, and M. Santos. 2014. Tolerance landscapes in thermal ecology. Functional Ecology 28:799–809. (i)

Richter, A., and S.A. Kolmes. 2005. Maximum temperature limits for Chinook, Coho, and Chum Salmon, and steelhead trout in the Pacific Northwest. Reviews in Fisheries Science 13:23–49. (i)

Rykken, J.J., S.C. Chan, and A.R. Moldenke. 2007. Headwater riparian microclimate patterns under alternative forest management treatments. Forest Science 53:270-280. (i)

Sather, N.K., and C.W. May. 2007. Riparian buffer zones in the interior Columbia River Basin: a review of best available science. Battelle Memorial Institute, Marine Sciences Laboratory, Sequim, Washington. (viii)

Sauter, S.T., L.I. Cershaw, and A.G. Maule. 2001. Behavioral thermoregulation by juvenile spring and fall Chinook Salmon, *Oncorhynchus tshawytscha*, during smoltification. Environmental Biology of Fishes 61:295–304. (i)

Sauter, S.T., and P.J. Connolly. 2010. Growth, condition factor, and bioenergetics modeling link warmer stream temperatures below a small dam to reduced performance of juvenile steelhead. Northwest Science 84:369-377. (i)

Schuett-Hames, D., A. Roorbach, and R. Conrad. 2012. Results of the westside type N buffer characterization, integrity and function study final report. Cooperative Monitoring Evaluation and Research Report, CMER 12-1201. Washington Department of Natural Resources, Olympia.

Sinokrot, B.A., and H.G. Stefan. 1993. Stream temperature dynamics: measurements and modeling. Water Resources Research 29:2299-2312. (i)

Sridhar,V., A.L. Sansone, J. Lamarche, T. Dubin, and D.P. Lettenmaier. 2004. Prediction of stream temperature in forested watersheds. Journal of the American Water Resources Association 40:197-213. (i)

Stanford, J.A. 1998. Rivers in the landscape: introduction to the special issues on riparian and groundwater ecology. Freshwater Biology 40:402-406. (i)

Steel, E.A., A. Tillotson, D.A. Larsen, A. Fullerton, K.P. Denton, and B.R. Beckman. 2012. Beyond the mean: the role of variability in predicting ecological effects of stream temperatures on salmon. Ecosphere 3:104 (i)

Stewart-Oaten, A., W.W. Murdoch, and K.R. Parker. 1986. Environmental impact assessment: pseudoreplication in time? Ecology 67:929–940. (i)

Stoddard, M.A., and J.P. Hayes. 2005. The influence of forest management on headwater stream amphibians at multiple spatial scales. Ecological Applications 15:811-823. (i)

Story, A., R.D. Moore, and J.S. Macdonald. 2003. Stream temperatures in two shaded reaches below cutblocks and logging roads: downstream cooling linked to subsurface hydrology. Canadian Journal of Forest Research 33:1383-1396. (i)

Strange, J.S. 2010. Upper thermal limits to migration in adult Chinook Salmon: evidence from the Klamath River basin. Transactions of the American Fisheries Society 139:1091-1108. (i)

Sweeney, B.W., and J.D. Newbold. 2014. Streamside forest buffer width needed to protect stream water quality, habitat, and organisms: a literature review. Journal of the American Water Resources Association 50:560-584. (i)

Tait, C.K., J.L. Li, G.A. Lamberti, T.N. Pearsons, and H.W. Li. 1994. Relationships between riparian cover and the community structure of high desert streams. Journal of the North American Benthological Society 13:45–56. (i)

Toledo, Z.O., and J.B. Kauffman. 2001. Root biomass in relation to channel morphology of headwater streams. Journal of the American Water Resources Association 37:1653-1663. (i)

Torgersen, C.E., R. Faux, B.A. McIntosh, N. Poage, and D.J. Norton. 2001. Airborne thermal remote sensing for water temperature assessment in rivers and streams. Remote Sensing of Environment 76:386-398. (i)

Torgersen, C.E., D.M. Price, H.W. Li, and B.A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associations of Chinook Salmon in northwestern Oregon. Ecological Applications 9:301-319. (i)

USEPA 2012. Technical memorandum to the Idaho Department of (state) Lands (IDL) Private Lands Forest Practices Act (FPA) Shade Subcommittee. Available: ftp://ftp.epa.gov/ reg10ftp/forestry/. (June 2015). (viii)

Ver Hoef, J.M., E.E. Peterson, and D. Theobald. 2006. Spatial statistical models that use flow and stream distance. Environmental and Ecological Statistics 13:449–464. (i)

Wahl, C.M., A. Neils, and D. Hooper. 2013. Impacts of land use at the catchment scale constrain the habitat benefits of stream riparian buffers. Freshwater Biology 58:2310–2324. (i)

Waite, I.R., and K.D. Carpenter. 2000. Associations among fish assemblage structure and environmental variables in Willamette Basin streams, Oregon. Transactions of the American Fisheries Society 129:754–770. (i)

Ward, J.V., F. Malard, and K. Tockner. 2002. Landscape ecology: a framework for integrating pattern and process in river corridors. Landscape Ecology 17(Supplement 1):35–45. (i)

Ward, J.V., and J.A. Stanford. 1982. Thermal responses in the evolutionary ecology of aquatic insects. Annual Review of Entomology 27:97-117. (i)

Ward, J.V., and J.A. Stanford. 1995. Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. Regulated Rivers: Research & Management 11:105-119. (i)

Webb, B.W., D.M. Hannah, R.D. Moore, L.E. Brown, and F. Nobilis. 2008. Recent advances in stream and river temperature research. Hydrological Processes 22:902–918. (i)

Weitkamp, L.A., D.J. Teel, M. Liermann, S.A. Hinton, D.M. Van Doornik, and P.J. Bentley. 2015. Stock-specific size and timing at ocean entry of Columbia River juvenile Chinook Salmon and steelhead: implications for early ocean growth. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science 7:370-392. (i)

Welsh, H.H. 1990. Relictual amphibians and old-growth forests. Conservation Biology 4:309-319. (i)

Welsh, H.H., Jr., G R. Hodgson, B.C. Harvey, and M.E. Roche. 2001. Distribution of juvenile Coho Salmon in relation to water temperatures in tributaries of the Mattole River, California. North American Journal of Fisheries Management 21:464-470. (i)

Welsh, H.H., Jr., and A.J. Lind. 1996. Habitat correlates of the Southern Torrent Salamander, *Rhyacotriton variegatus* (Caudata: Rhyacotritonidae), in northwestern California. Journal of Herpetology 30:385-398. (i)

Wiens, J.A. 2002. Riverine landscapes: taking landscape ecology into the water. Freshwater Biology 47:501–515. (i)

Winder, M., and D.E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology 85:2100–2106. (i)

Wondzell, S.M. 2012. Hyporheic zones in mountain streams: physical processes and ecosystem functions. Stream Notes (Jan. - Apr.):1-10. Stream Systems Technology Center, Rocky Mountain Research Station, Fort Collins, Colorado. (i)

Wondzell, S.M., and M.N. Gooseff. 2013. Geomorphic controls on hyporheic exchange across scales: watersheds to particles. Pages 203-218 *in* J. Shroder, editor-in-chief, and E. Wolh, editor. Treatise on Geomorphology. Academic Press, San Diego, California.

Wright, K.K., C.V. Baxter, and J.L. Li. 2005. Restricted hyporheic exchange in an alluvial river system: implications for theory and management. Journal of the North American Benthological Society 24:447-460. (i)

Zaugg, W.S., and H.H. Wagner. 1973. Gill ATPase activity related to parr-smolt transformation and migration in steelhead trout (*Salmo gairdneri*): influence of photoperiod and temperature. Comparative Biochemistry and Physiology 45:955-965. (i)

Zoellick, B.W. 2004. Density and biomass of redband trout relative to stream shading and temperature in southwestern Idaho. Western North American Naturalist 64:18–26. (i)



Long-toed salamander Ambystoma macrodactylum/*Scott Fitkin, WDFW*

Chapter 5. Pollutant Removal

By: Jeffrey L. Ullman and George F. Wilhere

5.1. Introduction

The capability of riparian areas to remove certain pollutants from runoff has been known to scientists for over 60 years (e.g., Trimble and Sartz 1957). Understanding the complex processes and associated factors that affect the pollutant removal function of riparian areas is essential for developing management strategies that will protect aquatic ecosystems. Management of riparian areas for pollutant removal differs from the other ecological functions discussed in this document in that the primary focus is on mitigating activities occurring outside the riparian area. The pollutant removal function is unique in that it only exists in the presence of human activities that generate polluted water, and it is only necessary when runoff from upland activities threaten to degrade water quality.

This chapter summarizes key information relevant to riparian pollutant removal function. First, a general background is presented on the main processes and related site-level factors affecting the transport and fate of nonpoint source pollutants in riparian areas. Next, the biological impacts, common sources, *in situ* chemistry, transport pathways, and mitigation are reviewed for five types of pollutants—sediments, excess nutrients, metals, pesticides and other organic compounds, and pathogens. Last, a summary of what is currently known about the relationships between riparian buffer width and pollutant removal is provided. Riparian buffer is not synonymous with riparian area. Riparian area is an ecological designation that is synonymous with riparian ecosystem (see Chapter 1). Riparian buffer is a management designation, and a buffer may be narrower or wider than the riparian ecosystem.



Yellowjacket Creek/George Fornes, WDFW

This chapter only addresses nonpoint-source chemical pollutants that interact with riparian areas. Hence, it does not deal with "thermal pollution" effects on water temperature (see Chapter 4), which is another important water quality parameter. Similarly, it does not deal with pollutants routed via roads, ditches, and drains into urban and suburban stormwater runoff systems, or with polluted water routed to rivers and streams via agricultural tile drainage.

While the scientific literature reviewed here includes information collected during the 1970s and 1980s, when scientists first started to rigorously investigate the removal of pollutants by riparian areas (Correll 1997), more recent findings are highlighted. Decades of research have revealed that the ecosystem structures and processes responsible for pollutant removal functions of riparian areas are complex, spatially and temporally variable, and dependent on site-level environmental conditions. This complexity and variability are the main reasons for inconsistent results found in the published research and the lack of definitive recommendations regarding the structure and size of riparian buffers required for pollutant removal. Nevertheless, general trends in research findings can guide policy makers and resource managers to management strategies that address these uncertainties and lead to adequate protection of water quality.

5.2. The Pollutant Removal Function of Riparian Areas

Water quality refers to the physical, chemical, and biological characteristics of water that indicate a waterbody's suitability to meet human needs or habitat requirements for fish and wildlife. Riparian areas exert a significant influence on water quality due to their position between terrestrial and aquatic ecosystems. Pollutants in dissolved, chemical, or suspended solid forms are transported by water from uplands to surface waterbodies, and while passing through riparian areas contaminated water undergoes a variety of physical, chemical, and biological processes that reduce pollutant concentrations. The processes in riparian areas affecting pollutant transport and fate are complex and often interrelated. Riparian areas slow surface runoff and increase infiltration of water into the soil, thereby enhancing both deposition of solids and filtration of water-borne pollutants. Riparian areas also intercept and act on contaminants in subsurface flow through dilution, sorption[1], physical transformation, chemical degradation, or volatilization by various biogeochemical processes and through uptake and assimilation by plants, fungi, and microbes.

There is overwhelming evidence in the scientific literature that riparian buffers reduce nonpoint source water pollution for a variety of pollutants—including sediments, excess nutrients, metals, organic compounds such as pesticides, and pathogens. Management activities can enhance the physical, chemical, and biological mechanisms that reduce the flow of polluted waters to river and streams.

1 Sorption or "to sorb" is a physical and chemical process by which one substance becomes attached to another. It encompasses two processes adsorption and absorption. Adsorption is the binding of molecules or particles to a substance's surface. The reverse of adsorption is desorption. Absorption is the filling of minute pores in a substance by molecules or particles.



Riparian buffer widths for pollution removal need not be one-size-fits-all/U.S. Dept. of Agriculture, National Agriculture Imagery Program

However, the science is very clear that results vary considerably depending on local conditions, and that the configuration of a riparian buffer may effectively remove one type of pollutant while having minimal effect on another. Although riparian management can reduce significantly the quantity of pollutants entering surface waters, riparian areas are not sufficient by themselves to fully mitigate pollution from nonpoint sources. Thus, it is critical to view pollution control from a holistic, watershed perspective that also manages contaminated runoff at its source, i.e., upland areas subjected to various intensive land uses: forestry, agriculture, commercial, and urban, suburban, and rural residential. Nevertheless, maintaining functional riparian areas is essential for reducing nonpoint source pollution and must be a key component in any suite of management actions focused on water quality.

5.3. Processes Influencing the Pollutant Removal Function

Riparian areas are consistently shown to remove a variety of nonpoint source pollutants, such as those originating from agricultural lands, urban areas, construction sites, and forestry operations. However, the effectiveness of riparian buffers is highly variable (Hickey and Doran 2004; Lee et al. 2004, Anbumozhi et al. 2005; Zhang et al. 2010). Inconsistencies among research results can be explained by the multi-dimensional heterogeneity of riparian ecosystems; the complex, interconnected processes that act on contaminant transport and fate; and the variety of research methods employed. Many site-specific factors contribute to this variability,

including riparian buffer width, slope, topography, surface and subsurface hydrology, soil properties, riparian vegetation, and adjacent upland characteristics. Of all these factors hydrology, soil, and vegetation play dominant roles governing pollutant transport and fate (NRC 2002). The following sections discuss the effects of these three site-level characteristics on the pollutant removal function of riparian areas.

5.3.1. Hydrology

Hydrologic regimes at the terrestrial-aquatic interface impart a particularly significant influence on the attenuation of pollutants by riparian areas. Three principal pathways govern water movement through these systems: 1) overland flow and shallow subsurface flow from adjacent uplands, 2) groundwater flow, and 3) instream water movement that includes hyporheic exchange as well as flood conditions (NRC 2002). Each of these flow paths can act as conduits for pollutant transport to aquatic ecosystems depending on site-specific conditions and pollutant type. Furthermore, seasonal stream flows, fluctuating water tables, and intermittent flooding create a dynamic environment that subjects pollutants to a range of biogeochemical processes.

Upland sources of water often originate as precipitation. During and immediately after a precipitation event, water from upland areas follows different flow paths to the stream channel, each contributing differently to pollutant transport and fate. Overland flow can be either infiltration-excess[2] (Hortonian overland flow) or saturation-excess[3] overland flow. Water that enters the soil profile can also travel downslope in shallow subsurface flow (interflow) through the unsaturated zone[4]. Depending on site-specific conditions, water in one of these flow paths may switch to another.

Collectively these flow paths are commonly termed hillslope runoff. Under certain circumstances, such as in the presence of deep, well-drained soils that facilitate percolation, portions of the shallow subsurface flow can reach the groundwater table and resume transport in the groundwater system. These pathways extend into riparian areas before reaching a surface waterbody.

As overland flow travels through the landscape it can pick up pollutants that can be in either particulate or soluble form. When water infiltrates the soil surface, suspended particulate matter and associated contaminants are entrapped at the soil surface, almost exclusively limiting the form of pollutants that are transported through the subsurface to soluble forms that remain in solution. However, recent research highlights the significance of colloid-facilitated transport as an additional means by which contaminants can move through the subsurface (Sen and Khilar 2006; Bradford and Torkzaban 2008). Colloidal forms (particles ranging from 1 to 1,000 nm) can remain dispersed in solution and exhibit characteristics resembling solutions. This behavior can consequently mobilize substances that tend to sorb to soil particles or organic matter that would otherwise not be able to move through the subsurface. While the fundamental physics and chemistry of this mechanism is understood, the contribution of colloids to pollutant migration through the soil profile is unresolved. Essentially no literature exists on the role of colloids in riparian areas, contributing to uncertainty in predicting the ultimate fate of associated pollutants.

The fundamental variables of interest regarding groundwater are flow rate and travel time, which influence natural chemical and biological processes that remove soluble pollutants, such as sorption to soils, microbial degradation, and plant uptake (Vogt et al.

2 Infiltration-excess overland flow occurs when water enters a soil system faster than the soil can absorb or transport it, such as when precipitation exceeds the infiltration capacity of the soil.

3 Saturation-excess overland flow occurs when the soil becomes saturated, and any additional precipitation results in runoff.

4 The unsaturated zone is also known as the vadose zone. It extends from the ground surface to the water table. Beneath the water table is the zone of saturation.

2012). As groundwater approaches the stream margin biogeochemical activity increases, and this gradient contributes to temporal and spatial variability in solute fluxes (Hayashi and Rosenberry 2002). It should be noted that groundwater exhibits a different geochemical composition than shallow subsurface flow that originates from precipitation events. Groundwater samples typically have a greater specific conductance (related to salinity), higher mineral content and elevated pH (Landmeyer 2011). Differences in chemical composition and biogeochemical activity are likely to manifest differences in pollutant removal from groundwater.

The hyporheic zone is the region beneath and alongside the streambed that represents the groundwater-surface water interface. While hydrologists have a solid understanding of most other hydrologic processes occurring in riparian areas, understanding of the exchanges between groundwater and in-channel surface waters is considerably less (UKEA 2009; Gu et al. 2012). Hyporheic flow patterns are multifaceted and influenced by the pressure gradient at the stream margin, (micro)morphology of the channel, the spatial distribution of hydraulic conductivity along the streambank, and the water exchange rate between the river and the riparian area (Kalbus et al. 2009; Lewandowski 2011). The complexity of the hydrologic regime is further compounded by seasonal variations, and at times intra-seasonal oscillations, in the direction of water flow (Wroblicky et al. 1998), as well as instances where ambient movement of deeper groundwater flows near the interface. Despite the confounding nature of the hyporheic zone, it is vital to consider hyporheic exchange when discussing subsurface fluxes of pollutants, as this zone is a direct link to streams through which contaminants can be transported to lotic systems (Gordon et al. 2004).

As groundwater approaches a streambank, biogeochemical activity increases. Groundwater flow rate and travel time through the riparian area influence natural chemical and biological processes that remove soluble pollutants.

Not only does the hyporheic zone play a critical role in regulating pollutant fluxes from riparian areas to the adjacent lotic environment, the heterogeneous structure at the interface, an oscillating water table, and shifting flow regimes exert a significant influence on biogeochemical cycling. The fluctuating water table alters oxygen concentrations and oxidation-reduction (redox) potential, and the flow regime provides a continuous source of reactants. This dynamic environment allows for anaerobic and aerobic processes to occur simultaneously and in close proximity (Wang et al. 2014). The strong hydraulic and biogeochemical gradients that result from mixing of the subsurface water coming from riparian areas and the surface water of the stream channel create biogeochemical hot spots that exhibit disproportionately high reaction rates compared to the surrounding matrix (McClain et al. 2003). For instance, the convergence of shallow subsurface flow and groundwater at the stream interface can generate hot spots of denitrification. Similarly, hot moments represent brief periods of elevated reaction rates relative to longer periods (e.g., during a rainfall event). Later sections of this chapter discuss this concept in more detail.

5.3.2. Soils

Soils play a critical role in influencing the transport and fate of pollutants in riparian areas. Soil texture and structure act as primary hydrologic regulators, significantly influencing the movement and distribution of contaminants. Comprised of a complex mixture of solid, liquid, and gaseous phases, riparian soils provide a heterogeneous matrix that supports plant and microbial communities. The solid phase encompasses mineral and organic particles of differing sizes and chemical composition that can sorb metals, organic chemicals, and other pollutants, thereby preventing them from migrating to the stream channel. The multiplicity and interaction of various biogeochemical processes in riparian soils contribute greatly to pollutant removal.

Unlike upland soils that are derived from terrestrial parent material, riparian soils primarily develop through the deposition of sediments that originate from various upstream sources. These alluvial deposits establish a heterogeneous patchwork of stratified sediments of different textures, which influences the movement of waterborne contaminants. Huggenberger et al. (1998) provide a good review of the geomorphology and characterization of alluvial soils, but a brief description is warranted here to provide a background related to the movement of contaminants through riparian soils. Deposits of clay, silt, sand, and gravel, and continual disturbance by seasonal high flows and occasional extreme flood events, create a complex mosaic of soil microenvironments that can vary considerably both vertically within the soil profile and along the length of the stream channel (Malanson 1993). A general trend can be observed where coarser sediments are deposited along steep-gradient streams while finer particles are washed downstream and deposited along low-gradient reaches as stream energy dissipates and wider floodplains develop (BLM 2003). Soil particle size also tends to decrease moving away from the stream edge (Huggenberger et al. 1998). This vertical, longitudinal, and lateral spatial structure results in disparate hydrologic conditions, and corresponding differences in pollutant fate, at locations in close proximity.



Rough-skinned Newt Taricha granulosa/*Renee Kinnick, WDFW*

The soil microenvironments described above influence hydrologic conditions, which consequently affect pollutant transport. Soil texture and structure dictate water storage capacity and retention, flow paths and hydraulic conductivity. Coarse textured soils enable a greater hydraulic conductivity that shortens hydraulic residence time in the riparian area, thereby reducing the period in which attenuation mechanisms can act on soluble contaminants before they reach the stream channel. Water may percolate below the root zone and limit potential interactions between vegetation and pollutants in deep, well-drained soils, such as those commonly found in forested riparian areas in humid climatic regions (NRC 2002). However, the root zone intercepts subsurface flow to a greater degree in forested riparian areas that exhibit shallow soils overlying a confining layer (e.g., shallow aquiclude). Overland flow that predominates in arid environments often undergoes limited infiltration due to a tendency for riparian soils to exhibit low permeability in these regions, which allows much of the runoff and associated waterborne contaminants to enter the stream with minimal attenuation (NRC 2002; Buffler et al. 2005).

Altered soil structure can influence pollutant attenuation (Vervoort et al. 1999). Compaction, for instance caused by over-grazing or vehicular traffic, and accompanying structural changes and surface soil instability can lead to diminished infiltration and amplified overland flow (Bohn and Buckhouse 1985; McInnis and McIver 2001). Soils with low infiltration rates typically exhibit a diminished capacity to retain pollutants in riparian areas (Johnson and Buffler 2008). Subsurface soil structure influences water movement and distribution in the unsaturated zone, affecting pollutant transport. Subsurface soil structure also impacts soil aeration and plant root growth, which have ramifications on pollutant fate. Preferential flow in soil macropores represents another facet of soil structure that affects pollutant removal (Allaire et al. 2015). Preferential flow of water through large connected void spaces in soils, which result from fractures, animal burrows and other processes, can enhance subsurface pollutant transport to river systems (Angier et al. 2002; Fuchs et al. 2009; Menichino et al. 2014). Alluvial deposits in riparian areas can further increase the connectivity of subsurface flows with stream channels, increasing lateral contaminant transport toward the stream channel. Preferential flow paths diminish the potential for contaminant sorption by both reducing interactions with soil particles and associated sorption sites and contributing to a higher flow velocity that reduces sorption kinetics. Although preferential flow paths have been a familiar concept in the field of soil science for some time, the recognized importance of these conduits has increased in recent years. This enhanced understanding is particularly important for controlling pollutants such as phosphorus that historically were not considered to undergo much, if any, subsurface transport (Angier et al. 2002; Fox et al. 2011a).

Artificial preferential flow also can be created by tile drains that are used by agricultural operations to remove excess water from the soil profile. Tile drains have been shown to enhance the movement of nutrients and herbicides from agricultural fields to streams, bypassing the natural attenuation processes that would have otherwise reduced the movement of these agrochemicals to aquatic ecosystems (Guan et al. 2011; Vidon and Cuadra 2011; Jaynes and Isenhart 2014).

In addition to playing an integral role in influencing the hydrologic linkage between upland areas and the stream channel, riparian soils provide a dynamic framework that regulates biogeochemical processes that act on contaminants. Soluble pollutants that have entered the soil profile, either from subsurface flow from upland areas or through infiltration in the riparian area, are subject to a variety of processes. Contaminants prone to sorption can be retained within the soil profile of the riparian area, reducing their potential of migrating to the stream channel. Chemicals typically have a greater affinity for clay minerals or organic matter, and thus the attenuation due to sorption will vary depending on



Riparian area along White River/Alan Bauer

the soil composition. Microbial assemblages in riparian soils can contribute to the assimilation, transformation, and degradation of a range of chemicals. Anaerobic conditions in saturated soils found in riparian areas differ considerably from the aerobic environments of adjacent uplands, altering the redox potential. The fate of numerous contaminants is influenced strongly by the redox potential of the soil and associated microbial communities. Fluctuating water tables can alter the redox state, resulting in seasonal variations in chemical species distributed within the riparian area. Although broad generalizations can be made, the literature highlights that temporal changes in soil complexities are not well understood (NRC 2002).

Vegetative communities are also impacted by soil conditions in riparian areas. Plant species exhibit habitat preferences that follow soil moisture gradients across riparian areas. The influence of vegetation on contaminant fate and transport will be discussed in the next section. However, it is salient to note here that soil compaction and other disturbances can lead to invasive plant species that can degrade riparian ecosystem function in relation to pollutant attenuation. Disturbed soils can lose their native species diversity and develop more homogenous stands of an exotic species (e.g., Himalayan Blackberry *Rubus armeniacus*) that often do not have the same vegetative density or root structure as the native population, thereby altering riparian area efficacy in pollutant removal.

5.3.3. Vegetation

Riparian vegetation also plays a critical role in attenuating pollutant transport to surface waters. Plants physically alter the movement of water and associated contaminants, provide habitat for microbial communities that assimilate and transform contaminants, and influence soil redox conditions that govern many biogeochemical cycles. Plant root systems provide bank stabilization, which reduces the direct introduction of sediments into aquatic ecosystems via streambank erosion. Soil stabilization also limits erosion and gully formation that can result from overland flow moving through a riparian area. In addition, forested riparian



Vegetated buffers reduce nonpoint source pollution to rivers and streams/U.S. Dept. of Agriculture, National Agriculture Imagery Program

areas have been shown to enhance instream processing of contaminants, including nutrients and pesticides (Sweeney et al. 2004). This section provides a brief overview of the influence vegetation has on pollutant attenuation in riparian areas and identifies critical points to consider when developing management plans. A number of focused review articles present further details on riparian vegetation-hydrology interactions and mechanisms by which plants can attenuate contaminants in riparian areas (e.g., Tabacchi et al. 2000; Williams and Scott 2009; Dosskey et al. 2010).

The high vegetation density inherent in streamside ecosystems serves a critical function in modulating overland flow and amplifying infiltration. The stems of grass and herbaceous groundcover, trunks of woody vegetation, and downed wood create resistance to overland flow, slowing it, and causing deposition onto and infiltration into the soil profile (Fisher and Binkley 2000; Schuster and Grismer 2004). Vegetation also helps maintain soil structure by increasing soil macropore formation through root growth and decay, which further enhances soil permeability. Soluble contaminants present in overland flow enter the soil column, augmenting attenuation through the various mechanisms discussed throughout this chapter. The reduced velocity of the overland flow caused by the riparian plant community causes suspended particles to settle out of the water column, reducing the transport of sediment and sediment-borne pollutants to the stream. Similarly, lower velocity flows will limit erosion within the riparian area, reducing potential contributions to stream sediment loads and avoiding gully formation, which concentrates overland flows and short circuits pollutant attenuation. A dense overstory canopy will further reduce erosion by intercepting precipitation



that would fall directly onto bare soil, and a dense plant community also reduces erosion of riparian soils by diminishing the velocity of runoff and floodwaters (Schultz et al. 2000).

Vegetation also increases soil surface roughness by producing herbaceous litter and woody debris, and by altering micro-topography, which slows surface flow and enhances infiltration of water. In contrast, sites with exposed mineral soil tend to exhibit low surface roughness that limits infiltration, and these sites are susceptible to increased transport to streams via overland flow.

Vegetation also influences the hydrologic behavior of subsurface and groundwater flow through streamside areas. Root uptake and transpiration by both herbaceous and woody plants can modify subsurface flow and soil moisture regimes in the unsaturated zone under unsaturated conditions. These alterations not only influence pollutant transport through riparian soils, but also affect redox conditions that govern biogeochemical transformations. Deeper-rooted plants can impact groundwater levels by reducing the pressure head at the water table through direct uptake or by extracting water along a water potential gradient. Hence, trees can cause daily or seasonal changes to water table levels, a phenomenon more prevalent in drier climates (Landmeyer 2011). Correspondingly, contaminant fluxes from riparian areas to surface waterbodies may exhibit similar diurnal and seasonal patterns. Water uptake by roots can similarly form a hydraulic barrier that creates an upward water flow through the soil profile that can reduce pollutant leaching and inhibit contaminant plumes from spreading horizontally (Pilon-Smits 2005).



Chinook salmon Oncorhynchus tshawytscha/*Morgan Bond*

While vegetation modulates water flow, it is vital to recognize the interconnected nature between riparian plant communities and hydrologic regimes. Riparian plant communities are determined largely by their adaptation to high moisture environments. Groundwater often represents a primary water source for riparian plants, principally trees and deeper-rooted flora. Consequently, alterations in groundwater regimes can have a detrimental impact on species diversity, density, and distribution, especially in drier regions where vegetation is typically concentrated along a narrow band of suitable soil moisture conditions (NRC 2002). Dramatic changes to plant communities can significantly limit the pollutant removal function of a riparian area. Thus, managers should consider the interrelationships between vegetation and subsurface hydrology. Kuglerová et al. (2014) expounded on this theme in a recent review examining the effects of forest management on groundwater processes and resultant water quality. The authors concluded that logging operations in riparian areas and hydrologically connected upland forests can alter groundwater regimes and affect water quality. They recommended site-specific riparian management where wider buffers would be implemented at critical groundwater discharge locations but narrower buffers would be allowed at sites lacking groundwater flow paths.

Riparian management strategies often emphasize the effectiveness of forested riparian areas for protecting water quality. However, research over the last two decades reveals that forests are not always the most effective vegetation for removing pollutants. Results can vary between sites, but research has shown that grass buffers (also called vegetative filter strips or grass filter strips) can yield similar reductions in sediments and sediment-borne pollutants (Correll 1997; Hawes and Smith 2004; Dosskey et al. 2010). Grasses and similar plants create a dense vegetative obstacle that slows overland flow, promotes deposition of sediments and attached pollutants, and provides an opportunity for the plants and associated microbes to capture soluble contaminants that enter the soil profile (Dillaha et al. 1989). Filter strips often serve as an effective alternative for protecting water quality from pollutants generated by upland activities where it is impractical to implement forested riparian areas, such as adjacent to agricultural fields, in urban settings, or along highways.

According to Lacas et al. (2005), much of the sediment removal effected by grass filter strips occurs mainly as a result of sedimentation immediately upslope of the strip in an area of still water that builds up against the strip's outer boundary. Furthermore, they note, the deposit formed upslope can expand into the filter strip, and that sediment deposition can increase to the point of forming channels that concentrate overland flow and induce the formation of water pathways with high velocities.

The primary drawback of a vegetative filter strip is that it addresses only pollutant removal and does not provide the other functions of forested riparian areas such as shading, large wood, and bank stability. Furthermore, grasses have a relatively shallow root

structure and thus vegetative filter strips are not as effective in removing pollutants from groundwater. In contrast, trees inherently have a deeper root zone that can effectively intercept subsurface flow and often reach shallow groundwater. Therefore, forested riparian areas can be more effective at removing soluble pollutants in subsurface and groundwater flow through plant uptake and by associated microbial communities that act on the pollutants in the rhizosphere. Considering both situations, structurally diverse riparian areas that contain a combination of grasses, shrubs and trees provide a more robust system for mitigating a range of pollutants (Fischer and Fischenich 2000). A similar concept was proposed by Welsch (1991), who presented a three-zone model that considered an herbaceous filter strip between uplands and the start of the riparian area, followed by a managed forest, and culminating with an undisturbed forest immediately adjacent to the streambank.

Vegetation in riparian buffers also provides a range of phytoremediation processes, wherein plants and associated microbial populations remove, contain, degrade or eliminate pollutants. Investigations on the phytoremediation potential of riparian vegetation to attenuate nutrients have been conducted for some time and results are well documented. The management of vegetation specifically as a pollutant treatment technology for organic compounds and metals has gained acceptance in general over the last couple of decades (Pilons-Smits 2005), but studies on phytoremediation specific to riparian areas remains fairly limited. However, recent research suggests that the promotion of specific plant species to attenuate organic chemicals and metals in riparian areas can be used to treat localized areas of concern (e.g., chemical spills, industrial sites, mine tailings). Design of a phytoremediation treatment system depends largely on the three primary factors identified by Susarla et al. (2002) that govern contaminant uptake and distribution in plants and the surrounding soil system: physicochemical characteristics of the pollutant (e.g., polarity, lipophilicity), environmental conditions (e.g., soil moisture, pH), and plant characteristics (e.g., available enzymes, root structure). Specifics on the phytoremediation potential of different pollutant classes in riparian areas will be discussed later in the respective sections of this chapter, while more detailed descriptions of phytoremediation are readily found in a large number of scientific reviews (e.g., Salt et al. 1998; Pulford and Watson 2003; Pilon-Smits 2005; Sarma 2011).

5.4. Specific Pollutants

For the purposes of riparian area management, we are most interested in five types of water pollutants: sediments, excess nutrients (in particular, nitrogen and phosphorus containing compounds), metals (in particular copper), toxic organic compounds (especially pesticides), and pathogens (especially those related to agricultural animal waste). The physical, chemical, and biological processes through which riparian areas remove these pollutants from water vary tremendously. Consequently, the degree to which riparian areas can remove each of these pollutants, and thereby protect aquatic ecosystems, varies significantly. The following sections describe the complicated processes and mechanisms involved in determining removal efficacy of specific pollutants by riparian areas.

Vegetation in riparian buffers provides a range of phytoremediation processes, wherein plants and associated microbial populations remove, contain, degrade or eliminate pollutants.

5.4.1. Sediments

Sediment transport in streams is a natural process, but excessive sediment loads can significantly degrade water quality. The impact of sediments on aquatic organisms has been researched extensively for many decades, and can consist of lethal, sub-lethal and behavioral effects (Newcombe and MacDonald 1991). Sediments that settle out of the water column can smother gravel and cobble streambeds that are essential for salmonid spawning and habitat for benthic macroinvertebrates and other organisms that form critical links in stream food webs. For example, the filling of interstitial spaces in coarse sediment matrices with fine sediments are thought to reduce or eliminate refuge and foraging habitat for selected life stages of stream-dwelling amphibians (Welsh and Ollivier 1998). Increased turbidity levels, indicative of suspended particles, can elicit physiological stress in fish through gill abrasion, impaired immune function and lowered growth rates (Redding et al. 1987; Au et al. 2004). High suspended sediment loads reduce visibility, which limits fish foraging ability and influences predator avoidance reactions (Redding et al. 1987). Aquatic vegetation and periphyton can be reduced due to diminished light penetration. Sediments also impart indirect effects on aquatic organisms. Elevated turbidity decreases the water albedo (reflectiveness), which increases the fraction of radiant energy absorbed by the water and increases stream temperature, leading to corresponding reductions in dissolved oxygen concentrations. Furthermore, sediments serve as a transport mechanism for other pollutants, carrying attached contaminants from upland sources to the stream channel. Soil particles that harbor legacy contaminants perpetuate water quality problems, such as those caused by DDT in some Washington streams despite this pesticide being banned in 1972 (Ecology 2007).



Restored vegetation in riparian area to capture pollutants in runoff/U.S. Dept. of Agriculture, National Agriculture Imagery Program

While the extent of these detrimental effects is largely a function of concentration and duration, and there is little agreement on the degree of ecological risk in the literature, sediments are a ubiquitous pollutant that many scientists regard as the worst form of pollution in aquatic ecosystems (Newcombe and MacDonald 1991; Waters 1995).

Erosion rates in uplands can be significantly increased by agricultural activities, construction sites, deforestation, and other land uses. Riparian areas effectively remove soil particles carried from upland areas via overland flow by slowing overland flow velocities, promoting sediment settling, and acting as sediment sinks[5]. Mass wasting (also referred to as mass movement, mass failure, or slope movement), wherein large masses of soil and geologic material move downslope into a stream, acts as another potential sediment source in hilly or steep mountainous environments. Although limited in spatial distribution, this geomorphic process can overwhelm the sediment removal capacity of riparian areas.

Our understanding of the riparian area's sediment removal function will be enhanced with a basic understanding of sediment erosion and transport processes. Briefly, the impact of falling raindrops can loosen soil particles via splash erosion. Overland flow picks up soil particles and transports them downslope through sheet erosion. Generation of concentrated flow paths results in rill erosion, which enhances sediment delivery and increases erosion rates through flow that is on the order of a few centimeters deep. Gully erosion develops when deep, narrow channels form, leading to increased erosion and more rapid sediment delivery. It is important to prevent the formation of rill and gully erosion entering riparian areas because channel formation extending into riparian areas short-circuits sediment removal and represents a direct conduit from terrestrial to aquatic systems. Merritt et al. (2003) provide an extensive review of various erosion and sediment transport models that can be employed to determine the potential sediment loads that could enter a riparian area.

While the upland hydrologic regime acts as a principal driver governing the movement of eroded soil particles, the aforementioned erosion mechanisms can be significantly tempered by intact soil cover. This can be accomplished by vegetation overlying a dense cover of herbaceous litter and woody debris. Vegetation increases surface roughness which slows surface flow and enhances water infiltration, both of which promote the settling out of sediments (Figure 5.1). Muñoz-Carpena et al. (1999) showed that spacing between vegetation is the most important parameter in sediment attenuation in riparian buffers, although soil characteristics, sediment load, and slope also play prominent roles.

Agriculturally generated nitrogen continues to present an issue, and it is becoming increasingly apparent that smaller hobby farms and lawn fertilizers used in suburban and urban areas can lead to severely degraded water quality.

[5] Streambank erosion, channel incision, and surface erosion in riparian areas present other potential sediment sources. As this chapter focuses on the removal of pollutants generated by upland activities, these geomorphological processes are outside the scope of this chapter. However, it should be noted that riparian vegetation can increase bank stability, thereby decreasing erosion along the stream channel (see Chapter 2).

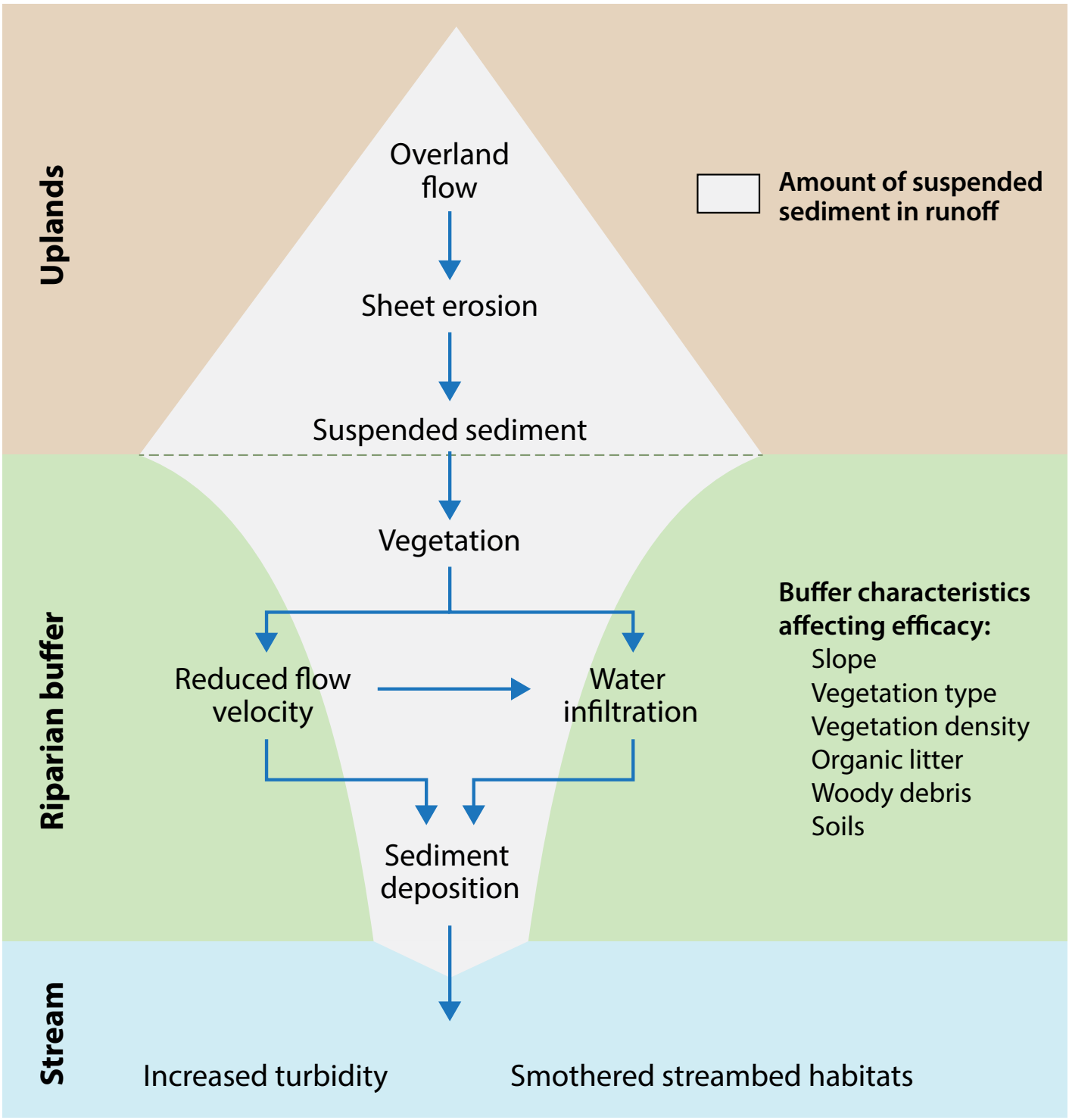


Figure 5.1 Efficacy of riparian buffer in removal of sediment from runoff. The amount of suspended sediment in runoff increases through sheet erosion of upland soils. Vegetation, woody debris, and organic litter in riparian buffer reduce flow velocity. Reduced flow velocity and increased water infiltration into soils causes deposition of suspended sediments. Sediments not removed from runoff increase turbidity and can smother gravel or cobble streambed habitats.

Riparian buffer widths required for sediment attenuation vary considerably depending on the site-specific conditions (e.g., slope, area of adjacent uplands, drainage paths, vegetation density). Sediment particle sizes are also a consideration in buffer width design – larger particles are deposited within the first 10 to 33 ft (3 to 10 m) of a buffer but smaller particles settle out at greater distances (Sheridan et al. 1999; Syversen et al. 2001; Dosskey et al. 2002; Yuan et al. 2009). The potential quantity of overland flow should also be a consideration when determining buffer widths, and hence, upland area should also factor into the determination of buffer width. Leeds et al. (1994) suggested that on agricultural lands the ratio of field drainage area to buffer area should be no greater than 50:1, and for consistently higher water quality the ratio should be on the order of 3:1 to 8:1. From research conducted on forested lands undergoing timber harvest, Clinton (2011) concluded that leaving a forested riparian buffer of 33 ft (10 m) would sufficiently reduce sediment transport to the adjacent stream, assuming responsible timber harvest practices, although greater widths have been recommended depending on the circumstance (Castelle et al. 1994). Furthermore, the relationship between buffer width and sediment attenuation is non-linear, necessitating a disproportionate increase in width to achieve an incremental increase in sediment removal. This relationship was described in a literature review of research on riparian buffers conducted by Sweeney and Newbold (2014). They concluded that a sediment removal efficiency of about 65% is typical for 30 ft (10 m) buffers but an 85% removal efficiency required more than twice that width, about 100 ft (30 m).

5.4.2. Excess Nutrients

Excess nutrients, in this context referring specifically to nitrogen and phosphorus, have long been recognized as significant water quality impairments. Eutrophication, the nutrient enrichment of aquatic systems, promotes algal blooms that shift community structure. Subsequent bloom die off leads to oxygen deficiency in the water column as oxygen is consumed by microorganisms during the decay of the excess organic matter. Hypoxia can have devastating consequences on aquatic animal communities, killing immobile organisms (e.g., clams) and mobile species (e.g., fish) that are not able to escape the deoxygenated zone. Excessive accumulation of cyanobacteria (formerly known as blue-green algae), resulting from shifts in nutrient ratios in the water, can release cyanotoxins which can cause dermal reactions, gastroenteritis, liver and kidney poisoning, and neurological impacts in humans or animals following water contact. Canine deaths due to cyanotoxin exposure have been confirmed throughout the country, with Washington reporting the highest number of cases among 27 states (Backer et al. 2013). In some cases, selected nutrients are toxic at concentrations within typical fertilizer application ranges. For example, embryos of the highly aquatic Oregon Spotted Frog *Rana pretiosa*, a federally threatened species in the Pacific Northwest, all died after 15-day exposure to nitrite (NO_2^-) concentrations lower than 2 mg/L (Marco et al. 1999).

Fertilizers and manures are major sources of excess nutrients entering riparian areas. Wastewater discharges and leaking septic tanks introduce nutrients to riverine systems, but those sources fall outside the scope of this review. Agricultural activities have long been blamed as the biggest nonpoint source for nutrients. The enormous contribution of phosphorus to the eutrophication of surface waters led to extensive promotion of various best management practices (BMPs)[6] for reducing off-field transport of phosphorus. Nevertheless, there has been a general lack of improvement in water quality of many receiving

6 In general usage "best management practice" (BMP) means one or more practices that are determined to be an effective and practicable means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals. Under Washington State regulations, BMP means physical, structural, and/or managerial practices approved by the Washington Department of Ecology that, when used singularly or in combination, prevent or reduce pollutant discharges (WAC 173-201A-020).

streams. In addition to existing agricultural sources of phosphorus, it is increasingly evident that "legacy phosphorus" from past activities that accumulated in watersheds contributes to current water quality problems (Jarvie et al. 2013). Agriculturally generated nitrogen continues to present an issue, as it can leach through the soil and move with shallow groundwater flows through riparian soils and enter receiving waters. It is also becoming increasingly apparent that smaller hobby farms and lawn fertilizers used in suburban/urban areas can lead to severely degraded water quality (Cheng et al. 2014).

For a thorough discussion of nitrogen and phosphorus dynamics in natural, undisturbed riparian areas see Chapter 6. For this chapter it is salient to note the differing biogeochemical cycles exhibited by nitrogen and phosphorus: nitrogen displays complex transformations between various species including atmospheric forms whereas phosphorus undergoes relatively simple shifts between soluble, sorbed, precipitate and organic forms. Nitrogen and phosphorus are often casually grouped together as nutrients, but this discrepancy in chemical behavior leads to significantly different considerations when assessing their removal by riparian areas.

Nitrogen

Due to its soluble nature in its aqueous forms, a significant portion of the excess nitrogen entering streamside areas will enter riparian soils either through infiltration or via groundwater transport. Nitrogen then can undergo attenuation through a variety of mechanisms. It is widely accepted that denitrification acts as the primary pathway for removing nitrate (NO_3^-) from water in riparian areas (Fennessy and Cronk 1997; Cey et al. 1999; Wang et al. 2014). This process is governed by specific denitrifying bacteria that use nitrate during anaerobic respiration, reducing it to the gaseous forms of nitric oxide (NO) and nitrous oxide (N_2O) and ultimately molecular nitrogen (N_2). These gaseous species can then volatilize in harmless forms to the atmosphere and be completely eliminated as a potential pollutant. This process requires the presence of a shallow water table, anoxic conditions, denitrifying bacteria and an available carbon source—conditions commonly associated with riparian areas. Hydric soils, despite occupying a limited area within riparian areas, are important sites of anaerobic activity that promote denitrification. If groundwater bypasses riparian soils then nutrient pollution of surface waters may occur despite the presence of a riparian buffer (Burt et al. 1999). In a highly cited critical review of research on nitrate removal in riparian areas, Hill (1996) asserted that understanding denitrification requires a better understanding of groundwater interactions with riparian vegetation and soils.

Plant uptake of dissolved nitrogen in subsurface flows moving through riparian areas provides an additional mechanism that can remove considerable amounts of nitrate. A significant difference from denitrification though is that vegetative uptake is often viewed as transient storage for nitrogen because nitrogen assimilated by plants will be reintroduced to the ecosystem following leaf senescence or plant death. Both grasses and trees have been widely shown to remove nitrogen in riparian areas, but studies have yielded contradictory observations and conclusions regarding which vegetation type is more effective (Groffman et al. 1991; Osborne and Kovacic 1993; Schnaebel et al. 1997). A meta-analysis performed to assess the key riparian variables responsible for nitrogen removal concluded that forested buffers exhibited the greatest propensity for nitrogen uptake, and surpassed the efficacy of both grasses and communities composed of both trees and grass (Zhang et al. 2010). Although this study did not end the debate, many researchers believe that deeper and more expansive root structure allows trees to take up greater proportions of nitrogen. A riparian area's age may also be a variable affecting nitrogen removal. Cors and Tchon (2007) evaluated denitrification enzyme activity in two

riparian areas of different ages: 6 and 20 years old. They found the older system was significantly more effective at denitrification, which was attributed to a greater accumulation of carbon.

Research focusing on hot spots and hot moments has provided a more nuanced understanding of nitrogen dynamics in riparian areas. Hot spots and hot moments that develop in the hyporheic zone are increasingly being recognized as a contributing mechanism to nitrogen attenuation (McClain et al. 2003; Vidon et al. 2010; Gu et al. 2012). A landmark paper by Hedin et al. (1998) exemplified the concept of enhanced nitrogen removal at hot spots along the soil-stream interface in a mixed forested-agricultural watershed. A first-order stream exhibited two converging primary flow paths, one consisting of shallow subsurface flow containing high concentrations of chemical reducers (i.e., dissolved organic carbon, CH_4, and NH_4^+) and the other a near-stream upwelling of deep groundwater containing high concentrations of oxidizers (i.e., NO_3^-, N_2O, and SO_4^{2-}). A zone of high denitrification resulted that was less than 3 ft (1 m) wide and remained active for the two-year study period. Hedin et al. (1998) suggested that nitrate removal via denitrification could be sustained depending on the spatial location of high flow pathways, the propensity of the chemical environment to support rapid denitrification, and the availability of oxidizable carbon. Furthermore, they recommended that management actions enhancing natural carbon inputs could be adopted to optimize nitrate removal by denitrification.

Phosphorus

Unlike nitrogen, phosphorus possesses a binding affinity for soil particles and typically enters riparian areas adsorbed to soil particles carried by overland flow. Hence, phosphorus removal is closely connected to sediment removal by riparian areas. A comprehensive review of phosphorus dynamics in grass buffer strips surmised that that optimum phosphorus retention occurs in filter strips that are at least 16 to 33 ft (5 to 10 m) wide (Dorioz et al. 2006), but this recommendation is debatable. It is generally recognized that a positive correlation exists between buffer width and phosphorus retention in riparian areas, and hence, buffers greater than 33 ft (10 m) offer greater removal efficacy. Independent studies have consistently found 60% to 80% phosphorus removal by buffers roughly 15 to 53 ft (4.6 to 16.3 m) wide (Dillaha et al. 1989; Vought et al. 1994; Lee et al. 2003). Forested riparian ecosystems assessments have yielded less consistent results, with studies showing phosphorus removal ranging from 30% to 80% in deciduous riparian areas (Lowrance et al. 1984; Cooper and Gilliam 1987). This discrepancy corresponds with the premise that a robust stand of grass provides better attenuation of sediments and associated pollutants than forested riparian areas.



Unknown species of crayfish in the Deschutes River/Steve Boessow, WDFW

Even though these results appear convincing at first glance, a significant proportion of the body of research consists of short-term studies that fail to account for changes in riparian function over time. While it can confidently be stated that riparian areas offer effective short-term control of sediment-bound phosphorus, uncertainty exists regarding their long-term efficacy. Filter strips receiving sediment loads are well known to become less effective over time due to internal erosion and sediment accumulation. The continual incorporation of phosphorus into surface soils presumably would lead to a saturation of the system that could not only decrease removal of new phosphorus entering the

riparian area, but also lead to release and export of dissolved phosphorus to the stream that had previously been stored in riparian soils (Muscutt et al. 1993). Some studies have reported significant removal of soluble phosphorus in surface runoff (Peterjohn and Correll 1984). However, contradictory reports indicate little retention of soluble forms, with the majority moving through the area in surface runoff (Daniels and Gilliam 1996). Plants take up some of the phosphorus in the riparian soils, but this mechanism is not nearly as significant in removal as it is for nitrogen. Increased removal of soluble forms could potentially be achieved with various amendments, such as biochar (charcoal used as a soil amendment), that could enhance phosphorus sorption (Zhang et al. 2014).

A relatively new research topic related to phosphorus attenuation focuses on subsurface transport of soluble phosphorus forms. It was long accepted as dogma that phosphorus did not leach or move through the soil profile. Although scattered findings contradicted this view during the preceding decades (e.g., Peverill et al. 1977), this conviction remained recalcitrant and was still taught in university soil courses up until the last decade. This belief has now been dispelled by increasing evidence that phosphorus can move through the soil profile, particularly in coarse textured soils. A preponderance of the recent research on this topic has been conducted in upland soils, but the findings are relevant for riparian areas and are particularly true in coarse alluvial soils. This has been demonstrated by the rapid transport of soluble phosphorus forms through preferential flow paths (Fuchs et al. 2009). This movement can serve as an important transport mechanism that should be considered when determining potential phosphorus fluxes reaching the stream channel. Although extensive literature exists on phosphorus cycling in a variety of settings, relatively little information is available on phosphorus dynamics in the hyporheic zone and further research is needed to understand phosphorus flux through this interface between the stream and groundwater flowing through riparian areas (Zhang 2014).

While it can confidently be stated that riparian areas offer effective short-term control of sediment-bound phosphorus, uncertainty exists regarding their long-term efficacy. Riparian filter strips are well known to become less effective over time.

5.4.3. Metals

Metals (as well as metalloids that share similar properties, such as arsenic) are elements naturally found in geologic material. They enter the environment either through natural weathering processes or through anthropogenic activities. Localized metal deposits can result in elevated concentrations in streams that can be hazardous to biota. Metal pollution in aquatic ecosystems appeared as a serious environmental issue on a wide scale in the late 19th and early 20th century due to increasing industrial and mining activities. Contamination sources have grown over time to include a range of other activities, the most pertinent to this discussion on riparian areas being runoff from urban and agricultural lands. While mining activities present significant metal inputs into certain streams in Washington, protecting water quality from these sources requires the implementation of specific remediation techniques that are outside the scope of this chapter.

Metals present a significant environmental hazard that can lead to a variety of health issues in plants and animals. While some metals are essential elements required for normal growth and development of biota, these can also impart toxicological issues when concentrations exceed a given threshold. Among other health effects, metals can be carcinogenic, cause reproductive problems, and interfere with the normal function of the heart, bones, intestines, and kidneys. While debate continues over the specific mechanisms associated with metal toxicity in plants, it is generally recognized that oxidative stress represents a primary driver that results in cellular damage (Pinto et al. 2003). Some heavy metals bioaccumulate and biomagnify, which leads to elevated concentrations exhibited at higher trophic levels (Boening 2000). The propensity for metals to bioaccumulate can be magnified by biologically mediated transformation into organometallic complexes, such as methylmercury. Metal toxicity is often related to the chemical species formed, which often relates to their bioavailability. For instance, chromium(III) compounds are not considered a significant health risk while chromium(V) is a well-known carcinogen. Similarly, metal complexation with dissolved organic carbon often inhibits their bioavailability.

While copper's detrimental environmental impacts have been recognized for many decades (Sprague and Ramsay 1965), it has received increased attention in recent years as toxicity symptoms have become more pronounced. Copper is an essential mineral for organisms, contributing to enzymatic and metabolic function, but toxic effects have been observed at all levels of the aquatic food chain when it exceeds particular concentrations. Copper has been shown to have detrimental effects on plants, retarding growth at concentrations as low as 1.0 part per billion (ppb) and impeding photosynthesis at 5.0 ppb levels (USEPA 1980). While reductions in algal production can theoretically exert an indirect effect on zooplankton by limiting their food source, copper can impart a lethal effect on these organisms at low parts per billion levels (Ingersoll and Winner 1982). Similarly, significant mortality has been shown to occur in benthic macroinvertebrates at similar copper



Juvenile salmon need clean water/Ned Pittman, WDFW

concentrations (Clements et al. 1992). Copper presents a litany of issues to fish. Lethal concentrations vary considerably between fish species and fluctuate depending on environmental conditions. Sub-lethal effects are conveyed at lower concentrations, which include hindering osmoregulation, weakening immune response, altering enzymatic and metabolic activity, impairing olfaction (sense of smell), altering migration patterns and predator avoidance behavior, and modifying hatch rates (Lortz and McPherson 1977; Sorensen 1991; Rougier et al. 1994; Baldwin et al. 2003; Monteiro et al 2005; Sandahl et al. 2007; McIntyre et al. 2012). Synergistic impacts that occur when copper is present in combination with other pollutants highlights the current concern over this element (Hecht 2007). Effects similar to those observed in fish have been recorded in amphibians following exposure to rather low concentrations of copper ions (Cu^{2+}). For example, the concentration of copper at which half of larval Northern Leopard Frogs *Rana pipiens* would die following a seven-day exposure was estimated at 0.067 mg/L (Redick and La Point 2004). The same study revealed lethargy, loss of equilibrium, and loss of appetite at copper concentrations of 36 ppb. A widespread pattern in copper exposure studies with amphibians is a general impairment of predator evasion behaviors (Garcia-Muñoz et al. 2011).

Anthropogenic copper inputs to the environment include those of other metals, but what sets copper apart are two significant sources. The first is the agricultural use of copper-based pesticides. Copper sulfate and other copper-based pesticides are frequently used as a fungicide to protect a variety of crops, including fruits and potatoes. The second is the release of copper from vehicle brake pads. This unique source has received considerable attention as an environmental hazard worldwide, and has led to the 2010 adoption of Washington State's Brake Material Friction Act (RCW 70.285) that is phasing out copper in automobile brakes (Straffelini et al. 2015). Copper can also enter the environment through atmospheric deposition, which is a potential pathway in industrial and mining regions (USEPA 1980). These sources introduce copper into the environment as a nonpoint source pollutant, which makes copper very different from other metals. While the following discussion will continue to refer to metals in general, the reader should recognize that the nonpoint source nature of copper makes it the primary metal of concern in Washington in regards to attenuation in riparian areas.

Metals form various inorganic and organic species, the nature of which directly relates to its bioavailability and mobility through a riparian area. Metal speciation is driven through complex biogeochemical processes. Environmental conditions and the chemical nature of the surrounding constituents play a significant role in dictating the form that a metal might take. This is particularly relevant to riparian areas where fluctuating water tables alter redox conditions, and correspondingly metal dynamics in riparian soils. Daily oscillations related to the photocycle, for instance, have been shown to occur in aquatic ecosystems as a result of biogeochemical interactions involving temperature, acidity, and biofilms (Nimick et al. 2011). Consequently, zinc, manganese, and cadmium can increase several-fold between late afternoon and early morning. In contrast, arsenic undergoes the opposite diel pattern; meanwhile copper and lead do not undergo regular diel cycling.

The metal species resulting from soil acidity and redox conditions can form precipitates, exhibit an affinity to clay minerals and oxide/hydroxide compounds, and thus be more readily retained in riparian areas. Conversely, metals stay in solution as more mobile forms that leach and move toward the stream. Typically, metals more readily enter solution under acidic conditions. Meanwhile the ionic strength of the water (a measure of the concentration of all the ions in solution) presents a confounding variable in these processes. The impact of other ions manifests through enhanced metal desorption from soil particles with increasing

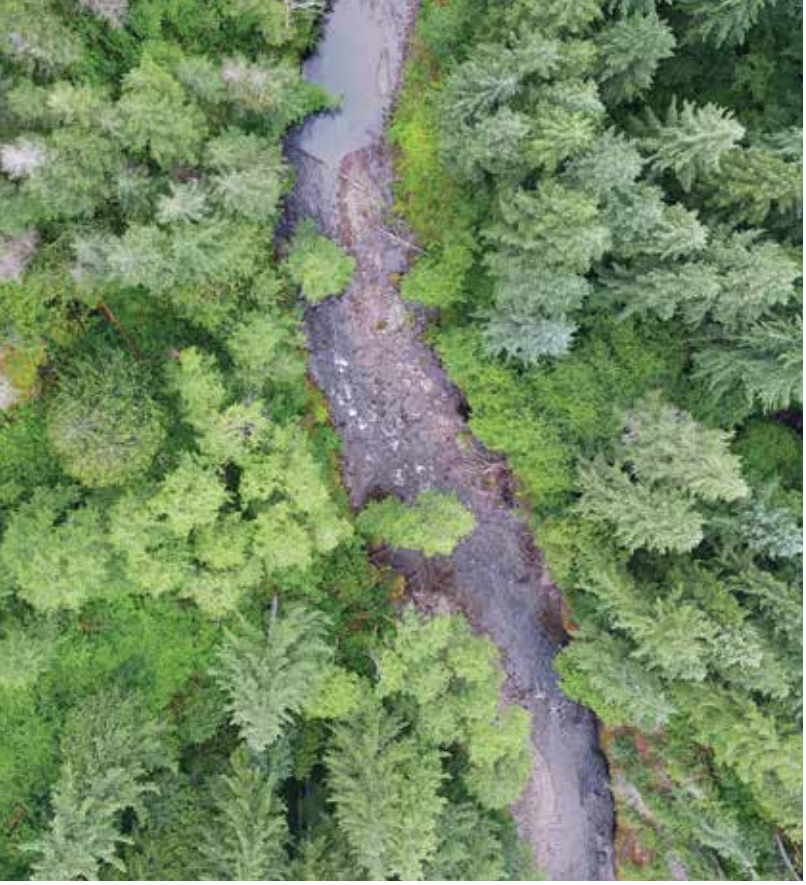
salinity. Carbonates in riparian soils promote metal retention by buffering acidity (i.e., preventing increased acidity), limiting metal solubility, and forming insoluble precipitates with metals.

Organic constituents in soil-water systems also play a major role in metal fate and transport processes. It has been clearly understood for some time that humic substances, a classification of complex and heterogeneous macromolecules that represent a substantial component of natural organic matter, have the capacity to bind significant amounts of metals (Reuter and Perdue 1977). While association of metal ions with soil organic matter can retain metals, humic substances can act as colloids and contribute to colloid-enhanced movement. The environmental factors and mechanisms involved in metal-humic interactions are multifaceted, but it is salient to recognize the impacts that organic matter in riparian soils can have on the movement of metals to the stream channel. A more detailed explanation of the inorganic and organic factors that influence metal behavior is presented in a review by Du Laing et al. (2009), which includes a specific focus on riparian areas.

Unlike organic contaminants that can degrade, metals are recalcitrant and removal in riparian areas depends largely on retention. Although the brief description of metal chemistry provided here elucidates the primary factors that affect their movement in the environment, management practices to enhance their attenuation are limited, and metal mobility will be driven overwhelmingly by environmental conditions. An exception to this statement is phytoremediation.

Phytoremediation of metals offers promise as a means to enhance metals removal in riparian areas. Although significant research on this process did not start in earnest until the late 1990s, since then hundreds of scientific papers have been published on the topic. Correspondingly, there is a plethora of review articles (e.g., Ghosh and Singh 2005; Sarma 2011; Koptsik 2014; Laghlimi et al. 2015). Four classes of phytoremediation can influence metal attenuation in soil, including phytoextraction (removal of metals from the soil-water system by plants), phytostabilzation (minimizing metal transport and sequestering them in the soil near the roots), phytovolatilization (uptake and transpiration by plants; this process is primarily limited to mercury and arsenic), and rhizofiltration (sorption, concentration and precipitation of metals in the root mass). Of these, the first two mechanisms are the most effective in attenuating metals (Laghlimi et al. 2015). In general, trees are a more effective form of vegetation due to their size, perennial nature, and the depth of root growth. Different metals will accumulate in different parts of a tree. For instance, copper tends to be immobilized and retained principally in the roots while zinc moves into the branches and leaf mass (Pulford and Watson 2003). Some plant and tree species act as hyper-accumulators that are tolerant of high metal concentrations in soils and can amass metals in their tissues through detoxification mechanisms (Sarma 2011). These species could be preferentially planted in areas where metals are a particular concern to help attenuate metal movement to the stream channel. As leaves will fall to the ground, riparian management could include the periodic removal of vegetative debris to off-site locations to avoid subsequent movement to the stream. Often there is no need to plant nonindigenous plants as a variety of common native riparian vegetative species can provide phytoremediation capabilities. For instance, willows (*Salix* spp.) have been shown to attenuate various metals in riparian areas to great effect (Bourret et al. 2009; Zhongmin et al. 2012).

Soil amendments offer another form of "green remediation" that has been increasingly used in soil systems since the turn of the century. A wide variety of amendments can be used either to mobilize metals by promoting uptake via phytoextraction or to immobilize (stabilize) metals in a solid phase. For instance, chelating agents have been applied at sites around the globe to enhance desorption, while phosphate



Tilton River/George Fornes, WDFW

fertilizers are common amendments intended to intensify metal sorption and form precipitates. Several topical reviews describing assorted soil additives have been published that provide more detail on this *in-situ* remediation technique (e.g., Bolan et al. 2014; Mahar et al. 2015). Similarly, over the last decade biochar has seen increased application in the context of attenuating metals (Ahmad et al. 2014). Although studies on the use of soil amendments to attenuate metals in riparian soils are limited, recent findings showed that additions of 11 different materials, such as biochar, bentonite, cement bypass kiln dust, and limestone to a floodplain soil could provide a potential remediation technique (Rinklebe and Shaheen 2015). An evaluation of the amendments in riparian soils heavily contaminated with copper (over 3,000 mg/kg) showed that most of the additives shifted the geochemical forms of copper through either increased sorption or by transformation to more plant available forms. Although the authors concluded that the low amendment rates that could practically be applied would inadequately immobilize copper, the increased copper concentration found in grass tissues at the same site indicates a means of enhanced phytoremediation.

Clearly, the use of soil amendments requires further field verification in riparian areas, but this approach to enhancing natural attenuation mechanisms shows promise.

5.4.4. Pesticides and Other Organic Compounds

An extensive array of organic contaminants exists in the environment that can threaten water quality in aquatic ecosystems. This category of compounds describes molecules that contain carbon covalently bonded to other elements, and includes both naturally derived and synthetic chemicals. This chapter focuses on anthropogenic compounds that exert a toxic effect on aquatic organisms.

The multitude of organic chemicals makes it impractical to touch on each class here, but common examples that present environmental health risks in aquatic habitats include polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides. While the detrimental effects of many of these pollutants have been recognized for some time, studies continually identify emerging contaminants of concern ("emerging" does not only connote new compounds, but also chemicals that have been in use without realizing the extent of their toxicity). For instance, hazards associated with flame retardants, such as polybrominated diphenyl ethers (PBDEs), have been highlighted over the last decade (Covaci et al. 2011; Ye et al. 2015). Recent research emphasis also has been placed on a variety of trace organic compounds, including pharmaceuticals and personal-care products (PPCPs), as it is now recognized that these chemicals can exert negative impacts on fish and other aquatic organisms at both the individual and population levels even at extremely low (e.g. parts per trillions) concentrations (Mueller 2004; Kümmerer 2009a; Kümmerer 2009b; Luo et al. 2014). In addition, there is growing awareness that while individual pesticides may have little or no effect

when examined alone, that same pesticide as part of a pesticide mixture may be lethal to amphibians (Hua and Relyea 2014).

While only a brief discussion was provided above on the various organic pollutants that act as environmental contaminants, a little more information on pesticides is warranted, as they are more likely to be used in uplands and transported into riparian areas. Pesticides consist of any substance that is used to control fungal, plant, or animal pests. These chemicals represent a broad range of different chemicals that are derived from various sources such as plant extracts (nicotine, pyrethrum, neem oil), inorganics (e.g., copper sulphate; inorganic pesticides will not be discussed here), and synthetics. Synthetic pesticides are themselves a broad class that includes legacy organochlorines (chlorinated hydrocarbons such as DDT), organophosphates (e.g., Malathion), phenoxyacetic acids (e.g., MCP), carbamates (e.g., carbaryl), and neonicotinoids (e.g., imidacloprid). Pesticide pollution of streams can impact non-target organisms resulting in a wide variety of physiological and ecological problems (Mann et al. 2009), including altered growth (Alvarez and Fuiman 2005) and reproduction (Moore et al. 2007), altered community dynamics (Fleeger et al. 2003), and the loss of species (Relyea and Diecks 2008).

The ecological impacts of organic pollutants on aquatic organisms vary considerably, depending on not only the contaminant type but also the environmental conditions. Various compounds can be carcinogenic (causing cancer), mutagenic (altering genetic material and fomenting mutations), and teratogenic (stimulating abnormalities). Organic pollutants can also act as endocrine disrupting chemicals (EDCs), adversely impacting development, reproduction, neurologic, and immune system function in humans and wildlife (Colborn et al. 1993). Endocrine disruption has emerged as a key issue as studies have identified more cases of detrimental impacts, such as the discovery of atrazine-induced feminization of male Northern Leopard Frogs at very low concentrations (Hayes et al. 2003). This finding is controversial, but it has increased awareness that many organic compounds have potentially unrecognized endocrine-disrupting effects. Some organic contaminants, such as halogenated hydrocarbons, are capable of bioaccumulating in individuals and biomagnify up the food chain (Rahman et al. 2001).

To further complicate potential risk, pesticides rarely occur singly in aquatic environments. For example, a comprehensive decadal assessment of 178 streams in agricultural, urban, and mixed-land use watersheds found two or more pesticides more than 90% of the time and ten or more pesticides 20% of the time (USGS 2006). Ecological and toxicological research is increasingly recognizing the complexity of contaminant mixtures, which may have antagonistic, additive, or synergistic interactions in biota (Cedergreen 2014). For example, combining the pesticides diazinon and Malathion inhibits brain activity, and therefore swimming performance in fish at concentrations more than 50 times lower than the concentrations that cause an impact when these pesticides are used singly (Laetz et al. 2013). Although the examples given focused on pesticides, mixtures of hydrocarbons originating from roadways, parking lots and other locations can also be found in urban watersheds, including pollutants such as PAHs that originate from coal-tar-sealed parking lots (Scoggins et al. 2007). Amalgamations of these urban generated organic contaminants have been shown to impart both sub-lethal and lethal effects on aquatic organisms and disrupt stream communities (PSAT 2007; Scoggins et al. 2007; Spromberg et al. 2016).

The sheer number of different sub-classes of pesticides makes it impractical to provide information on the chemical behavior of all the potential contaminants that might be encountered in riparian areas. Pesticide pollution is extremely complex due to the multitude of types, the wide range of molecular sizes, the diversity of chemical structures, and the ability of these compounds to react and transform into new products. However,

some basic information on organic compounds will enable a better understanding of the effects riparian buffer size and structure have on pesticide pollutants. It is essential to identify the physicochemical properties of organic contaminants to adequately assess fate and transport pathways through riparian areas. Specific gravity, water solubility, vapor pressure, and partitioning coefficients such as the octanol/water partition (log K_{OW}) and organic carbon partition coefficients (K_{OC}) all serve as predictors of a substance's potential mobility and attenuation in riparian areas.

Natural organic matter has a significant impact on the degree of attenuation riparian soils impart on pesticides. The aforementioned K_{OC} represents the ratio of the amount of chemical adsorbed to the soil to the amount of chemical that remains in solution, related to the mass fraction of organic matter in the soil (Delle Site 2001). This value essentially indicates the affinity of a pollutant to soil organic matter and is a predictor of its potential mobility through the soil, where higher K_{OC} values correlate to less mobile organic contaminants and low K_{OC} values correlate to more mobile organic contaminants. Hydrophobic, nonpolar compounds, such as PAHs, are typically associated with particles in soil-water systems, whereas polar contaminants often exist in dissolved forms that exhibit a greater propensity for movement through the ecosystem.

The relationship between pesticides and their respective K_{OC} values can be confounded by humic substances, which are a heterogeneous mixture of chemically complex macromolecules that comprise a substantial component of natural organic matter. Humic substances have long been known to exert a significant impact on the movement of organic contaminants (Hayes 1970; Khan 1972). These amorphous compounds, which are classified into humic acid, fulvic acid, and humin fractions based on their molecular size and chemical behavior, can effectively bind organic pollutants and present either water-insoluble entities that are retained in the soil column or water-soluble colloids that can facilitate transport through riparian soils to the stream channel. Even when present in small quantities, these chemically reactive compounds can dramatically influence the binding, persistence, and translocation of organic pollutants. The interactions between humic substances and organic contaminants are beyond the scope of this chapter, but their potential to affect K_{OC} values by up to an order of magnitude is salient to predicting their attenuation by riparian buffers (Grathwohl 1990; Kopinke et al. 2001). Nevertheless, in general the attenuation of organic pollutants in riparian areas is positively correlated with soil organic matter.

Pesticides and other organic pollutants can also be retained in riparian areas through sorption to mineral components in the soil, although often to a lesser extent than to organic matter (Delle Site 2001). The surface area of soil particles enhances the binding of organic pollutants, which increases with finer soil textures such as those found in clays. The mineral composition of the soil particles also influences binding affinity by offering different forms of attachment sites. Those compounds that do not attach to soil material are susceptible to leaching, which can result in them entering the groundwater and being transported to the stream. Contaminants associated with inorganic particulates are usually much less bioavailable, although they can become bioavailable if particles are ingested by biota (Moermond et al. 2004).

Pesticides and other organic pollutants can undergo abiotic and biotic transformations that further compound the complexity of their chemistry. Abiotic processes include degradation due to chemical reactions such as hydrolysis (Mitchell et al. 2014; Mitchell et al. 2015). Biotic transformations include biologically mediated reactions, such as bacterial metabolism. Although the potential for biodegradation is dependent on the chemical structure of the contaminant, indigenous soil bacteria can use many organic compounds as a metabolic substrate. Repeated exposure to the same type of pesticides can foster microbial communities that

become contaminant specialists (Vidon et al. 2010). For example, soils receiving repeated applications of the pesticide 2,4-D harbor more 2,4-D-degrading microbes than similar plots receiving fewer applications (Gonod et al. 2006). Similarly, PAH-degrading bacteria were more abundant in rain gardens receiving stormwater runoff than upland control plots (LeFevre et al. 2012). The robust microbial communities found in riparian areas, resulting from conditions discussed previously, helps attenuate many organic compounds in riparian soils. Being biologically mediated, however, the degradation rates will fluctuate seasonally depending on temperature and soil moisture.

Phytoremediation by riparian vegetation provides an additional attenuation mechanism for organic contaminants. Although phytoremediation has received significant interest over the last two decades, the literature contains few papers on this method specific to pesticides in riparian areas. However, the principles are the same as those described in the vegetation section found earlier in this chapter, and presumably the results would be similarly positive. This premise was highlighted in a review article on the potential effectiveness of phytoremediation in riparian areas, where Karthikeyan et al. (2004) drew on similarities between streamside areas and other locations where phytoremediation has been effectively employed to treat pesticide-contaminated soil and water. Similarly, another review paper summarized a range of studies that investigated phytoremediation in aquatic settings, addressing plant species such as cattail (*Typha* spp.) and Cutgrass *Leersia oryzoides* which can be found along the riparian-aquatic ecosystem transition (Moore et al. 2011). A study directly examining the use of phytoremediation in riparian areas found that Tussock Sedge *Carex stricta*, Switchgrass *Panicum virgatum* and Gamagrass *Tripsacum dactyloides* led to approximately 70% reduction in total petroleum hydrocarbons under controlled riparian conditions, while there was only about 20% reduction associated with a Narrowleaf Willow *Salix exigua* and poplar (*Populus* spp.) (Euliss 2008). Following the same procedure in an uncontrolled riparian field site did not reproduce these promising results, but the authors presumed there was a continuous pollutant source re-contaminating the site during the study. A field study examining the phytoremediation potential of willows (*Salix* spp.) in riparian areas yielded a 49% decrease in PCB concentrations before contaminated groundwater reached the stream margin (Skłodowski et al. 2014). Although there is not enough information available in the literature to provide design guidelines for implementing a phytoremediation-based system, there is promise in this approach to attenuating organic contaminants in riparian areas and further research should be encouraged.

Mycoremediation, the degradation of contaminants by fungi, is a type of bioremediation that occurs in soils. This process likely takes place in riparian soils with high organic matter content where lignin-degrading fungi (more commonly known as wood-decay fungi, a class that includes brown rot, soft rot, and white rot) exist. These microorganisms possess the ability to breakdown organic contaminants, particularly PAHs, through the release of a variety of oxidizing enzymes (Haritash and Kaushik 2001). Research on promoting lignin-degrading fungi as a remediation agent started to appear in

The central problem faced by resource managers is determining the adequate riparian buffer width, composition, and structure to protect water quality with high degrees of efficacy, efficiency, and certainty.



Spawning Chum Salmon Oncorhynchus keta*/Ned Pitman, WDFW*

the literature in the 1990s, but did not receive much attention until after the turn of the century (Lamar et al. 1993; Boonchan et al. 2000; Canet et al. 2001). Results vary considerably, but it is not uncommon to observe 50% to 90% reductions in organic pollutants resulting from mycoremediation-mediated degradation (Lamar et al. 1993; Boonchan et al. 2000; Haritash and Kaushik 2001). Although this degradation process is mentioned here to highlight the mechanisms affecting organic pollutants in riparian soils, it has been suggested that mycoremediation could potentially be capitalized on as an engineered mitigation technique in riparian areas, but more research is needed (Jones 2009).

Despite the large body of knowledge that has been developed, the mechanistic understanding of pesticide transport through riparian areas is incomplete. The following summarizes our understanding of the typical transport pathways of a pesticide; this is essential information to consider when determining appropriate riparian widths for attenuation. Pesticide migration from terrestrial sources to stream channels can follow a number of different pathways. The specific transport mechanism governing pesticide movement from uplands through riparian areas and into surface waters is highly correlated to the type of pesticide in question. Surface runoff can carry pesticides off fields as either dissolved forms or attached to eroded soil particles. Leaching of compounds entails their vertical movement through the soil, after which they can either move toward the stream through the unsaturated zone or via groundwater flow. The chemicals that move in the dissolved form tend to be those that exhibit low to moderate sorption properties, as compounds that possess lower partition coefficients are prone to leach into the soil profile. Leaching is further promoted in regions with high precipitation and in soils that are coarse-textured, contain a low percentage of organic matter, or demonstrate a high degree of macropore flow. Pesticides that predominantly follow sediment-facilitated transport are generally those that display a strong affinity to soil particles (i.e., K_{OC} > 1,000 L/kg).

While the literature lacks information on the potential attenuation in riparian areas for most organic pollutants, there are a substantial number of papers on the movement of pesticides through buffer strips. A number of review papers evaluate pesticide attenuation in riparian areas, with a particular emphasis on managed vegetative filter strips (Krutz et al. 2005; Lacas et al.

2005; Reichenberger et al. 2007). Due to the complexity of the attenuation mechanisms involved, the removal rates within buffers vary considerably between disparate compounds, as well as when comparing the removal rates of the same pesticide at different locations. Depending on the conditions, mass removal rates for some pesticides can be negligible while others can reach 100%. Research has shown that herbicide type and filter strip width are primary factors affecting herbicide retention in riparian areas, while antecedent moisture conditions exert an additional effect wherein pesticide attenuation is generally negatively correlated with soil moisture. The type of vegetation appears to have negligible impact on pesticide retention, with studies showing that a grass-shrub-tree mixture exhibited comparable mitigation as grass only. Interestingly, one study found that pesticide mitigation was greater at higher incoming concentrations, which was attributed to better sorption to soil and plant material (Misra et al. 1996).

Due to confounding and often conflicting results, after 35 years of research, there remains a lack of consensus on the minimum filter strip widths needed for effective pesticide removal from surface and surface overland flow. The NRCS recommends a standard width of 49 ft (15 m) with the aim of achieving 50% effectiveness, but there is not much evidence to support this guidance (NRCS 2000). Another general recommendation for diffuse runoff suggests riparian widths of 33 and 66 ft (10 and 20 m) for hillslopes of under and over 328 ft (100 m) in length, respectively (Lacas et al. 2005). However, because this recommendation is based on only one experimental study, it may not be applicable to other locations with different hydrological, soil, and vegetative conditions.

Pesticide Spray Drift

Pesticide spray drift, the aerial transport of pesticide droplets off target areas during spray application, presents another pathway by which these chemicals can enter aquatic ecosystems. Unlike hydrological transport, pesticide physicochemical properties play a negligible role in aerial transport (although formulation does act as an influencing factor). Weather conditions (e.g., wind speed, temperature, and humidity), equipment type, application practices, and target crop all affect aerial transport. There is a better understanding of pesticide aerial drift to streams than that of hydrological pathways, either as a result of occurring in a less complex matrix, or as Reichenberger et al. (2007) asserts, due to aerial drift receiving more regulatory scrutiny.

Management of riparian areas can significantly reduce pesticide spray drift in many cases, particularly when conducted in conjunction with proper application practices. However, in their review of mitigation via windbreaks, Ucar and Hall (2001) found no general consensus on optimum riparian buffer widths to protect water quality. Their review reports that research has yielded buffer width recommendations that range from 20 to 150 ft (6 to 45 m) for ground application and 80 to over 4,000 ft (25 to over 1,200 m) for aerial application. Despite this lack of harmony in recommendations, individual cases have yielded positive results. Analysis of a forested riparian area in British Columbia found that a 25 ft (7.6 m) buffer limited the amount of herbicide reaching the stream to less than 0.1% of the aerial application (Feng et al. 1990). In an agricultural setting, a simple 10 ft (3 m) no-spray buffer reduced herbicide drift deposition to adjacent surface waters by 95%, and no measurable drift reached the stream at a width of 20 ft (6 m) as long as the wind-speed was below 15 mph (25 kph) in the direction towards the buffer (De Snoo and De Wit 1998). Many factors contribute to the effectiveness in reducing pesticide drift to acceptable levels. While wind-speed and application method exert significant impacts, vegetation height, density, orientation, and species composition all play pivotal roles. For instance, Ucar and Hall (2001) suggest that, in general, evergreen species display capture efficiencies 2 to 4 times greater than deciduous trees.

5.4.5. Pathogens

Pathogens impair more waterbodies in Washington than any other contaminant (USEPA 2015). Fecal contamination of surface waters can lead to the introduction of various pathogenic bacteria, fungi, viruses, protozoans, and worms that infect the gastrointestinal tract and present a health risk to both humans and wildlife. Common infections related to fecal pollution result from the presence of pathogenic bacteria such as *Escherichia coli* (*E. coli*), *Salmonella* spp. and *Vibrio* spp. or viruses such as Rotavirus. Primary pathogenic protozoans of concern include *Cryptosporidium parvum* and *Giardia lamblia,* which are able to form oocysts (protective spores) that allow them to survive outside of a host for long periods. Helminths represent a general class of parasitic worms, including flatworms and roundworms, which can act as intestinal parasites. The myriad pathogens that can be found in riverine systems following fecal contamination makes it impractical to list them here, but it is important to understand the four different pathogenic categories that can be conveyed to people through surface water contact or ingestion.

Pathogens comprise a diverse range of microorganisms that are typically found in low concentrations, making it impractical to test for specific pathogens when conducting water quality assessments. As an alternative, "pathogen indicator organisms" are used as a proxy to assess the potential presence of pathogens in a water sample. Commonly employed pathogen indicators include total coliforms, fecal coliforms, and *E. coli.* Total coliforms comprise a group of five genera of bacteria that easily can be analytically differentiated from other microorganisms, and while some occur naturally in soils, many are found in the gastrointestinal tract of warm-blooded animals and can serve as a general marker for fecal contamination. Fecal coliforms represent a sub-group of total coliforms that more specifically reside in the intestines of warm-blooded animals, making them a more accurate indication of the presence of fecal material in water. Washington water quality standards use fecal coliforms as indicator organisms to determine water quality impairment. *E. coli,* a species in the fecal coliform group, is a dominant inhabitant in the digestive tract and is generally considered the best indicator of fecal pollution of the three. As *E. coli* are indigenous enteric bacteria, they are not in themselves pathogenic although some strains are (e.g., *E. coli* O157:57). Although most of these indicator organisms are not pathogenic, it is common to refer to them as pathogens when discussing water quality (shortening the phrase "pathogens and pathogenic indicator organisms"), and while technically inaccurate, we will use that term in this section. We use the term in a way that should allow the reader to differentiate between whether we are referencing pathogens specifically or the broader group that includes pathogen indicator organisms.

As the pathogens in question are enteric, they are introduced into the environment through the feces of warm-blooded animals. Principal pathways for pathogens entering aquatic ecosystems are through direct defecation by livestock, wildlife, and pets in the riparian area and via overland flow carrying fecal material from upland pastures, animal feeding operations, fields that have received land-applied manures, or seepage from septic or sewage systems. Feces from domesticated dogs can be a predominant pathogen source in urban areas, as a study in Seattle attributed 30% of the fecal contamination to canines (Tobiason et al. 2002). Hobby farms also present an often-overlooked source adversely affecting water quality, and this has been shown to be an issue in Washington (Morace and McKenzie 2002).

The fate of pathogenic microorganisms in the environment is still not well understood in general and much uncertainty remains in the context of riparian areas. While many of the pathogens that can contaminate surface waters are obligate parasites,

some can persist outside of an animal's gastrointestinal tract in the environment. The length of time these microorganisms can survive under different conditions is a current topic of debate in the research community. The general assumption in the past was that these enteric organisms were not able to persist in the environment for more than a few days following excretion in feces. However, more recent research indicates that bacterial pathogens can survive for much longer periods, and it is generally recognized that persistence in the environment for two to three months is not uncommon. Longer survival rates are possible given the correct conditions, as demonstrated in a laboratory study where *E. coli* O157:H7 persisted for over 190 days in manure-amended soils (Jiang et al. 2002). General factors that influence the survival of pathogenic bacteria that enter riparian areas include soil moisture, temperature, pH, sunlight, nutrient availability, soil texture, and biological interactions. Moist, nutrient-laden, shady conditions such as those often found in riparian areas theoretically would provide an environment in which pathogens could survive longer, potentially being picked up by overland flow and introduced to adjacent stream channels.

Although considerable research has been conducted through the years on bacterial movement through environmental systems, research is in the nascent stages of examining the transport and fate of pathogens across the landscape and in riparian areas. Unc and Goss (2004) offer a concise review on the transport of bacteria from manure in relation to protecting water resources, and although the material presented does not focus on streamside areas it does provide fundamental information on the mechanisms involved in pathogen transport. The body of research that has examined pathogen attenuation in riparian areas is small although expanding, and almost all findings are related to vegetative filter strips and do not consider natural riparian ecosystems.

The capacity of vegetative filter strips to remove pathogens is not well established and research results have demonstrated that these systems exhibit great variability in their effectiveness in removing pathogens. A number of studies have shown that filter strips impart no significant influence on pathogen and pathogenic indicator organism concentrations moving toward a stream channel (Walker et al. 1990; Schellinger and Clausen 1992; Chaubey et al. 1995; Coyne at al. 1995; Entry et al. 2000). Contradictory findings have been generated by other studies that promote the idea that well maintained filter strips can serve as an effective BMP to prevent pathogens from reaching surface waterbodies (Coyne et al. 1998; Fajardo et al. 2001; Tate et al. 2006).

Inconsistent findings result from a number of factors. Soil infiltration, antecedent soil moisture conditions prior to a rain event, vegetation status, topography, and rainfall intensity and duration all have been identified as key controlling variables (Muñoz-Carpena et al. 1999; Guber et al. 2009). Each of these parameters relates to the concept that pathogens being carried in overland flow are removed by their infiltration into the soil where they typically are filtered or adsorbed to soil particles. High intensity rain events and concentrated flow can significantly reduce pathogen removal efficacy below that which would occur under low-flow conditions (Fox et al. 2011b). Vegetative filter strip width plays a significant role in pollutant removal, where a linear

Although considerable research has been conducted on bacterial movement through environmental systems, research is in the nascent stages of examining the transport and fate of pathogens across the landscape and in riparian areas.

decrease in pathogenic bacteria has been consistently observed with increasing buffer width (Young et al. 1980). However, a potential exists for trapped pathogens to later be remobilized in subsequent runoff events. Higher concentrations of pathogens have been recorded in runoff during a second runoff event, which suggests that filter strips could become indirect sources of pathogens under some conditions (Collins et al. 2004).

5.5. Effect of Riparian Buffer Width on Pollutant Removal

The pollutant removal function of riparian areas has been studied for at least 40 years (e.g., Doyle et al. 1975), and the enormous quantity of scientific research over the past four decades has motivated numerous reviews of the scientific literature (Norris 1993; Osborne and Kovacic 1993; Barling and Moore 1994; Vought et al. 1995; Fennesy and Cronk 1997; Lyons et al. 2000; Dosskey 2001; Hickey and Doran 2004; Lacas et al. 2005; Krutz et al. 2005; Polyakov et al. 2005; Hoffman et al. 2009; Dosskey et al. 2010). Despite the large quantity of research and number of literature reviews, no widely accepted recommendations have emerged on minimum buffer widths needed to protect water quality. The lack of agreement amongst scientists is due, in part, to the surprising complexity of the mechanisms that remove pollutants from surface and subsurface flows in riparian areas, to the variety of research methods used to study pollutant removal by riparian buffers, and to the many different environmental conditions at research sites.

The quantitative metric of pollutant removal by riparian areas is referred to as removal efficacy, removal efficiency, or percent removal. These measures are usually defined as:

$$E_R = \frac{m_{in} - m_{out}}{m_{in}} \times 100 \qquad (1)$$

where m_{in} and m_{out} are the mass or concentration of the pollutant entering and exiting a riparian buffer, respectively. The primary question addressed by nearly all research on the pollutant removal function of riparian areas, and by nearly all literature reviews, is how does riparian buffer width affect removal efficacy? The main answers are: 1) removal efficacy increases as buffer width increases, 2) topographic slope and vegetation type strongly affect removal efficacy, and 3) the relationship between removal efficacy and buffer width is highly variable.

In addition to the many literature reviews cited above, several statistical meta-analyses of research results (Mayer et al. 2007; Liu et al. 2008; Yuan et al. 2009; Zhang et al. 2010; Sweeney and Newbold 2014) provide synoptic perspectives on what is currently known about the relationship between buffer width and removal efficacy (Table 5.1). Research results from throughout the world were collected by all five meta-analyses, but the majority were from North America. The remainder of this section discusses the findings of those meta-analyses.

Four meta-analyses looked at the results of research on sediment removal. The meta-analyses found that buffer width alone explained 28% to 37% of the variance in sediment removal results. Models for removal efficacy versus buffer width predicted a wide range of buffer widths necessary for 90% efficacy: 33, 39, 75, and 170 ft (10, 12, 23, and 52 m) (Figure 5.2). Three of the meta-analyses found that adding slope as an independent variable significantly improved the fit of their models to the data. Two meta-analyses (Liu et al. 2008; Zhang et al. 2010) using the same studies but different modeling assumptions, found that optimum slope for sediment removal was about 10%. In other words, removal efficacy increased as slope increased from 1 to 10%, but then removal efficacy decreased as slope increased above 10%. However, extrapolating these findings to other locations should be done cautiously as this relationship may not hold under many conditions. Zhang et al. (2010) found that buffer width, slope,

and vegetation type together could explain 65% of the variance in sediment removal results. Curiously, they also found that buffers composed of grasses only or trees only were more efficacious at removing sediment than buffers composed of both grasses and trees (Figure 5.4).

Three separate meta-analyses looked at the results of research on nitrogen removal. The meta-analyses of Zhang et al. (2010) and Mayer at al. (2007) produced very different relationships for removal efficacy versus buffer width. Zhang et al. (2010) found that buffer width alone explained 44% of the variance in nitrogen removal results, but Mayer et al. (2007) found buffer width alone explained only 9%. Furthermore, Zhang et al. (2010) predicted that buffer widths of 80 ft (24 m) are necessary for 90% removal efficacy, while Mayer et al. (2007) predicted buffer widths of 436 ft (133 m) for the same efficacy (Figure 5.3). Separate models by Mayer et al. (2007) for surface and subsurface flows found a significant relationship (assuming $\alpha = 0.05$) between buffer width and removal efficacy for surface flows ($R^2 = 0.21$, $P = 0.03$) but not for subsurface flows ($R^2 = 0.02$, $P = 0.3$). Despite this result, Mayer et al. (2007) found that riparian buffers were more efficacious in removing nitrogen from subsurface waters than from surface waters. Mayer et al. (2007) found no significant relationship between nitrogen removal and buffer vegetation type but their collection of studies did show that buffers lacking trees (herbaceous cover only) were the least efficacious at removing nitrogen.

Zhang et al. (2010) found a relationship between vegetation type and nitrogen removal and that buffers composed of trees remove more nitrogen than buffers completely or partially composed of grasses. Zhang et al.'s model that included buffer width and vegetation type explained 49% of the variance in nitrogen removal results.

Comparing regression models for sediment and nitrogen removal (Figures 5.2 and 5.3) illustrates three important points regarding the pollutant removal function of riparian areas. First, the magnitude of removal efficacy for different pollutants can be very different. According to the models, 80% of sediment was removed at roughly 50 to 65 ft (15 to 20 m), but 80% removal of nitrogen may require buffer widths two to four times wider. Second, the variability of removal efficacy for various pollutants can be significantly different. The regression models for nitrogen removal show much more variation than the models for sediment removal. The wider variation is due, in part, to the greater complexity of the chemical and biological processes affecting nitrogen removal compared to the simpler physical processes affecting sediment removal. Hence, our ability to predict removal efficacy and our certainty about water quality protection can be very different for different pollutants. Third, for all pollutants the relationship between buffer width and removal efficacy follows a law of diminishing marginal returns. That is, the marginal (or incremental) amount of pollutant removal decreases as buffer width increases.

Zhang et al. (2010) also conducted meta-analysis for phosphorus and pesticides. Buffer width alone explained 35% of the variance in phosphorus removal results (Figure 5.5), and with the addition of vegetation as an independent variable, the model explained 47% of the variance. The buffer-width-only model predicts 89% phosphorus removal with a buffer 98 ft (30 m) wide.[7] Buffers with trees were found to remove more phosphorus than buffers completely or partially composed of grasses. The pesticide meta-analysis included 11 chemicals (norfluranzon, fluometuron, lindane, deisopropylatrazine, deethylatrazine, atrazine, permethrin, bromide, terbuthylazine, metolachlor, isoproturon). Buffer width alone explained 60% of the variance in pesticide removal results, and vegetation was found to be an insignificant predictor variable. The model predicts 92% pesticide removal with a buffer 65 ft (20 m) wide.

7 Because Zhang et al. (2010) assumed an asymptotic equation for their regression, the phosphorus model was invalid for efficacies greater than 89.5%.

Using data provided by Zhang et al. (2010), we calculated prediction intervals for their phosphorus model.[8] A prediction interval describes the precision of a model's predictions and the interval's width is a metric of uncertainty. For a buffer 33 ft (10 m) wide, the width of the 90% prediction interval is 64%. Therefore, while the model predicts that a 33 ft (10 m) buffer will provide an average removal efficacy of 70%, the actual removal efficacy obtained by another study on phosphorus removal (i.e., one which was not included in the meta-analysis) is likely to be somewhere between 38 and 100% (70% ± 32%). The low precision of the model's prediction interval is related to the unexplained variance that could be attributed to other variables not included in the regression, such as site slope and various soil properties.

Table 5.1. Descriptive information for functional relationships on sediment removal shown in Figure 5.2 and nitrogen removal shown in Figure 5.3. Reference numbers 1 through 4 correspond to numbers in Figures 5.2 and 5.3. In the equations, E_R is the removal efficacy, *width* is riparian buffer width, and *a*, *b*, *c*, *d*, and k_{50} are parameters determined through linear or nonlinear regression.

Pollutant	Meta-analysis	Form of equation	Model	*N****	R^2	*P* value
Sediment	(1) Liu et al. (2008)**	$E_R = a + b\ \ln(width)$	width	79	0.34	< 0.001
		$E_R = a + b \times width + c \times slope + d \times slope^2$	width & slope = 5% width & slope = 10% width & slope = 15%	79	0.43	< 0.0001
	(2) Yuan et al. (2009)	$E_R = a + b\ \ln(width)$	width	75	0.30	na*
			width & slope ≤ 5%	53	0.32	na
			width & slope > 5%	14	0.17	na
	(3) Zhang et al. (2010)**	$E_R = a\ (1 - e^{b \times width})$	width	81	0.37	< 0.0001
		$E_R = a\ (1 - e^{b \times width}) + c + d \times slope$	width & slope = 5% & grass or trees width & slope = 10% & grass or trees width & slope = 15% & grass or trees	81	0.65	< 0.001
	(4) Sweeney and Newbold (2014)	$E_R = \frac{width}{k_{50} + width}$	width	22	0.28	na
Nitrogen	(1) Mayer et al. (2007)	$E_R = a \times width^b$	width, surface water only	23	0.21	0.03
			width & herbaceous vegetation	32	0.21	0.009
			width & herbaceous/forest vegetation	11	0.39	0.04
	(2) Zhang et al. (2010)	$E_R = a\ (1 - e^{b \times width})$	width	61	0.44	< 0.0001
		$E_R = a\ (1 - e^{b \times width}) + c$	width & trees vegetation width & grass or mixed grass/trees veg.	61	0.49	< 0.001
	(3) Sweeney and Newbold (2014)†	$E_R = 100\ (1 - e^{b \times width/q})$	width & q set to 58‡ width & q set to 115	30	0.37	na*

* Signifies that *P* value was not reported in cited study.

** Nearly all the studies included by Liu et al. (2008) and Zhang et al. (2010) in their meta-analyses were the same studies.

*** *N* signifies number of studies in meta-analysis.

† Studies for subsurface nitrate removal only.

‡ q represents subsurface water flux. 58 and 115 L/m/day are median and mean subsurface water fluxes for studies collected by Sweeney and Newbold (2014).

[8] A prediction interval is a range that is likely to contain the dependent response value (Y_i) for a new observation (X_i). A prediction interval assumes that the new observation is taken from the same population used to create the regression equation.

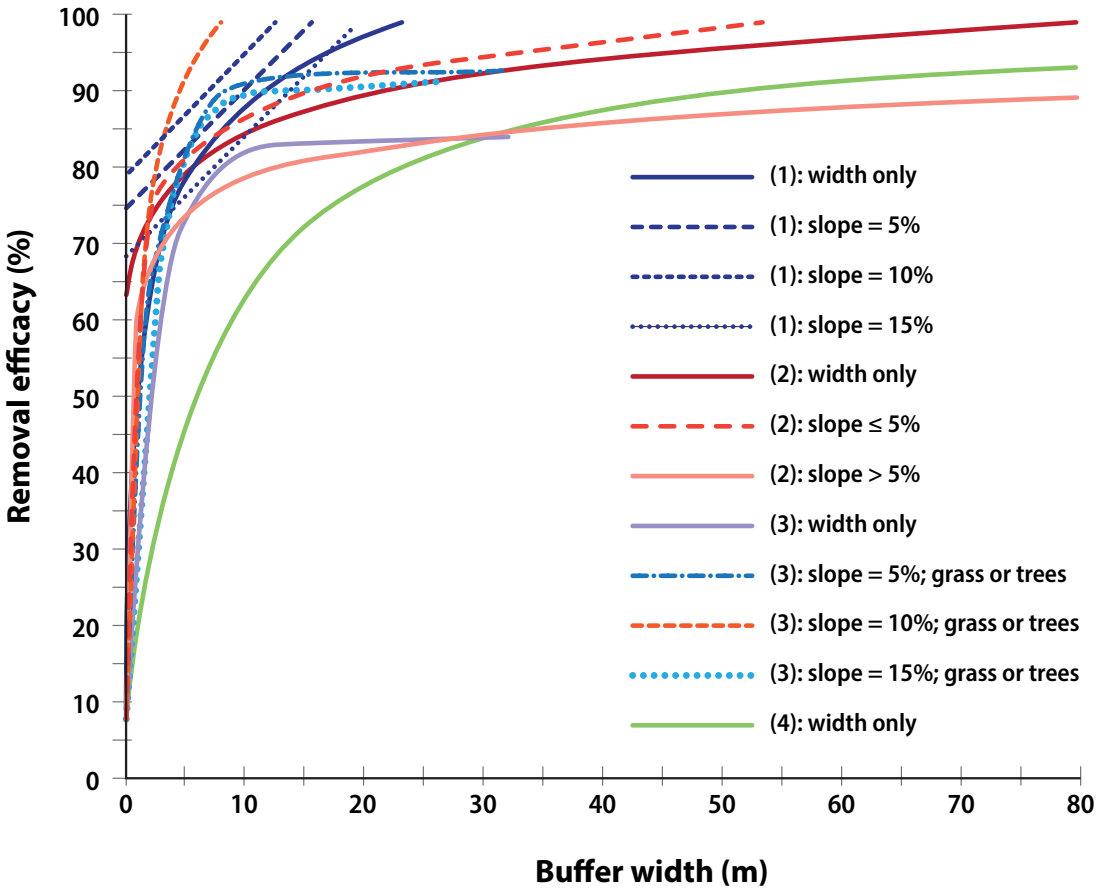


Figure 5.2. Relationships between sediment removal efficacy and riparian buffer width developed by four separate meta-analyses. Numbers in parentheses refer to different meta-analyses. See descriptive information in Table 5.1.

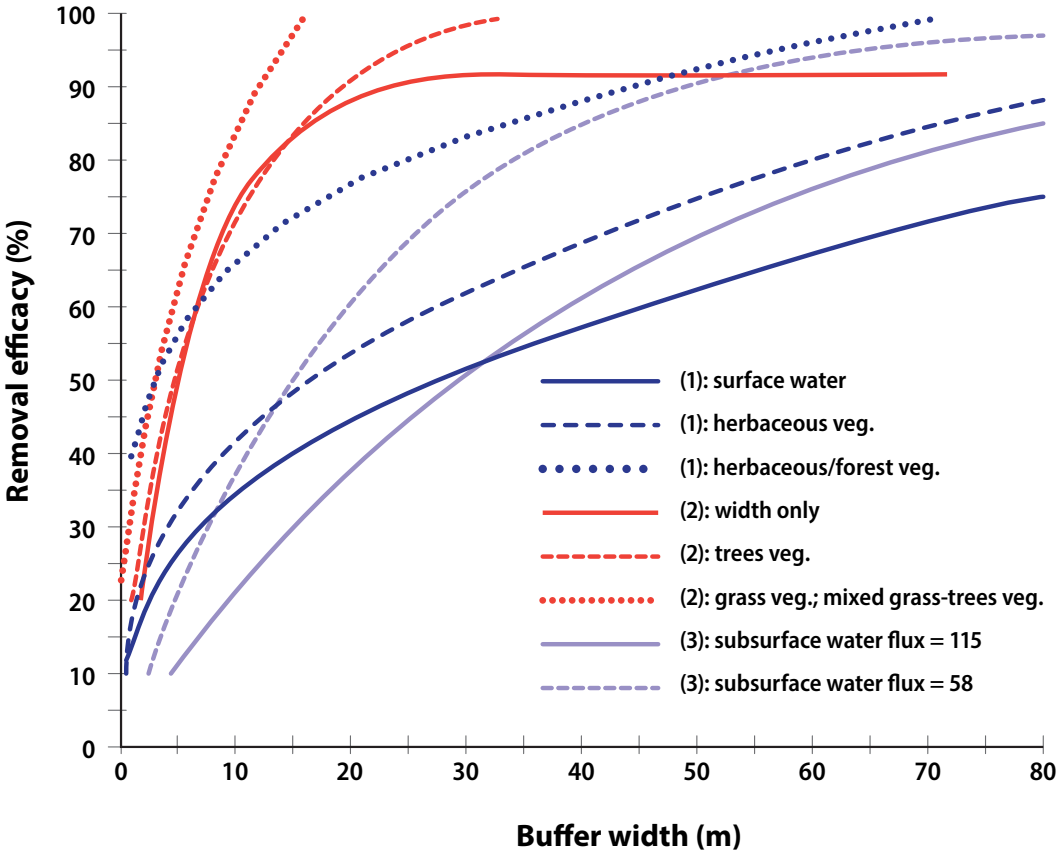


Figure 5.3. Relationships between nitrogen removal efficacy and riparian buffer width developed by three separate meta-analyses. Numbers in parentheses refer to different meta-analyses. See descriptive information in Table 5.1.

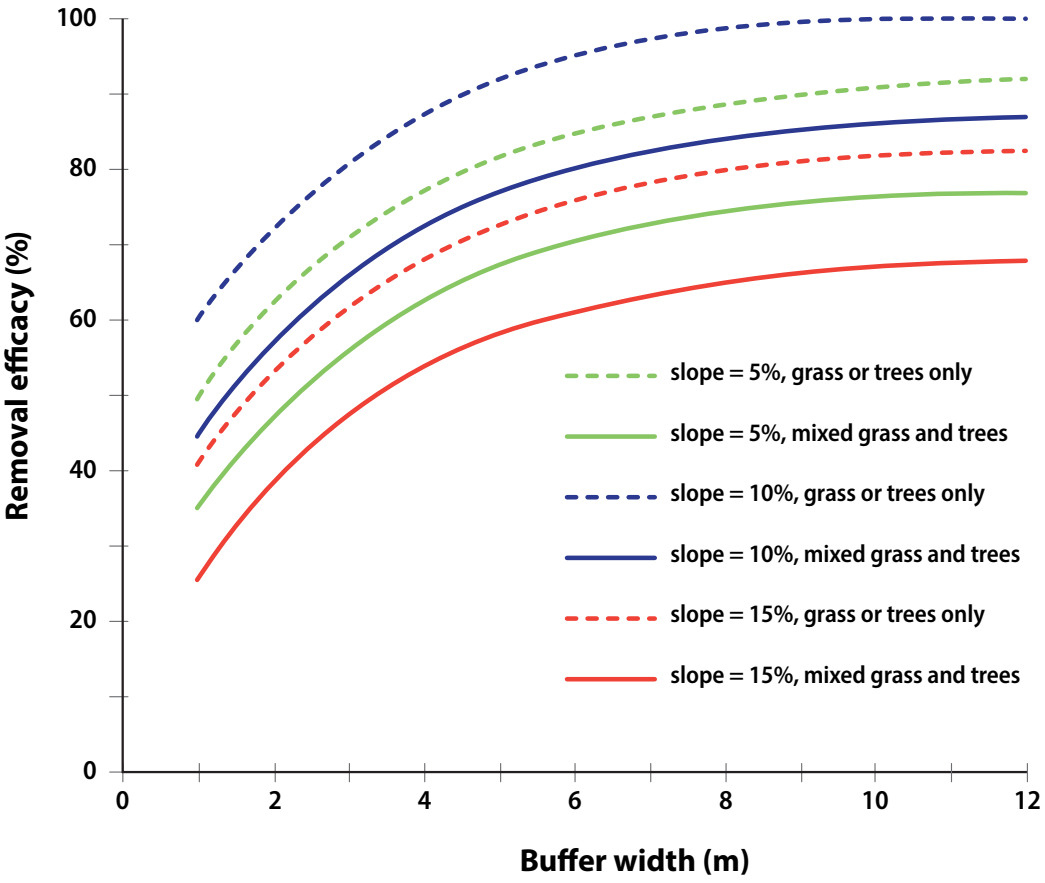


Figure 5.4. A result from meta-analysis of Zhang et al. (2010). Sediment removal efficacy as a function of buffer width, site slope, and buffer vegetation ($N = 81$, $R^2 = 0.65$, $P < 0.001$).

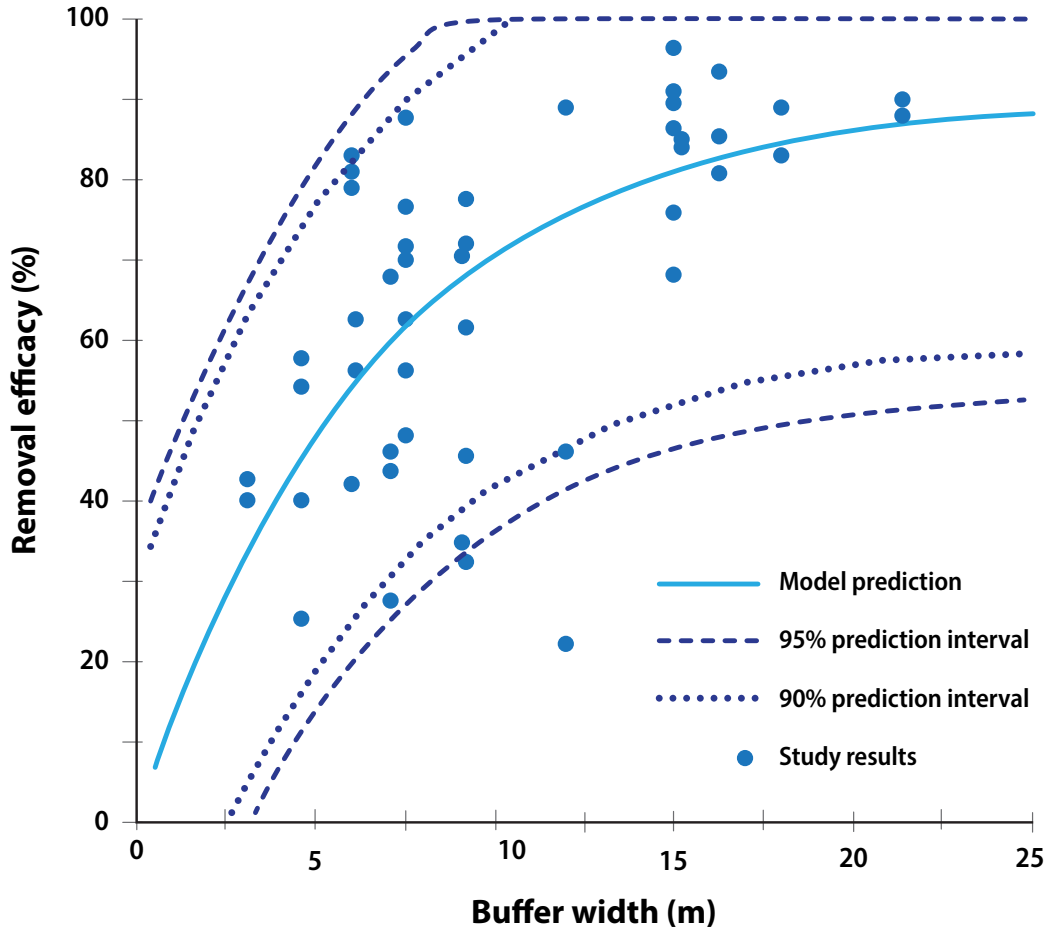


Figure 5.5. Meta-analysis of Zhang et al. (2010). Results of nonlinear regression for phosphorus removal efficacy as a function of buffer width ($N = 52$, $R^2 = 0.35$, $P < 0.0001$) with 90% and 95% prediction intervals.

5.6. Reanalysis of Meta-Analyses

A major assumption made by each of the meta-analyses was the type of equation that would result in the best fit to their data. Zhang et al. (2010), for instance, chose to use a nonlinear asymptotic equation of the form:

$$E_R = a\,(1 - e^{b \times width}) \qquad (2)$$

where E_R is removal efficacy, ***width*** refers to buffer width, and ***a*** and ***b*** are coefficients determined through nonlinear regression. In equation (2), *a* determines the maximum removal efficacy possible (i.e., it is an asymptote). Zhang et al. (2010) conducted their regression such that *a* could be less than 100%. For sediment, pesticide, nitrogen, and phosphorus pollutants, *a* equaled 91, 93, 92, and 89.5 percent, respectively. Hence, we could not determine buffer widths needed for removal efficacies greater than these values of *a* in their models. This limitation was particularly problematic for pesticides and phosphorus because Zhang et al. (2010) was the only meta-analysis for those pollutants.

To determine buffer widths needed for higher removal efficacies (90, 95, 99%), we reanalyzed Zhang et al.'s data with a nonlinear equation of the form:

$$E_R = a + b\ \ln(width) \qquad (3)$$

This form of model is the same used by Liu et al. (2008) and Yuan et al. (2009).[1] We performed linear regression in R (RCT 2013) using the lm function, but first we established that we could obtain the same regression results (same values for ***a*** and ***b***) as Zhang et al. (2010) using equation (2). This confirmed that the data we downloaded from the internet were the same data used by Zhang et al. (2010). We then redid the regression using equation (3). With the exception of sediment, the resulting models fit the data as well or better than the original models of Zhang et al. (2010) (Table 5.2). Graphical comparisons of our results and those of Zhang et al. (2010) are presented in Figure 5.6.

Table 5.2. Comparison of R^2 values for Zhang et al.'s (2010) model and our reanalysis using equation (3). *N* is the number of studies included in the meta-analysis.

Pollutant	*N*	R^2	
		Zhang et al. (2010)	Reanalysis
Sediment	81	0.37	0.31
Nitrogen	61	0.44	0.44
Phosphorus	52	0.35	0.39
Pesticides	49	0.60	0.61



Juvenile fish find shelter in a root wad/Terra Hegy, WDFW

1 Xuyang Zhang, the lead author of Zhang et al. (2010), also recommended that we use equation (3) because equation (2) cannot model 100% removal efficacy (X. Zhang, California Department of Pesticide Regulation, personal communication, May 14, 2019).

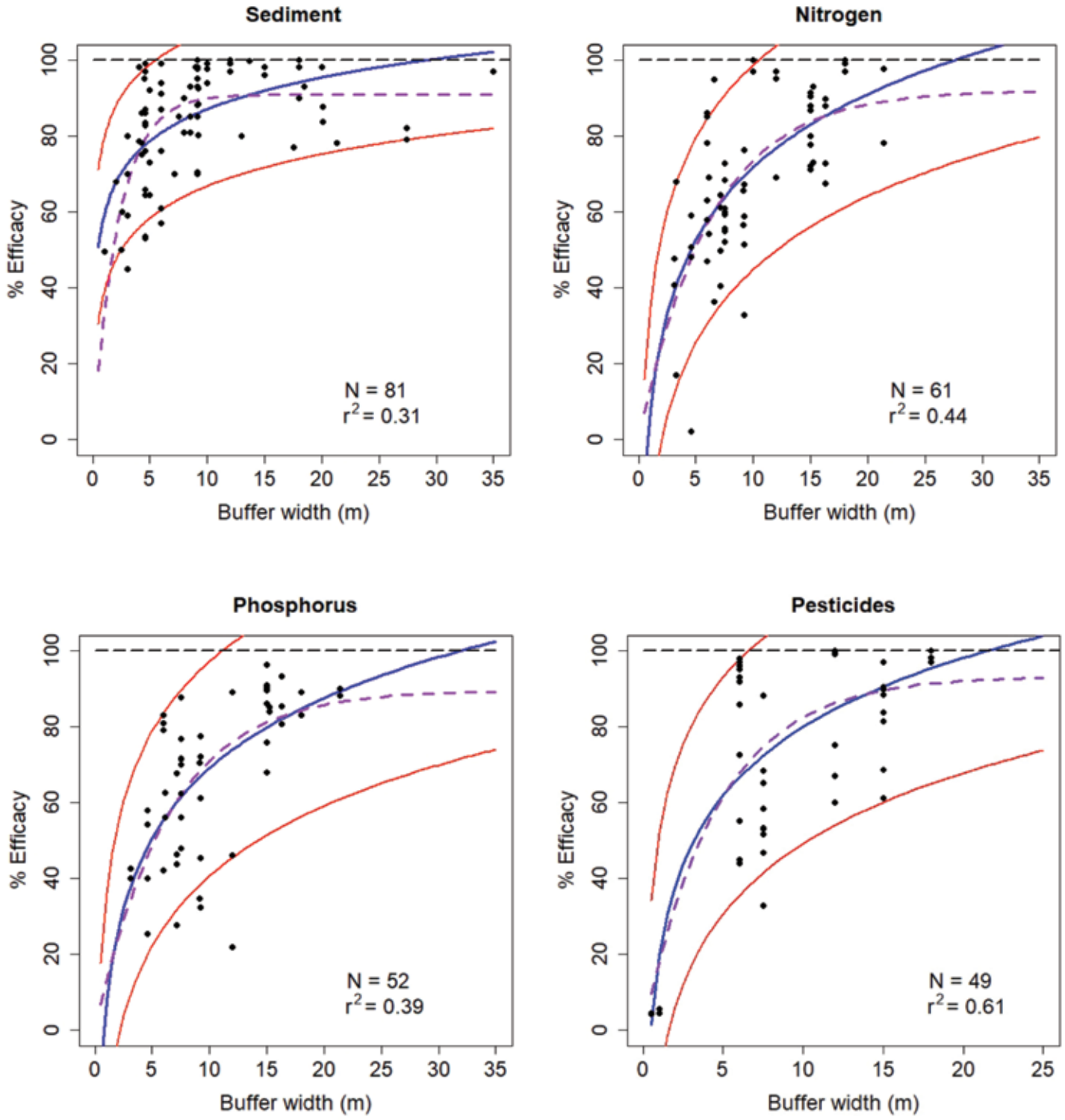


Figure 5.6. Relationship between removal efficacy and buffer width. Data from meta-analysis of Zhang et al. (2010) but reanalyzed using different form of nonlinear model. Line colors: blue: best fit model, red: 90% prediction interval, purple dashed: original model of Zhang et al. (2010), black dashed: 100% removal efficacy

We also reanalyzed two other meta-analyses – Mayer et al. (2007), and Sweeney and Newbold (2014) – for two reasons. The first reason was consistency across meta-analyses. The meta-analyses gave different answers for the relationship between removal efficacy and buffer width. For example, Zhang et al. (2010) predicted that buffer widths of 80 ft (24 m) are necessary for 90% removal efficacy of nitrogen, while Mayer et al. (2007) predicted buffer widths of 436 ft (133 m) for the same efficacy. Part of this discrepancy may be due to the type of equations adopted for their nonlinear or linear regressions, so we redid both meta-analyses using the same equation. Second, as noted earlier, a major assumption made by each of the meta-analyses was the type of equation that would result in the best fit to their data. We tested that assumption, and found that equation (3) often resulted in a better fit.

Mayer at al. (2007) chose to use a power function of the form:[2]

$$E_R = a\ width^b \qquad (4)$$

where ***a*** and ***b*** are coefficients determined through linear regression. We reanalyzed their data using equation (3). The resulting models fit the data as well or better than the original models of Mayer et al. (2007) (Table 5.3, Figure 5.7). For subsurface flow, the relationship between removal efficacy and buffer width was statistically insignificant ($P = 0.30$) and R^2 was only 0.02 for both their model and ours. We also note that both models produce somewhat absurd results – 60% of subsurface nitrogen can be removed with buffers only 2 ft wide but 90% removal requires buffers over 1200 ft wide. Hence, we will use neither model in further discussions of sub-surface nitrogen removal. For surface flow, the reanalysis resulted in a slightly better fit to the data – R^2 improved from 0.21 to 0.28.

We did not reanalyze the meta-analysis that Sweeny and Newbold (2014) did on studies of nitrogen removal from groundwater. While Sweeney and Newbold (2014)

Table 5.3. Comparison of R^2 values for Mayer et al.'s (2007) model and our reanalysis using equation (3). *N* is the number of studies included in the meta-analysis.

		Mayer et al. (2007)		Reanalysis	
Model	*N*	R^2	*P*	R^2	*P*
nitrogen, surface	23	0.21	0.03	0.28	0.009
nitrogen, subsurface	65	0.02	0.30	0.02	0.30

found a significant statistical relationship between nitrogen removal from subsurface flow and buffer width, other studies suggest the buffer width has little or no effect on nitrogen removal from subsurface flow (Hruby 2013, pp. 10-11).

For sediment removal, Sweeney and Newbold (2014) chose an equation of the form:

$$E_R = \frac{width}{k_{50} + width} \qquad (5)$$

where k_{50} equals the buffer width expected to remove 50% of sediments and it is determined through nonlinear regression. We reanalyzed their data using equation (3). The resulting model fits the data better than the original model of Sweeney and Newbold (2007). Their R^2 was 0.28 and the new R^2 is 0.33 (Figure 5.7).

Table 5.4 shows the buffer width needed to achieve desired levels of pollutant removal as predicted by meta-analyses and our reanalyses of meta-analyses. We combined predictions from multiple meta-analyses using a weighted average with the weights being the products of *N* and R^2. Note that values in Table 5.4 are predicted averages for removal efficacy. The actual efficacy realized by implementing a particular buffer width could be much better or worse. The amount of uncertainty in the realized removal efficacy is depicted by prediction intervals in Figures 5.6 and 5.7. The

2 The equation $E_R = a\ width^b$ can be transformed to the equation $\ln(E_R) = a' + b\ \ln(width)$, which is similar in structure to equation (3) and results in a similar fit to the data. Equation (3) was also the form used by Mayer et al. (2006).



Riparian areas capture pollutants/Marlin Greene, One Earth Images

reanalyzed meta-analysis of Zhang et al. (2010), for example, predicts that 90% of sediment can be removed with a 42 ft (13 m) wide buffer, however, according to the prediction interval, the buffer width needed for 90% removal could be as narrow as 8 ft (2.4 m) or as wide as 225 ft (69 m). Better models that include other independent variables, such as slope and vegetation (e.g., Zhang et al. 2010), will reduce this uncertainty, but there is a trade-off. The application of more complicated models leads to more complicated management. If, for example, managers adopted a model that includes vegetation type or vegetation structure, then, in addition to buffer width, they must also manage the condition of vegetation within the buffer.

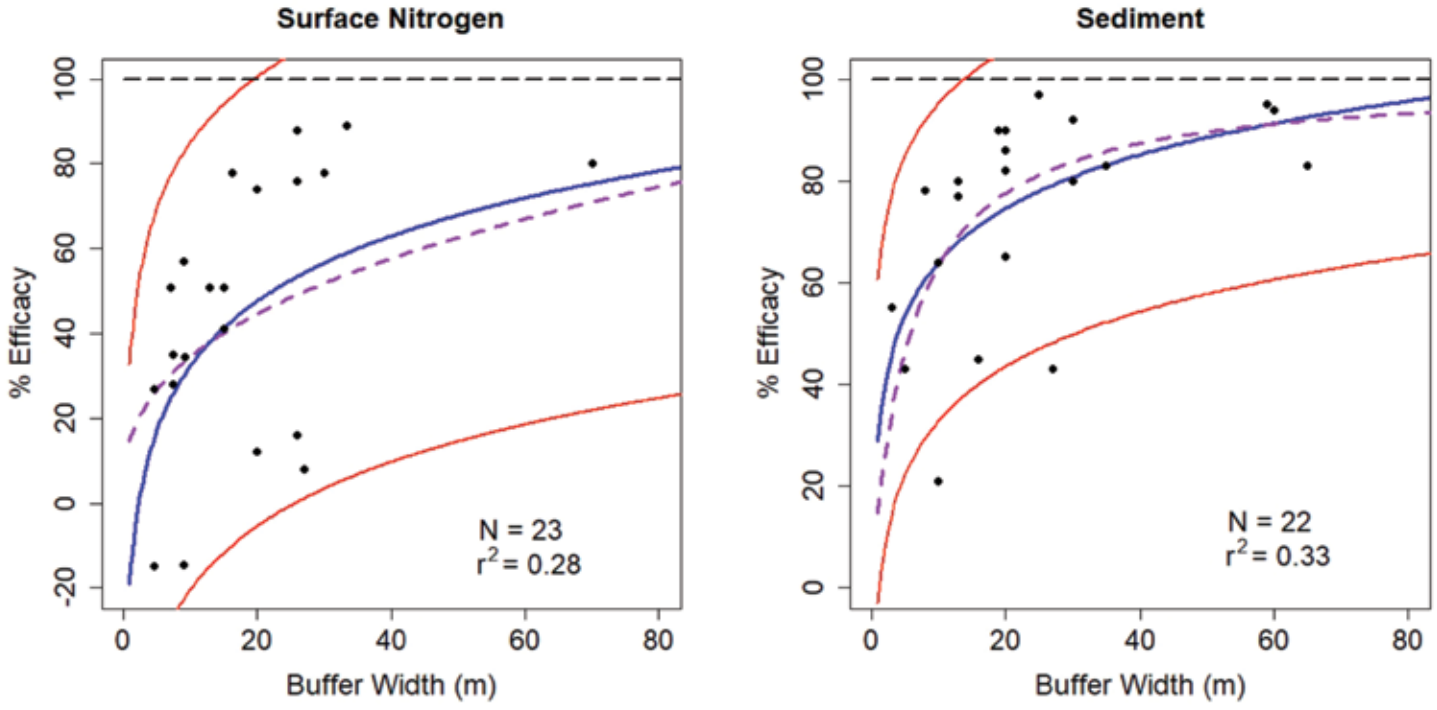


Figure 5.7. Relationship between removal efficacy and buffer width. Study results from meta-analyses reanalyzed using different form of equation in a linear regression. Left: nitrogen study results from Mayer et al. (2007). Right: sediment study results from Sweeney and Newbold (2014). Line colors: blue: best fit model, red: 90% prediction interval, purple dashed: original models from meta-analyses, black dashed: 100% removal efficacy.

Table 5.4. Buffer width in feet needed to achieve desired levels of pollutant removal from run-off. Buffer width calculated with model and/or data from the cited literature. Models had only one predictor variable, which was buffer width. Mean buffer width for sediment and nitrogen removal are weighted averages of widths determined by each meta-analysis. Weights were the product of *N* and R^2.

				Average Removal Efficacy (%)	80	90	95	99
Pollutant	**Meta-analysis**	***N***	***R^2***	**Buffer Width (ft)**				
Sediment	Liu et al. (2008)*	79	0.34		18	39	56	76
	Yuan et al. (2009)	75	0.30		18	74	149	261
	Zhang et al. (2010)*, *reanalyzed*	81	0.31		18	42	64	89
	Sweeney and Newbold (2014), *reanalyzed*	22	0.33		94	181	251	326
				Weighted mean	**25**	**62**	**101**	**153**
Nitrogen, surface	Mayer et al. (2007), *reanalyzed*	23	0.28		283	444	556	666
	Zhang et al. (2010), *reanalyzed*	61	0.44		44	63	76	88
				Weighted mean	**90**	**137**	**169**	**200**
Nitrogen, subsurface	Sweeney and Newbold (2014) ‡	30	0.37		112	161	210	322
Phosphorus	Zhang et al. (2010), *reanalyzed*	52	0.39		50	72	87	101
Pesticides	Zhang et al. (2010), *reanalyzed*	49	0.61		33	48	59	68

* Nearly all the studies included by Liu et al. (2008) and Zhang et al. (2010) were the same studies.

‡ The parameter q, which represents subsurface water flux, was set to 58, which is the median value for 30 studies analyzed by Sweeney and Newbold (2014).

5.7. Conclusions

There is a consensus in the scientific literature that riparian areas reduce the flow of pollutants to aquatic ecosystems, and that pollutant removal functions are contingent on complex interactions between hydrology, soil, and vegetation, and are influenced by many other factors as well. Because hydrology, soil, vegetation and other factors exhibit high spatial and temporal variability, the efficacy of pollutant removal functions provided by riparian areas differs substantially among sites, as well as within sites. Determining the potential for riparian areas to protect water quality is further complicated by the disparate behavior of different contaminant types in the environment. While space limitations required us to simplify this review of the scientific literature regarding pollutant removal functions of riparian areas, we provided the basic information needed for understanding these important ecological functions.

Our review of the literature presents a substantial body of scientific research with which to develop strategies, plans, or policies regarding the pollutant removal functions of riparian areas. The central problem faced by resource managers is determining the adequate riparian buffer width, composition, and structure to protect water quality with high degrees of efficacy, efficiency, and certainty. Riparian function is often simplistically characterized by buffer width and vegetation type, but these parameters only partially explain the effects that riparian areas have on pollutant removal. The current conservation paradigm remains strongly tied to the

premise that wider riparian areas are the only way to increase pollutant removal efficacy, but this is not always the case; other site-specific factors, such as conditions within the buffer, also exert a significant influence on removal efficacy. Therefore, consideration of the entire system (i.e., riparian area, uplands, vegetation, soils, ground and surface water pathways, topography, type of pollutant, etc.) is essential to developing cost-effective pollutant removal. In theory, buffer width and vegetation could be optimized for site conditions such that water quality is protected while minimizing economic costs for landowners.

Despite the many scientific uncertainties, management decisions must be made. Management decisions regarding pollutant removal by riparian buffers should be informed by science, but determining the "right" buffer width for pollutant removal cannot be purely scientific. Determining the "right" buffer width begins with choosing a desired removal efficacy, and that choice is normative. That is, the desired removal efficacy is a social choice influenced by cultural values, economic costs, and risk tolerance. Choosing a desired removal efficacy and determining the "right" buffer requires: 1) factual information regarding the anticipated impacts or outcomes of policy options (i.e., science); 2) an understanding of stakeholders' priorities and preferences (i.e., values); and 3) a process for using science and values to explore tradeoffs amongst policy options (Wilhere and Quinn 2018).

5.8. Literature Cited[3]

Ahmad, M., A.U. Rajapaksha, J.E. Lim, M. Zhang, N. Bolan, D. Mohan, M. Vithanage, S.S. Lee, and Y.S. Ok. 2014. Biochar as a sorbent for contaminant management in soil and water: a review. Chemosphere 99:19-33. (i)

Allaire, S.E., C. Sylvain, S.F. Lange, G. Thériault, and P. Lafrance. 2015. Potential efficiency of riparian vegetated buffer strips in intercepting soluble compounds in the presence of subsurface preferential flows. PLoS ONE 10: e0131840. (i)

Alvarez, M.D., and L.A. Fuiman. 2005. Environmental levels of atrazine and its degradation products impair survival skills and growth of Red Drum larvae. Aquatic Toxicology 74:229-241. (i)

Anbumozhi, V., J. Radhakrishnan, and E. Yamaji. 2005. Impact of riparian buffer zones on water quality and associated management considerations. Ecological Engineering 24:517-523. (i)

Angier, J.T., G.W. McCarty, C.P. Rice, and K. Bialek. 2002. Influence of a riparian wetland on nitrate and herbicides exported from an agricultural field. Journal of Agricultural and Food Chemistry 50:4424-4429. (i)

Au, D.W.T., C.A. Pollino, R.S.S. Wu, P.K.S. Shin, S.T.F. Lau, and J.Y.M. Tang. 2004. Chronic effects of suspended solids on gill structure, osmoregulation, growth, and triiodothyronine in juvenile Green Grouper *Epinephelus coioides.* Marine Ecology Progress Series 266:255-264. (i)

Backer, L.C., J.H. Landsberg, M. Miller, K. Keel, and T.K. Taylor. 2011. Canine cyanotoxin poisonings in the United States (1920s-2012): review of suspected and confirmed cases from three data sources. Toxins 5:1597-1628. (i)

Baldwin, D.H., J.F. Sandahl, J.S. Labenia, and N.L. Scholz. 2003. Sublethal effects of copper on Coho Salmon: impacts on non-overlapping receptor pathways in the peripheral olfactory nervous system.

[3] References are classified according to RCW 34.05.271 (see Appendix 1) denoted by a lower case roman numeral (i – viii) in parentheses at the end of the citation.

Environmental Toxicology and Chemistry 22:2266-2274. (i)

Barling, R.D., and I.D. Moore. 1994. Role of buffer strips in management of waterway pollution: a review. Environmental Management 18:543-558. (i)

BLM (Bureau of Land Management). 2003. Riparian area management: riparian-wetland soils. Technical Reference 1737-19. Denver. (viii)

Boening, D.W. 2000. Ecological effects, transport, and fate of mercury: a general review. Chemosphere 40:1335-1351. (i)

Bohn, C.C., and J.C. Buckhouse. 1985. Some responses of riparian soils to grazing management in northeastern Oregon. Journal of Range Management 38:378-381. (i)

Bolan, N., A. Kunhikrishnan, R. Thangarajan, J. Kumpiene, J. Park, T. Makino, M.B. Kirkham, and K. Scheckel. 2014. Remediation of heavy metal(loid)s contaminated soils–to mobilize or to immobilize? Journal of Hazardous Materials 266:141-166. (i)

Boonchan, S., M.L. Britz, and G.A. Stanley. 2000. Degradation and mineralization of high-molecular-weight polycyclic aromatic hydrocarbons by defined fungal-bacterial cocultures. Applied and Environmental Microbiology 66:1007-1019. (i)

Bourret, M.M., J.E. Brummer, and W.C. Leininger. 2009. Establishment and growth of two willow species in a riparian zone impacted by mine tailings. Journal of Environmental Quality 38:693-701. (i)

Bradford, S.A., and S. Torkzaban. 2008. Colloid transport and retention in unsaturated porous media: a review of interface-, collector-, and pore-scale processes and models. Vadose Zone Journal 7:667-681. (i)

Buffler, S., C. Johnson, J. Nicholson, and N. Mesner. 2005. Synthesis of design guidelines and experimental data for water quality function in agricultural landscapes in the Intermountain West. National Agroforestry Center, Lincoln, Nebraska. (viii)

Burt, T.P., L.S. Matchett, W.T. Goulding, C.P. Webster, and N.E. Haycock. 1999. Denitrification in riparian buffer zones: the role of floodplain hydrology. Hydrologic Processes 13:1451-1463. (i)

Canet, R., J.G. Brinsting, D.G. Malcolm, J.M. Lopez-Real, and A.J. Beck. 2001. Biodegradation of polycyclic aromatic hydrocarbons (PAHs) by native microflora and combinations of white-rot fungi in a coal-tar contaminated soil. Bioresource Technology 76:113-117. (i)

Castelle, A.J., A.W. Johnson, and C. Conolly. 1994. Wetland and stream buffer size requirements–a review. Journal of Environmental Quality 23:878-882. (i)

Cedergreen, N. 2014. Quantifying synergy: a systematic review of mixture toxicity studies within environmental toxicology. PLoS ONE 9:e96580. (i)

Cey E.E., D.L. Rudolph, R. Aravena, and G. Parkin. 1999. Role of the riparian zone in controlling the distribution and fate of agricultural nitrogen near a small stream in southern Ontario. Journal of Contaminant Hydrology 37:45–67. (i)

Chaubey, I., D.R. Edwards, T.C. Daniel, P.A. Moore, and D.J. Nichols. 1995. Effectiveness of vegetative filter strips in controlling losses of surface-applied poultry litter constituents. Transactions of the American Society of Agricultural Engineers 38:1687-1692. (i)

Cheng, Z.Q., E.L. McCoy, and P.S. Grewal. 2014. Water, sediment, and nutrient runoff from urban lawns established on disturbed subsoil or topsoil and managed with inorganic or organic fertilizers. Urban Ecosystems 17:277-289. (i)

Clements, W.H., D.S. Cherry, and J. Cairns, Jr. 1990. Macroinvertebrate community responses to copper in laboratory and field experimental streams. Archives of Environmental Contaminants and Toxicology 19:361-365. (i)

Clinton, B.D. 2011. Stream water responses to timber harvest: riparian buffer width effectiveness. Forest Ecology and Management 261:979-988. (i)

Colborn, T., F.S.V. Saal, and A.M. Soto. 1993. Developmental effects of endocrine-disrupting chemicals in wildlife and humans. Environmental Health Perspectives 101:378-384. (i)

Collins, R., A. Donnison, C. Ross, and M. McLeod. 2004. Attenuation of effluent-derived faecal microbes in grass buffer strips. New Zealand Journal of Agricultural Research 47:565-574. (i)

Cooper, J.R., and J.W. Gilliam. 1987. Phosphorus redistribution from cultivated fields into riparian areas. Soil Science Society of American Journal 51:1600-1604. (i)

Cors, M., and B. Tychon. 2007. Grassed buffer strips as nitrate diffuse pollution remediation tools: management impact on the denitrification enzyme activity. Water Science and Technology 55:25-30. (i)

Correll, D.L. 1997. Buffer zones and water quality protection: general principles. Pages 7-20 *in* N. Hancock, T. Burt, K. Goulding, and G. Pinay, editors. Buffer zones: their processes and potential in water protection. Quest Environmental, Hertfordshire, United Kingdom. (viii)

Covaci, A., S. Harrad, M.A.E. Abdallah, N. Ali, R.J. Law, D. Herzke, and C.A. de Wit. 2011. Novel brominated flame retardants: a review of their analysis, environmental fate and behavior. Environment International 37:532-556. (i)

Coyne, M.S., R.A. Gilfillen, R.W. Rhodes, and R.L. Blevins. 1995. Soil and fecal-coliform trapping by grass filter strips during simulated rain. Journal of Soil and Water Conservation 50:405-408. (i)

Coyne, M.S., R.A. Gilfillen, A. Villalba, Z. Zhang, R. Rhodes, L. Dunn, and R.L. Blevins. 1998. Fecal bacteria trapping by grass filter strips during simulated rain. Journal of Soil and Water Conservation 53:140-145. (i)

Daniels, R.B., and J.W. Gilliam. 1996. Sediment and chemical load reduction by grass and riparian filters. Soil Science Society of America Journal 60:246-251. (i)

De Snoo, G.R., and P.J. De Witt. 1998. Buffer zones for reducing pesticide drift to ditches and risks to aquatic organisms. Ecotoxicology and Environmental Safety 41:112-118. (i)

Delle Site, A. 2001. Factors affecting sorption of organic compounds in natural sorbent/water systems and sorption coefficients for selected pollutants—a review. Journal of Physical and Chemical Reference Data 30:187-439. (i)

Dillaha, T.A., R.B. Reneau, S. Mostaghimi, and D. Lee. 1989. Vegetative filter strips for agricultural nonpoint source pollution control. Transactions of American Society of Agricultural Engineers 32:513-519. (i)

Dorioz, J.M., D. Wang, J. Poulenard, and D. Trévisan. 2006. The effect of grass buffer strips on phosphorus dynamics—a critical review and synthesis as a basis for application in agricultural landscapes in France. Agriculture, Ecosystems and Environment 117:4-21 (i)

Dosskey, M.G. 2001. Toward quantifying water pollution abatement in response to installing buffers on crop land. Environmental Management 28:577-598. (i)

Dosskey, M.G., M.J. Helmers, D.E. Eisenhauer, T.G. Franti, and K.D. Hoagland. 2002. Assessment of concentrated flow through riparian buffers. Journal of Soil and Water Resources Association 57:336-343. (i)

Dosskey, M.G., P. Vidon, N.P. Gurwick, C.J. Allan, T.P. Duval, and R. Lowrance. 2010. The role of riparian vegetation in protecting and improving chemical water quality in streams. Journal of the American Water Resources Association 46:261-277. (i)

Doyle, R.C., D.C. Wolf, and D.F. Bezdicek. 1975. Effectiveness of forest buffer strips in improving the water quality of manure polluted runoff. Pages 299-302 *in* Managing livestock wastes. Proceedings of 3rd international symposium on livestock wastes. Food and Agricultural Organization of the United Nations, Rome. (viii)

Du Laing, G., J. Rinklebe, B. Vandecasteele, E. Meers, and F.M.G. Tack. 2009. Trace metal behavior in estuarine and riverine floodplain soils and sediments: a review. Science of the Total Environment 407:3972-3985. (i)

Ecology (Washington State Department of Ecology). 2007. Mission Creek watershed DDT total maximum daily load: water quality improvement report. Publication number 07-10-046. Olympia, Washington. (viii)

Entry, J.A., R.K. Hubbard, J.E. Thies, and J.J. Fuhrmann. 2000. The influence of vegetation in riparian filterstrips on coliform bacteria: II. Survival in soils. Journal of Environmental Quality 29:1215-1224. (i)

Euliss, K., C. Ho, A.P. Schwab, S. Rock, and M.K. Banks. 2008. Greenhouse and field assessment of phytoremediation for petroleum contaminants in a riparian zone. Bioresource Technology 99:1961-1971. (i)

Fajardo, J.J., J.W. Bauder, and S.D. Cash. 2001. Managing nitrate and bacteria in runoff from livestock confinement areas with vegetative filter strips. Journal of Soil and Water Conservation 56:185-191. (i)

Feng, J.C., D.G. Thompson, and P.E. Reynolds. 1990. Fate of glyphosate in a Canadian Forest Watershed. 1. Aquatic residues and off-target deposit assessment. Journal of Agricultural and Food Chemistry 38:1110-1118. (i)

Fennesy, M.S., and J.K. Cronk. 1997. The effectiveness and restoration potential of riparian ecotones for the management of nonpoint source pollution, particularly nitrate. Critical Reviews in Environmental Science and Technology 27:285-317. (i)

Fisher, R.F., and D. Binkley. 2000. Ecology and management of forest soils. Wiley, New York. (i)

Fischer, R.A., and J.C. Fischenich. 2000. Design recommendations for riparian corridors and vegetative buffer strips. U.S. Army Engineer Research and Development Center, Vicksburg, Mississippi. (viii)

Fleeger, J.W., K.R. Carman, and R.M. Nisbet. 2003. Indirect effects of contaminants in aquatic ecosystems. Science of the Total Environment 317:207-233. (i)

Fox, G.A., D.M. Heeren, R.B. Miller, A.R. Mittelstet, and D.E. Storm. 2011a. Flow and transport experiments for a streambank seep originating from a preferential flow pathway. Journal of Hydrology 403:360-366. (i)

Fox, G.A., E.M. Matlock, J.A. Guzman, D. Sahoo, and K.B. Stunkel. 2011b. *Escherichia coli* load reduction from runoff by vegetative filter strips: a laboratory-scale study. Journal of Environmental Quality 40:980-988. (i)

Fuchs, J.W., G.A. Fox, D.E. Storm, C.J. Penn, and G.O. Brown. 2009. Subsurface transport of phosphorus in riparian floodplains: influence of preferential flow paths. Journal of Environmental Quality 38:473-484. (i)

Garcia-Muñoz, E., F. Guerrero, and G. Parra. 2011. Larval escape behavior in anuran amphibians as a wetland rapid pollution biomarker. Marine and Freshwater Behaviour and Physiology 44:109-123. (i)

Ghosh, M., and S.P. Singh. 2005. A review of phytoremediation of heavy metals and utilization of its byproducts. Applied Ecology and Environmental Research 3:1-18. (i)

Gonod, L.V., F. Martin-Laurent, and C. Chenu. 2006. 2,4-D impact on bacterial communities, and the activity and genetic potential of 2,4-D degrading communities in soil. FEMS Microbiology Ecology 58:529-537. (i)

Gordon, N.D., T.A. McMahon, B.L. Finlayson, C.J. Gippel, and R.J. Nathan. 2004. Stream hydrology: an introduction for ecologists. Wiley, West Sussex, England. (i)

Grathwohl, P. 1990. Influence of organic matter from soils and sediments from various origins on the sorption of some chlorinated aliphatic hydrocarbons: Implications on K_{OC} correlations. Environmental Science & Technology 24:1687-1693. (i)

Groffman, P.M., E.A. Axelrod, J.L. Lemonyon, and W.M. Sullivan. 1991. Dentrification in grass and forest vegetated filter strips. Journal of Environmental Quality 20:671-674. (i)

Gu, C., W. Anderson, and F. Maggi. 2012. Riparian biogeochemical hot moments induced by stream fluctuation. Water Resources Research 48:W09546. (i)

Guan, K., S.E. Thompson, C.J. Harman, N.B. Basu, P.S.C. Rao, M. Sivapalan, A.I. Packman, and P.K. Kalita. 2011. Spatiotemporal scaling of hydrological and agrochemical export dynamics in a tile-drained midwestern watershed. Water Resources Research 47:W00J02. (i)

Guber, A.K., A.M. Yakirevich, A.M. Sadeghi, Y.A. Pachepsky, and D.R. Shelton. 2009. Uncertainty evaluation of coliform bacteria removal from vegetative filter strip under overland flow condition. Journal of Environmental Quality 38:1636-1644. (i)

Haritash, A.K., and C.P. Kaushik. 2001. Biodegradation aspects of polycyclic aromatic hydrocarbons (PAHs): a review. Journal of Hazardous Materials 169:1-15. (i)

Hawes, E., and M. Smith. 2004. Riparian buffer zones: functions and recommended widths. Yale School of Forestry and Environmental Studies, New Haven, Connecticut. (viii)

Hayashi, M., and D.O. Rosenberry. 2002. Effects of ground water exchange on the hydrology and ecology of surface water. Ground Water 40:309–316. (i)

Hayes, M.H.B. 1970. Adsorption of triazine herbicides on soil organic matter, including a short review on soil organic matter chemistry. Residue Reviews 32:137-174. (i)

Hayes, T., K. Haston, M. Tsui, A. Hoang, C. Haeffele, and A. Vonk. 2003. Atrazine-induced hermaphroditism at 0.1 ppb in American Leopard Frogs *Rana pipiens*: laboratory and field evidence. Environmental Health Perspectives 111:568-575. (i)

Hecht, S.A., D.H. Baldwin, C.A. Mebane, T. Hawkes, S.J. Gross, and N.L. Scholz. 2007. An overview of sensory effects on juvenile salmonids exposed to dissolved copper: applying a benchmark concentration approach to evaluate sublethal neurobehavioral toxicity. Tech Memo NMFS-NWFSC-83. National Marine Fisheries Service, Seattle. (viii)

Hedin, L.O., J.C. von Fischer, N.E. Ostrom, B.P. Kennedy, M.G. Brown, and G.P. Robertson. 1998. Thermodynamic constraints on nitrogen transformations and other biogeochemical processes at soil-stream interfaces. Ecology 79:684-703. (i)

Hickey, M.B., and B. Doran. 2004. A review of efficiency of buffer strips for the maintenance and enhancement of riparian ecosystems. Water Quality Research Journal of Canada 39:311-317. (i)

Hoffmann, C.C., C. Kjaergaard, J. Uusi-Kämppä, H.C.B. Hansen, and B. Kronvang. 2009. Phosphorus retention in riparian buffers: review of their efficiency. Journal of Environmental Quality 38:1942-1955. (i)

Hill, A.R. 1996. Nitrate removal in stream riparian zones. Journal of Environmental Quality 25:743-755. (i)

Hruby, T. 2013. Update on wetland buffers: the state of the science, final report. Washington State Department of Ecolgy, Olympia, Washington. (viii)

Hua, J., and R. Relyea. 2014. Chemical cocktails in aquatic systems: pesticide effects on the response and recovery of >20 animal taxa. Environmental Pollution 189(June):18-26. (i)

Huggenberger, P., E. Hoehn, R. Beschta, and W. Woessner. 1998. Abiotic aspects of channels and floodplains in riparian ecology. Freshwater Biology 40:407-425. (i)

Ingersoll, C.G., and R.W. Winner. 1982. Effect on *Daphnia pulex* (De Geer) of daily pulse exposures to copper or cadmium. Environmental Toxicology and Chemistry 1:321-327. (i)

Jarvie, H.P., A.N. Sharpley, B. Spears, A.R. Buda, L. May, and P.J.A. Kleinman. 2013. Water quality remediation faces unprecedented challenges from "legacy phosphorus". Environmental Science & Technology 47:8997–8998. (i)

Jaynes, D.B., and T.M. Isenhart. 2014. Reconnecting tile drainage to riparian buffer hydrology for enhanced nitrate removal. Journal of Environmental Quality 43:631-638. (i)

Jiang, X., J. Morgan, and M.P. Doyle. 2002. Fate of *Escherichia coli* O157:H7 in manure-amended soil. Applied and Environmental Microbiology 68:2605-2609. (i)

Johnson, C.W., and S. Buffler. 2008. Riparian buffer design guidelines for water quality and wildlife habitat functions on agricultural landscapes in the Intermountain West. RMRS-GTR-203. U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado. (viii)

Jones, G.K. 2009. Bioremediation of contaminated riparian zones using mycorrhizal fungi–an exploration of the feasibility of restoration through mycoremediation. Master's thesis. The Evergreen State College, Olympia, Washington. (i)

Kalbus, E., C. Schmidt, J.W. Molson, F. Reinstorf, and M. Schirmer. 2009. Influence of aquifer and streambed heterogeneity on the distribution of groundwater discharge. Hydrology and Earth System Sciences 13:69-77. (i)

Karthikeyan, R., L.C. Davis, L.E. Erickson, K. Al-Khatib, P.A. Kulakow, P.L. Barnes, S.L. Hutchinson, and A.A. Nurzhanova. 2004. Potential for plant-based remediation of pesticide-contaminated soil and water using nontarget plants such as trees, shrubs, and grasses. Critical Reviews in Plant Sciences 23:91-101. (i)

Khan, S.U. 1972. Adsorption of pesticide by humic substances—a review. Environmental Letters 3:1-12. (i)

Kopinke, F.D., A. Georgi, and K. Mackenzie. 2001. Sorption of pyrene to dissolved humic substances and related model polymers. 1. Structure-property correlation. Environmental Science & Technology 35:2536-2542. (i)

Koptsik, G.N. 2014. Problems and prospects concerning the phytoremediation of heavy metal polluted soils: a review. Eurasian Soil Science 47:923-939. (i)

Krutz, L.J., S.A. Senseman, R.M. Zablotowicz, and M.A. Matocha. 2005. Reducing herbicide runoff from agricultural fields with vegetative filter strips: a review. Weed Science 53:353-367. (i)

Kuglerová, L., A. Ågren., R. Jansson, and H. Laudon. 2014. Towards optimizing riparian buffer zones: ecological and biogeochemical implications for forest management. Forest Ecology and Management 334:74-84. (i)

Kümmerer, K. 2009a. Antibiotics in the aquatic environment—a review—Part I. Chemosphere 75:417-434. (i)

Kümmerer, K. 2009b. Antibiotics in the aquatic environment—a review—Part II. Chemosphere 75:435-441. (i)

Lacas, J., M. Voltz, V. Gouy, N. Carluer, and J. Gril. 2005. Using grassed strips to limit pesticide transfer to surface water: a review. Agronomy for Sustainable Development 25:253-266. (i)

Laetz, C.A., D.H. Baldwin, V. Hebert, J.D. Stark, and N.L. Scholz. 2013. Interactive neurobehavioral toxicity of diazinon, malathion, and ethopop to juvenile Coho Salmon. Environmental Science & Technology 47:2925-2931. (i)

Laghlimi, M., B. Baghdad, H. El Hadi, and A. Bouabdli. 2015. Phytoremediation mechanisms of heavy metal contaminated soils: a review. Open Journal of Ecology 5:375-388. (i)

Lamar, R.T., J.W. Evans, and J.A. Glaser. 1993. Solid-phase treatment of a pentachlorophenol-contaminated soil using lignin-degrading fungi. Environmental Science & Technology 27:2566-2571. (i)

Landmeyer, J.E. 2011. Introduction to phytoremediation of contaminated groundwater: historical foundation, hydrologic control, and contaminant remediation. Springer Science& Business Media, New York. (i)

Lee, K.H., T.M. Isenhart, and R.C. Schultz. 2003. Sediment and nutrient removal in an established multi-species riparian buffer. Journal of Soil and Water Conservation 58:1-8. (i)

Lee, P., C. Smith, and S. Boutin. 2004. Quantitative review of riparian buffer width guidelines from Canada and the United States. Journal of Environmental Management 70:165-180. (i)

Leeds, R., L.C. Brown, M.R. Sulc, and L. VanLieshout. 1994. Vegetative filter strips: application, installation and maintenance. Publication number AEX-467-94. Ohio State University Extension, Columbus, Ohio. (viii)

LeFevre, G.H., R.M. Hozalski, and P.J. Novak. 2012. The role of biodegradation in limiting the accumulation of petroleum hydrocarbons in raingarden soils. Water Research 46:6753-6762. (i)

Lewandowski, J., L. Angermann, G., Nutzmann, and J.H. Fleckenstein. 2011. A heat pulse technique for the determination of small-scale flow directions and flow velocities in the streambed of sand-bed streams, Hydrological Processes 25:3244-3255. (i)

Liu, X., X. Zhang, and M. Zhang. 2008. Majors factors influencing the efficacy of vegetated buffers on sediment trapping: a review and analysis. Journal of Environmental Quality 37:1667-1674. (i)

Lortz, H.W., and B.P. McPherson. 1977. Effects of copper and zinc on smoltification of Coho Salmon. EPA-600/3-77-032. U.S. Environmental Protection Agency, Corvallis, Oregon. (i)

Lowrance, R., R. Todd, J. Fail, Jr., O. Hendrickson, Jr., R. Leonard, and L. Asmussen. 1984. Riparian forests as nutrient filters in agricultural watersheds. Bioscience 34:374-377. (i)

Luo, Y.L., W.S. Guo, H.H. Ngo, L.D. Nghiem, F.I. Hai, J. Zhang, S. Liang, and X.C.C. Wang. 2014. A review on the occurrence of micropollutants in the aquatic environment and their fate and removal during wastewater treatment. Science of the Total Environment 473:619-641. (i)

Lyons, J., S.W. Trimble, and L.K. Paine. 2000. Grass versus trees: managing riparian areas to benefit streams of central North America. Journal of the American Water Resources Association 36:919-930. (i)

Mahar, A., W. Ping, L.I. Ronghua, and Z. Zengqiang. 2015. Immobilization of lead and cadmium in contaminated soil using amendments: a review. Pedosphere 25:555-568. (i)

Malanson, G.P. 1993. Riparian landscapes. Cambridge studies in ecology. Cambridge University Press, Cambridge, United Kingdom. (i)

Mann, R.M., R.V. Hyne, C.B. Choung, and S.P. Wilson. 2009. Amphibians and agricultural chemicals: review of the risks in a complex environment. Environmental Pollution 157:2903–2927. (i)

Marco, A., C. Quilchano, and A. Blaustein. 1999. Sensitivity to nitrate and nitrite in pond-breeding amphibians from the Pacific Northwest, USA. Environmental Toxicology and Chemistry 18:2836-2839. (i)

Mayer, P.M., S.K. Reynolds, M.D. McCutchen, and T.J. Canfield. 2006. Riparian buffer width, vegetative cover, and nitrogen removal effectiveness: a review of current science and regulations. EPA/600/R-05/118. U.S. Environmental Protection Agency, Cincinnati, Ohio. (viii)

Mayer, P.M., S.K. Reynolds, M.D. Marshall, D. McCutchen, and T.J. Canfield. 2007. Meta-analysis of nitrogen removal in riparian buffers. Journal of Environmental Quality 36:1172-1180. (i)

McClain, M.E., E.W. Boyer, C.L. Dent, S.E. Gergel, N.B. Grimm, P.M. Groffman, S.C. Hart, J.W. Harvey, C.A. Johnston, and E. Mayorga. 2003. Biogeochemical hot spots and hot moments at the interface of terrestrial and aquatic ecosystems. Ecosystems 6:301-312. (i)

McInnis, M.L., and J. McIver. 2001. Influence of off-stream supplements on stream banks of riparian pastures. Journal of Range Management 54:648-652. (i)

McIntyre, J.K., D.H. Baldwin, D.A. Beauchamp, and N.L. Scholz. 2012. Low level copper exposure increases visibility and vulnerability of juvenile Coho Salmon to Cutthroat Trout predators. Ecological Applications 22:1460-1471. (i)

Menichino, G.T., A.S. Ward, and E.T. Hester. 2014. Macropores as preferential flow paths in meander bends. Hydrological Processes 28:482-495. (i)

Merritt, W.S., R.A. Letcher, and A.J. Jakeman. 2003. A review of erosion and sediment transport models. Environmental Modelling & Software 18:761-799. (i)

Misra, A.K., J.L. Baker, S.K. Mickelson, and H. Shang. 1996. Contributing area and concentration effects on herbicide removal by vegetative buffer strips. Transactions of the American Society of Agricultural Engineers 39:2105-2111. (i)

Mitchell, S.M., J.L. Ullman, A.L. Teel, and R.J. Watts. 2014. pH and temperature effects on the hydrolysis of three - lactam antibiotics: ampicillin, cefalotin and cefoxitin. Science of the Total Environment 466-467:547-555. (i)

Mitchell, S.M., J.L. Ullman, A.L. Teel, and R.J. Watts. 2015. Hydrolysis of amphenicol and macrolide antibiotics: chloramphenicol, florfenicol, spiramycin, and tylosin. Chemosphere 134:504-511. (i)

Moermond, C.T.A., F. Roozen, J.J.G. Zwolsman, and A.A. Koelmans. 2004. Uptake of sediment-bound bioavailable polychlorobiphenyls by Benthivorous Carp (*Cyprinus carpio*). Environmental Science & Technology 38:4503-4509. (i)

Monteiro, S.M., J.M. Mancera, A. Fontainhas-Fernandes, and M. Sousa. 2005. Copper induced alterations of biochemical parameters in the gill and plasma of

Oreochromis niloticus. Comparative Biochemistry and Physiology C—Toxicology & Pharmacology 141:375-383. (i)

Moore, M.T., R. Kröger, and C.R. Jackson. 2011. The role of aquatic ecosystems in the elimination of pollutants. Pages 288-304 ***in*** F. Sánchez-Bayo, P.J. van den Brink, and R.M. Mann, editors. Ecological impacts of toxic chemicals. Bentham Science, Oxford, Mississippi.

Moore, A., N. Lower, I. Mayer, and L. Greenwood. 2007. The impact of a pesticide on migratory activity and olfactory function in Atlantic Salmon (*Salmo salar L.*) smolts. Aquaculture 273:350-359. (i)

Morace, J.L., and S.W. McKenzie. 2002. Fecal-indicator bacteria in the Yakima River Basin, Washington—an examination of 1999 and 2000 synoptic-sampling data and their relation to historic data. Water Resources Investigations Report 02-4054. U.S. Geological Survey, Portland, Oregon. (viii)

Mueller, S.O. 2004. Xenoestrogens: mechanisms of action and detection methods. Analytical and Bioanalytical Chemistry 378:582-597. (i)

Muñoz-Carpena, R., J.E. Parsons, and J.W. Gilliam. 1999. Modeling hydrology ad sediment transport in vegetative filter strips. Journal of Hydrology 214:111-129. (i)

Muscutt, A.D., G.L. Harris, S.W. Bailey, and D.B. Davies. 1993. Buffer zones to improve water-quality—a review of their potential use in UK agriculture. Agriculture Ecosystems & Environment 45:59-77. (i)

Newcombe, C.P., and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. North American Journal of Fisheries Management 11:72-82. (i)

Nimick, D.D., C.H. Gammons, and S.R. Parker. 2011. Diel biogeochemical processes and their effect on the aqueous chemistry of streams: a review. Chemical Geology 283:3-17. (i)

Norris, V. 1993. The use of buffer zones to protect water quality: a review. Water Resources Management 7:257-272. (i)

NRC (National Research Council). 2002. Riparian areas: functions and strategies for management. National Academy Press, Washington, D.C. (i)

Osborne, L.L., and D.A. Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. Freshwater Biology 29:243-258. (i)

Peterjohn, W.T., and D.L. Correll. 1984. Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest. Ecology 65:1466-1475. (i)

Peverill, K.I., L.A. Douglas, and N.B. Greenhill. 1977. Leaching losses of applied P and S from undisturbed cores of some Australian surface soils. Geoderma 19:91-96. (i)

Pilon-Smits, E. 2005. Phytoremediation. Annual Review of Plant Biology 56:15-39. (i)

Pinto, E., T.C.S. Sigaud-Kutner, M.A.S. Leitão, O.O. Okamoto, D. Morse, and P. Colepicolo. 2003. Heavy metal-induced oxidative stress in algae. Journal of Phycology 39:1008-1018. (i)

Polyakov, V., A. Fares, and M.H. Ryder. 2005. Precision riparian buffers for the control of nonpoint source pollutant loading into surface water: a review. Environmental Reviews 13:129-144. (i)

PSAT (Puget Sound Action Team). 2007. 2007 Puget Sound update: ninth report of the Puget Sound Ambient Monitoring Program. Puget Sound Action Team, Olympia, Washington. (viii)

Pulford, I.D., and C. Watson. 2003. Phytoremediation of heavy metal-contaminated land by trees—a review. Environment International 29:529-540. (i)

Rahman, F., K.H. Langford, M.D. Scrimshaw, and J.N. Lester. 2001. Polybrominated diphenyl ether (PBDE) flame retardants. Science of the Total Environment 275:1-17. (i)

RCT (R Core Team). 2013. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. (viii)

Redding, J.M., C.B. Schreck, and F.H. Everest. 1987. Physiological effects on Coho Salmon and steelhead

of exposure to suspended solids. Transactions of the American Fisheries Society 116:737-744. (i)

Redick, M.S., and T.W. La Point. 2004. Effects of sublethal copper exposure on behavior and growth of *Rana pipiens* tadpoles. Bulletin of Environmental Contamination and Toxicology 72:706-710. (i)

Reichenberger, S., M. Bach, A. Skitschak, and H. Frede. 2007. Mitigation strategies to reduce pesticide inputs into ground- and surface water and their effectiveness; a review. Science of the Total Environment 384:1-35. (i)

Relyea, R.A., and N. Diecks. 2008. An unforeseen chain of events: lethal effects of pesticides on frogs at sublethal concentrations. Ecological Applications 18:1728-1742. (i)

Reuter, J.H., and E.M. Perdue. 1977. Importance of heavy metal-organic matter interactions in natural waters. Geochimica et Cosmochimica Acta 41:325-334. (i)

Rinklebe, J., and S.M. Shaheen. 2015. Miscellaneous additives can enhance plant uptake and affect geochemical fractions of copper in a heavily polluted riparian grassland soil. Ecotoxicology and Environmental Safety 119:58-65. (i)

Rougier, F., D. Troutaud, A. Ndoye, and P. Deschaux. 1994. Nonspecific immune-response of Zebrafish, *Brachydanio rerio* (Hamilton-Buchanan) following copper and zinc exposure. Fish & Shellfish Immunology 4:115-127. (i)

Salt, D.E., R.D. Smith, and I. Raskin. 1998. Phytoremediation. Annual Review of Plant Physiology and Plant Molecular Biology 49:643-668. (i)

Sandahl J.F., D.H. Baldwin, J.J. Jenkins, and N.L. Scholz. 2007. A sensory system at the interface between urban stormwater runoff and salmon survival. Environmental Science & Technology 41:2998-3004. (i)

Sarma, H. 2011. Metal hyperaccumulation in plants: a review focusing on phytoremediation technology. Journal of Environmental Science and Technology 4:118-138. (i)

Schellinger, G.R., and J.C. Clausen. 1992. Vegetative filter treatment of dairy barnyard runoff in cold regions. Journal of Environmental Quality 21:40-45. (i)

Schnaebel, R.R., J.A. Shaffer, W.L. Stout, and L.F. Cornish. 1997. Denitrification distributions in four valley and ridge riparian ecosystems. Environmental Management 21:283-290. (i)

Schultz, R.C., J.P. Colletti, T.M. Isenhart, C.O. Marquez, W.W. Simpkins, and C.J. Ball. 2000. Riparian forest buffer practices. Pages 189-281 *in* H.E. Garett, W.J. Rietveld, and R.F. Fisher, editors. North American agroforestry: an integrated science and practice. American Society of Agronomy, Madison, Wisconsin. (viii)

Schuster, S., and M.E. Grismer. 2004. Evaluation of water quality projects in the Lake Tahoe Basin. Environmental Monitoring and Assessment 90:225-242. (i)

Scoggins, M., N.L. McClintock, L. Gosselink, and P. Bryer. 2007. Occurrence of polycyclic aromatic hydrocarbons below coat-tar-sealed parking lots and effects on stream benthic macroinvertebrate communities. Journal of the North American Benthological Society 26:694-707. (i)

Sen, T.K., and K.C. Khilar. 2006. Review on subsurface colloids and colloid-associated contaminant transport in saturated porous media. Advances in Colloid and Interface Science 119:71-96. (i)

Sheridan, J.M., R. Lowrance, and D.D. Bosch. 1999. Management effects on runoff and sediment transport in riparian forest buffers. Transactions of the American Society of Agricultural Engineers 42:55-64. (i)

Skłodowski, M., E. Kiedrzynska, M. Kiedrzynski, M. Urbaniak, K.M. Zielinska, J.K. Kurowski, and M. Zalewski. 2014. The role of riparian willows in phosphorus accumulation and PCB control for lotic water quality improvement. Ecological Engineering 70:1-10. (i)

Sorensen, E.M. 1991. Metal poisoning in fish. CRC Press, Boca Raton, Florida. (i)

Sprague, J.B., and A. Ramsay. 1965. Lethal levels of mixed copper-zinc solutions for juvenile salmon. Journal of the Fisheries Research Board of Canada 22:425-432. (i)

Spromberg, J.A., D.H. Baldwin, S.E. Damm, J.K. McIntyre, M. Huff, C.A. Sloan, B.F. Anulacion, J.W. Davis, and N.L. Scholz. 2016. Coho Salmon spawner mortality in western US urban watersheds: bioinfiltration prevents lethal storm water impacts. Journal of Applied Ecology 53:398–407. (i)

Straffelini, G., R. Ciudin, A. Ciotti, and S. Gialanella. 2015. Present knowledge and perspectives on the role of copper in brake materials and related environmental issues: a critical assessment. Environmental Pollution 207:211-219. (i)

Susarla, S., V.F. Medina, and S.C. McCutcheon. 2002. Phytoremediation: an ecological solution to organic chemical contamination. Ecological Engineering 18:647-658. (i)

Sweeney B.W., T.L. Bott, J.K. Jackson, L.A. Kaplan, J.D. Newbold, L.J. Standley, W.C. Hession, and R.J. Horwitz. 2004. Riparian deforestation, stream narrowing, and loss of stream ecosystem services. Proceedings of the National Academy of Science 101:14132-14137. (i)

Sweeney, B.W., and J.D. Newbold. 2014. Streamside buffer width needed to protect stream water quality, habitat, and organisms: a literature review. Journal of the American Water Resources Association 50:560-584. (i)

Syversen, N., L. Oygarden, and B. Salbu. 2001. Cesium-134 as a tracer to study particle transport processes within a small catchment with a buffer zone. Journal of Environmental Quality 30:1771-1783. (i)

Tabacchi, E., L. Lambs, H. Guilloy, A. Planty-Tabacchi, E. Muller, and H. Décamps. 2000. Impacts of riparian vegetation on hydrological processes. Hydrological Processes 14:2959-2976. (i)

Tate, K.W., E.R. Atwill, J.W. Bartolome and G. Nader. 2006. Significant *Escherichia coli* attenuation by vegetative buffers on annual grasslands. Journal of Environmental Quality 35:795-805. (i)

Tobiason, S.A., C. Nickerson, R. Zisette, and M. Samadpour. 2002. Stormwater bacteria source tracing at Seattle-Tacoma International Airport. Proceedings of the Water Environment Federation's technical exhibition and conference. Water Environment Federation, Alexandria, Virginia. (viii)

Trimble, G.R., and R.S. Sartz. 1957. How far from a stream should a logging road be located? Journal of Forestry 55:339-341. (i)

Ucar, T., and F.R. Hall. 2001. Windbreaks as a pesticide drift mitigation strategy: a review. Pest Management Science 57:663-675. (i)

UKEA (United Kingdom Environmental Agency). 2009. The hyporheic handbook: a handbook on the groundwater–surface water interface and hyporheic zone for environment managers. Science report SC050070. Integrated Catchment Science Programme, Bristol, United Kingdom. (viii)

Unc, A., and M.J. Goss. 2004. Transport of bacteria from manure and protection of water resources. Applied Soil Ecology 25:1-18. (i)

NRCS (National Resources Conservation Service). 2000. Conservation buffers to reduce pesticide losses. Washington, D.C. (i)

USEPA (U.S. Environmental Protection Agency). 1980. Ambient water quality criteria for copper. EPA 440/5-80-036. Washington D.C. (viii)

USEPA (U.S. Environmental Protection Agency). 2003. Evaluation of sediment transport models and comparative application of two watershed models. EPA/600/R-03/139. Cincinnati, Ohio. (viii)

USEPA (U.S. Environmental Protection Agency). 2015. Washington causes of impairment for 303(d) listed waters. Available: http://iaspub.epa.gov/tmdl_waters10/attains_state.control?p_state=WA#causes/. (January 2019). (viii)

USGS (U.S. Geological Survey). 2006. Pesticides in the nation's streams and ground water 1992-2001 – a summary. Fact Sheet 2006-3028. Sacramento, California . (i)

Vervoort, R.W., D.E. Radcliffe, and L.T. West. 1999. Soil structure development and preferential solute flow. Water Resources Research 35:913-928. (i)

Vidon, P., C. Allan, D. Burns, T.P. Duval, N. Gurwick, S. Inamdar, R. Lowrance, J. Okay, D. Scott, and S. Sebestven. 2010. Hot spots and hot moments in riparian zones: potential for improved water quality management. Journal of the American Water Resources Association 46:278-298. (i)

Vidon, P., and P.E. Cuadra. 2011. Phosphorus dynamics in tile-drain flow during storms in the US Midwest. Agricultural Water Management 98:532-540. (i)

Vogt, T., M. Schirmer, and O.A. Cirpka. 2012. Investigating riparian groundwater flow close to a losing river using diurnal temperature oscillations at high vertical resolution. Hydrology and Earth System Sciences 16:473-487. (i)

Vought, L.B.-M., J. Dahl, C.L. Pedersen, and J.O. Lacoursière. 1994. Nutrient retention in riparian ecotones. Ambio 23:343-348. (i)

Vought. L.B.-M., G. Pinay, A. Fuglsang, and C. Ruffinoni. 1995. Structure and function of buffer strips from a water quality perspective in agricultural landscapes. Landscape and Urban Planning 31:323-331. (i)

Walker, S.E., S. Mostaghimi, T.A. Dillaha, and F.E. Woeste. 1990. Modeling animal waste management practices–impacts on bacteria levels in runoff from agricultural lands. Transactions of the American Society of Agricultural Engineers 33:807-817. (i)

Wang, Z., Z. Wang, and Y. Pei. 2014. Nitrogen removal and microbial communities in a three-stage system simulating a riparian environment. Bioprocess and Biosystem Engineering 37:1105-1114. (i)

Waters, T.F. 1995. Sediment in streams: sources, biological effects and control. American Fisheries Society Monograph 7. American Fisheries Society, Bethesda, Maryland. (i)

Welsch, D.J. 1991. Riparian forest buffers: function and design for protection and enhancement of water resources. NA-PR-07-91. U.S. Forest Service, Radnor, Pennsylvania. (viii)

Welsh, H.H., and L.M. Ollivier. 1998. Stream amphibians as indicators of ecosystem stress: A case study from California's Redwoods. Ecological Applications 8:1118-1132. (i)

Wilhere, G.F., and T. Quinn. 2018. How wide is wide enough?: values, science, and law in riparian habitat conservation. Natural Resources Journal 58:279-318. (i)

Williams, D.G., and R. Scott. 2009. Vegetation-hydrology interactions: dynamics of riparian plant water use. Pages 37-56 *in* J. Stromberg and B. Tellman, editors. Ecology and conservation of the San Pedro River. University of Arizona Press, Tucson, Arizona. (i)

Wroblicky, G.J., M.E. Campana, H.M. Valett, and C.N. Dahm. 1998. Seasonal variation in surface-subsurface water exchange and lateral hyporheic area of two stream-aquifer systems. Water Resources Research 34:317-328. (i)

Young, R.A., T. Huntrods, and W. Anderson. 1980. Effectiveness of vegetated buffer strips in controlling pollution from feedlot runoff. Journal of Environmental Quality 9:483-487. (i)

Yuan, Y., R.L. Bingner, and M.A. Locke. 2009. A review of effectiveness of vegetative buffers on sediment trapping in agricultural areas. Ecohydrology 2:321-336. (i)

Zhang, Z. 2014. Nonpoint source and water quality monitoring. Pages 261-299 *in* S. Eslamian, editor. Handbook of engineering hydrology: environmental hydrology and water management. CRC Press, Boca Raton, Florida. (i)

Zhang, M., B. Gao, J. Fang, A.E. Creamer, and J.L. Ullman. 2014. Self-assembly of needle-like layered double hydroxide (LDH) nanocrystals on hydrochar: characterization and phosphate removal ability. RSC Advances 4:28171-28175. (i)

Zhang, X., X. Liu, M. Zhang, and R.A. Dahlgren. 2010. A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution. Journal of Environmental Quality 39:76-84. (i)

Zhongmin, J., C. Hua, W. Hong, and L. Changxiao. 2012. Photosynthetic responses of the riparian Salix variegate to cadmium stress in Three Gorges Reservoir region. Scientia Silvae Sinicae 48:152-158. (i)



Okanogan National Forest/Scott Fitkin, WDFW

Chapter 6. Nutrient Dynamics in Riparian Ecosystems

By: Paul M. Mayer, Jana E. Compton, and George F. Wilhere

6.1. Introduction

Riparian ecosystems play a vital role in the dynamics of nutrients within watersheds, especially for the three primary macronutrients carbon (C), nitrogen (N), and phosphorus (P). Because they are positioned at the interface between the stream and upland areas, riparian ecosystems mediate the movement of materials and energy between land and water. Riparian areas can be sources or sinks of energy, water, nutrients, organic matter, and organisms within a watershed. Organic matter from riparian areas, an important source of energy and nutrients, makes its way into streams via plant litterfall, or through transport by water, wind, or animals. Organic matter in streams provides habitat and food for microbes, insects, fish, amphibians, birds, and other organisms, and decomposes to release plant-available inorganic nutrients like ammonium, nitrate, and phosphate. Riparian areas also store energy and nutrients from organic matter coming from upland and instream sources through biotic uptake, sorption and exchange, and slowing or trapping particles. Riparian areas also are sites with high rates of nutrient transformation, including conversion of inorganic nitrogen into the gases N_2 or N_20 via denitrification. Riparian ecosystems are influenced by upland activities that supply nutrients that follow flow paths through these ecosystems, eventually reaching streams via surface and subsurface flows. Age, vegetation composition, topography, soil type, and condition of the riparian ecosystem all factor into the fate and transport of nutrients. In addition, the position in the drainage network and connectivity of the riparian area, along with disturbance and management history, affect nutrient processing rates.

Nutrients and the hydrological and biogeochemical processes that dictate their transport and fate are the subject of much current research in riparian ecology (Mayer et al. 2010a, 2014) because of their critical importance for growth and maintenance of life in the riparian ecosystem and the subsequent effects on stream biota and water quality. Although many micro- and macro-nutrients cycle through riparian areas, this chapter addresses only the three primary macronutrients C, N, and P.

Streams in the Pacific Coastal Ecoregion of Washington State are generally oligotrophic, well shaded, and sensitive to nutrient enrichment (Welch et al. 1998). When more N and P enters a riparian ecosystem than can be immediately utilized or stored, degradation of aquatic habitat conditions can occur and negative consequences within or beyond the riparian ecosystem may result. Excess N and P input to streams and estuaries may lead to harmful algal blooms, hypoxia, fish kills, and contamination of drinking water supplies. Although stream nutrient concerns have a somewhat lower profile in the Pacific Northwest (PNW) relative to other areas of the US, such as the Chesapeake Bay or Great Lakes watersheds, approximately 20% of assessed rivers and 8% of assessed lakes in Washington are regarded by the state as having impaired conditions related to an overabundance of nutrients (USEPA ATTAINS database).

Here, we describe nutrient cycles in riparian areas in the PNW, focusing on C, N, and P from natural and anthropogenic sources. Other nutrients, such as calcium, sulfur, or molybdenum, are not as widely studied but have been shown to be important in areas of the PNW for forest growth or other ecosystem processes (Silvester 1989; Chappell et al. 1991; Perakis et al. 2006). When possible, we discuss implications of common land management activities on nutrient dynamics by contrasting disturbed versus undisturbed riparian ecosystems. We also discuss new information gained from recent stable isotope studies and meta-analyses of riparian nutrient removal that have greatly improved our understanding of the permanence and effectiveness of nutrient removal processes in PNW riparian ecosystems.

6.1.1. Nutrient Dynamics in the Pacific Northwest

Figure 6.1 illustrates processes occurring in a largely undisturbed PNW forested riparian ecosystem and associated stream and upland. Water traveling through the riparian area (surface and subsurface flow) is the main transport mechanism for dissolved C, N, and P. These nutrients can be taken up directly by primary producers and decomposers, passively transported to groundwater or the hyporheic zone, or carried to surface waters via subsurface, overland, or channelized flow. The hydrologic regime dictates the timing and magnitude of nutrient movement into aquatic systems, and can create instream pulses of C, N, and P both in particulate and dissolved form (Kaushal et al. 2010).

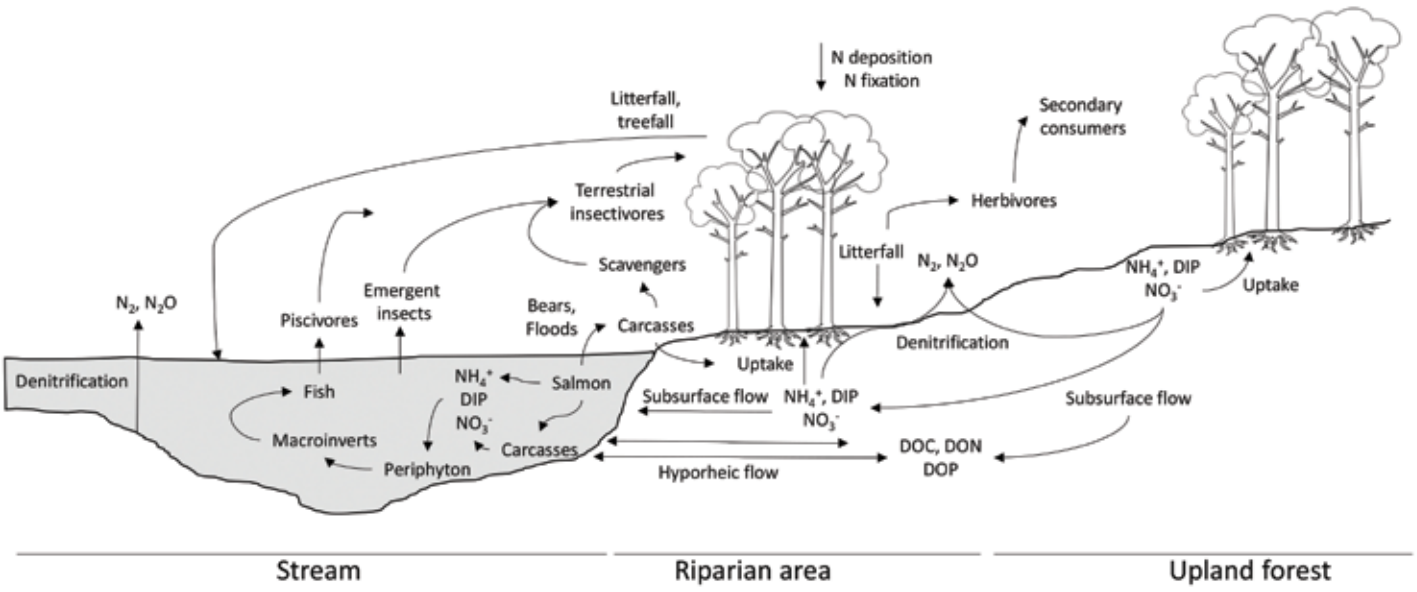


Figure 6.1. Nutrient cycle of an undisturbed PNW forested riparian ecosystem and connected stream and upland forest. Modified from Moyle et al. (2009). DIP = dissolved inorganic phosphorus; DOC, DON, DOP = dissolved organic carbon, nitrogen and phosphorus, respectively.



Most streams in the Pacific Northwest are nutrient-poor ecosystems/Ned Pittman, WDFW

Soil compaction and impervious surfaces typically reduce retention capacity of nutrients in space and time by preventing infiltration and thereby limit the interaction of nutrients with soils, roots, and soil biota. Riparian ecosystems exhibit a continuum of physical characteristics which have implications for nutrient dynamics. Riparian ecosystems along low-order streams, for example, are often narrower and steeper than those along mainstem rivers with wide, level floodplains. Consequently, surface and subsurface hydrological regimes controlling biogeochemical processes in riparian areas also differ along a continuum. Along small, steep forested streams, the water table is usually low and aerobic processes dominate, whereas level areas adjacent to larger rivers may provide water table conditions favoring anaerobic processes that reduce N via denitrification, a microbial transformation of dissolved nitrate N to gaseous molecular N (Burt et al. 2002; Hefting et al. 2004). The hyporheic zone is an area beneath the stream and riparian area where surface water and ground water continually interact. This zone can have a large influence on chemical characteristics of the surface water and, therefore, plays a role in determining biological attributes of streams (Wondzell et al. 2011).

As nutrient molecules move downstream, they may be taken up by algae and microbes living on rocks and wood in the channel in slick mats called biofilms (Cardinale et al. 2002). The polysaccharide layers of biofilms are sites of active nutrient turnover where microscopic algae, fungi, and bacteria consume N and P, die and release nutrients that then move further downstream. Microbial communities may be consumed by grazers such as larval aquatic insects or snails, which in turn may be consumed by larger predators such as fishes or birds. As prey and predators are consumed or die, they release nutrients to the aquatic and terrestrial environments through decay and in this way C, N, and P cycle in a process of uptake and release called nutrient spiraling (Newbold et al. 1982). The distance a molecule moves downstream during a complete cycle is its spiraling length, a metric that explicitly relates nutrient utilization to nutrient supply (Newbold et al. 1982). Long spiraling lengths indicate that: 1) nutrient uptake is inefficient because the system is saturated with nutrients and organisms

can no longer fully exploit the incoming nutrient loads, 2) conditions are not optimal for uptake, such as when water flow is too fast, or 3) the stream does not support a community of organisms that effectively processes the nutrients.

In anthropogenically undisturbed Pacific Northwest watersheds, nutrients are ultimately derived from atmospheric and geologic sources, while plants play an important role in the initial uptake of N and P from these sources (McClain et al. 1998). Spatial variation in vegetation, geologic substrates, and human activities drive the variation in stream N and P concentrations and fluxes across the PNW (Wigington et al. 1998; Wise and Johnson 2011). The geology and geomorphology of a watershed and stream channel set the conditions for mineral composition of the groundwater reaching the stream because the shape and slope of the channel and banks affect water movement and velocity. Some bedrock types yield high stream P (Ice and Binkley 2003), leading to high regional P variability in riparian ecosystems and streams. Some types of vegetation can fix atmospheric gaseous N via symbiotic relationships with bacteria in their root systems, and in turn produce more biologically available N than they consume, thereby contributing to N loads in watersheds. A prime example is N_2-fixing Red Alder *Alnus rubra*, an important source of dissolved N in streams in western Oregon and Washington (Compton et al. 2003; Wise and Johnson 2011; Greathouse et al. 2014).

Nitrogen may occur in organic forms as microbial, plant, or animal tissue and in dissolved organic forms, or, if inorganic, primarily as nitrate ($N0_3^-$) and ammonium (NH_3^+), which are forms that can be assimilated by organisms into organic molecules. Forests in the PNW generally have fairly tight N and P cycles with little N or P lost or leached from the system. Rather, there are low rates of N and P inputs and outputs, but high rates of internal cycling (Sollins et al. 1980; Compton and Cole 1998). Triska et al. (1984) showed that N inputs to a stream reach in an old-growth forest watershed in Oregon's Cascade Mountains were dominated by dissolved organic N from groundwater (69% of inputs), with litterfall and precipitation playing smaller roles.

Human activities like timber harvest, farming, or urban development alter nutrient cycles (Figure 6.2), producing higher fluxes, shorter storage durations, and higher concentrations of nutrients in subsurface flow, some of which will enter streams. Disturbances through forestry, grazing, agriculture or urbanization can alter the timing and routing of water through a landscape (Tague and Grant 2004), which can influence nutrient uptake and delivery to streams. Agriculture can contribute to excess nutrients in riparian and aquatic ecosystems through increased runoff of N and P from fertilizer and livestock manure (Wise and Johnson 2011). Point sources and urban stormwater runoff are the dominant sources of N within urban areas. For P, geologic materials dominate natural sources, with point sources such as urban runoff, farm manure, and fertilizer important in areas under anthropogenic land uses. Timber harvest increases stream nitrate and to a lesser extent phosphate concentration (Fredricksen et al. 1975; Scrivener 1975; Martin and Harr 1989). These increases generally persist for a short time, although Brown et al. (1973) saw increases in nitrate persist for six years post-timber harvest and burning.

Historically, a major source of allochthonous[1] nutrients and energy-rich carbon compounds was anadromous salmon (Cederholm et al. 1999; Gende et al. 2002). Anadromous, semelparous fish return from the ocean to spawn and die in their natal streams. The mass of every salmon carcass, of which 95% is accumulated in the marine environment (Naiman et al. 2002), is deposited in oligotrophic freshwater environments. The magnitude of nutrient and chemical energy losses to freshwater ecosystems caused by declines in salmon populations can best be appreciated by comparing current and historical salmon run sizes. Gresh et al. (2000)

1 Allochthonous means originating or formed in a place other than where found. Hence, in the context of aquatic ecosystems, allochthonous nutrients found in a stream originated in terrestrial ecosystems. In contrast, autochthonous means originating or formed in the place where found.



Historically, carcasses of adult salmon delivered approximately 100,000 tons of nutrients to rivers and streams of Washington/Ned Pittman, WDFW

estimated that the current biomass of salmon runs for all Pacific salmon species (Chinook *Oncorhynchus tshawytscha,* Coho *Oncorhynchus kisutch,* Sockeye *Oncorhynchus nerka,* Chum *Oncorhynchus keta,* and Pink *Oncorhynchus gorbuscha*) in Puget Sound, the Washington Coast, and the Columbia River Basin are 25, 5, and 1% of historical biomass (circa early 1900s), respectively. This represents a loss of 122,470 US tons per year (111,104 metric tons) of marine-derived nutrients and chemical-energy in these watersheds. Naiman et al. (2002) estimated that in the Willapa Bay Watershed the biomass of Chinook, Coho, and Chum Salmon carcasses in streams decreased from 2,920 to 226 US tons (2,649 to 205 metric tons per year), and that marine derived N and P decreased by more than 90%.

Figure 6.2 represents nutrient cycling in a watershed with more human-associated disturbance, including an

absence of salmon returns; by comparing Figures 6.1 and 6.2, changes in the cycling loop and intra-system transfers are evident when salmon are missing. Much of the cycling of marine-derived nutrients is mediated by predators and scavengers that move large amounts of marine-derived nutrients substantial distances into the terrestrial environment either as salmon carcasses or as metabolic waste products, i.e., urine and feces (Naiman et al. 2002). In several small streams on the Olympic Peninsula, Cederholm et al. (1989) observed that Coho Salmon carcasses were consumed by 22 species of mammals and fish (e.g., American Black Bear *Ursus americanus,* Northern River Otter *Lontra canadensis,* Mink *Mustela vison,* Bald Eagles *Haliaeetus leucocephalus,* and Ravens *Corvus corax*), and that 40% of salmon carcasses were moved by scavengers from the water to riparian areas. Flooding also can deposit salmon carcasses in riparian areas (Ben-David et al. 1998). Salmon carcasses provide N and P nutrients for microbes, plants, and animals, and influence all trophic levels in riparian ecosystems (Willson and Halupka 1995; Compton et al. 2006). Trees and shrubs in riparian areas along spawning sites in the Kadashan and Indian rivers of southeast Alaska derived approximately 23% of their foliar nitrogen from decayed salmon carcasses, and growth rates of Sitka Spruce *Picea sitchensis* were significantly increased (Helfield and Naiman 2001). On average, 17% of the nitrogen incorporated into the riparian vegetation of a stream in western Washington was derived from carcasses of spawning salmon, and significant percentages of marine-derived N (up to 30%) and C (up to 39%) were found in aquatic insects, Cutthroat Trout *Oncorhynchus clarkii*, and juvenile salmon (Bilby et al. 1996).

Other animals subsidize riverine food webs by transporting nutrients across watersheds or by altering the hydrology (Chapter 8 in this document; Naiman and Rogers 1997; Masese et al. 2015). As ecosystem engineers, American Beaver *Castor canadensis* have a significant influence on stream nutrients. Beaver can influence biogeochemical cycles by impounding streams and changing hydrologic regimes and organic matter and sediment transport (Pollock et al. 2007).

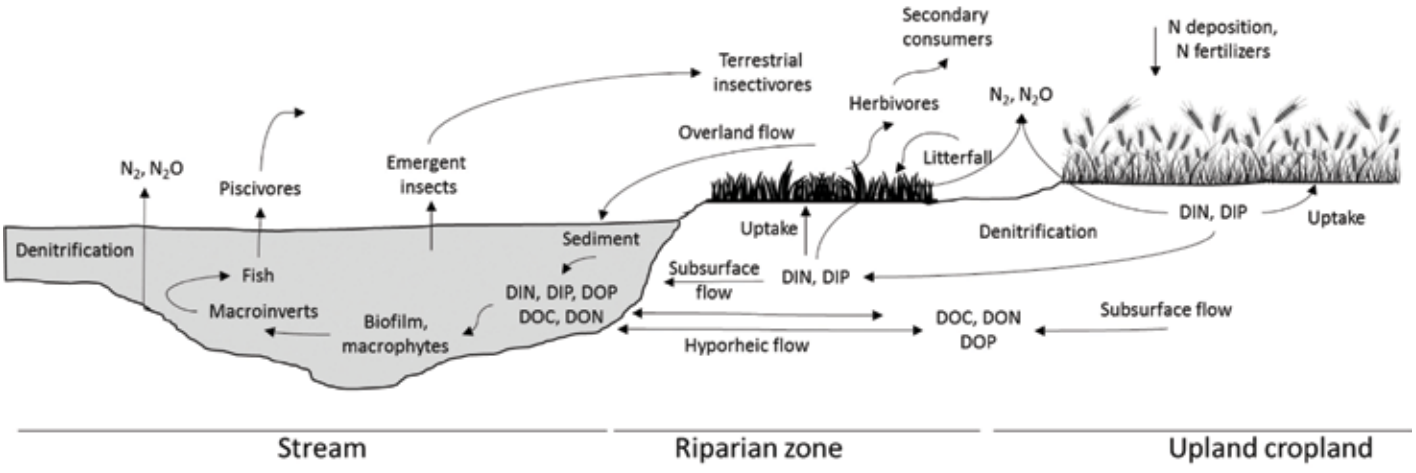


Figure 6.2. Nutrient cycle of a disturbed PNW riparian ecosystem and connected stream and upland cropland. Much of the cycling of marine-derived nutrients is facilitated by predators and scavengers that move nutrients into the terrestrial environment either as salmon carcasses or as urine and feces. Modified from Moyle et al. (2009). DIP = dissolved inorganic phosphorus; DIN = dissolved inorganic nitrogen (nitrate and ammonium); DOC, DON, DOP = dissolved organic carbon, nitrogen and phosphorus, respectively.

Retention of total N and P increased 72% and 43%, respectively after Beaver populations recovered in a Minnesota watershed (Naiman et al. 1994) and organic matter (carbon) retention increased three-fold after a stream was impounded by Beaver (Naiman et al. 1988). However, Beaver impoundments also influence N dynamics by flooding riparian forests, creating anoxic conditions in forest soils leading to an increase in denitrification and subsequent reduction in N (Naiman et al. 1988). Elk *Cervus canadensis*, deer (*Odocoileus* spp.), and livestock can also be important sources of N and P when found in close proximity to streams.

Riparian vegetation can affect uptake and delivery of nutrients to streams. Riparian plant roots can slow water movement and stabilize soils as well as take up dissolved nutrients. The types of vegetation and growth patterns in riparian areas determine the amount and timing of litterfall and woody material delivery to a stream. The height and density of vegetation dictate shading and solar input to the stream, thus affecting conditions for plant growth and N and P uptake. The key limiting nutrients for primary production in PNW streams are N and P (Welch et al. 1998), but there has not been enough experimental work conducted across the region to determine precisely when and where this occurs.

Shallow groundwater adjacent to stream channels often is a hot spot for N removal processes and a storage zone for other solutes.

6.1.2. Carbon

The cycling of C in riparian and aquatic ecosystems is complex and can differ among locations and through time because C can be available in different forms and is produced by different sources, thereby affecting its transport and fate. Carbon is tightly linked to N and P, driving biological transformations of these nutrients. Organic C regulates ecosystem functions in streams and rivers because dissolved organic carbon (DOC) is a primary energy source for microorganisms. Riparian vegetation in forests influences DOC composition and contributes a substantial proportion of stream organic C budgets (McDowell and Likens 1988). DOC in streams is a mixture of recalcitrant, (i.e., difficult to process components) and more easily metabolized labile fractions that drive biogeochemical processes involving nitrogen (Kaushal and Lewis 2005). For example, availability of dissolved and particulate organic C can limit denitrification, a microbial process critical to maintaining water quality, which has important implications for managing N in streams (Newcomer et al. 2012). Denitrification occurs only under anaerobic conditions where microbes shift from respiring oxygen to respiring nitrate, releasing nitrous oxide, and inert N_2 gas. These conditions may be ephemeral, fluctuating in response to water tables and associated changes in redox potential (Mayer et al. 2010b).

Anoxic conditions also promote the production of methane. Production of methane and nitrous oxides, increase in riparian areas with increased organic C supply (Kaushal et al. 2014). Dissolved organic carbon also can increase biological oxygen demand, thereby reducing oxygen for fish (Stanley et al. 2012).

Various organic C types from biofilm, leaves, and soil organic matter may have differential effects on ecosystem functions in forested streams (McDowell and Likens 1988), agricultural streams (Royer and David 2005), and urban streams. For example, C derived from

grasses supports more denitrification than C from tree leaves (Newcomer et al. 2012). Because the microbes that influence the transport and fate of N in riparian ecosystems require C as an energy source, C and N are inextricably linked in a biogeochemical sense.

Shading of small headwater streams in forested watersheds can obscure 95% of sunlight (Murphy 1998); hence, in-stream productivity is typically light-limited. Consequently, the main energy source for such streams is allochthonous chemical energy contained in litter from riparian areas (Conners and Naiman 1984; Bisson and Bilby 1998). In headwater streams, litter directly supports an animal community compromised predominantly of invertebrate detrivores which, in turn, support a community of invertebrate predators (Wallace et al. 1997). Detrivores, microbes, and physical breakup convert the coarse particulate organic material (CPOM) of litter to fine particulate organic material (FPOM) which is utilized by invertebrate communities downstream (Bisson and Bilby 1998; Richardson and Danehy 2007). Headwaters comprise 60 to 80% of the cumulative length of a watershed's drainage network (Benda et al. 2005); hence, headwaters contribute a substantial amount of chemical energy to mainstem rivers and associated biota. For example, Wipfli (2005) estimated that every kilometer of fish-bearing stream received enough energy from headwaters to support 100 to 2,000 young-of the-year salmonids.

Carbon cycles through riparian ecosystems via CO_2 uptake from the atmosphere through photosynthesis, litterfall, decomposition and/or consumption. Riparian litter is a critically important source of C for streams as energy for invertebrates and microbes that form the basis of food webs. Deciduous-dominated riparian forests grow quickly and initially deliver more litter to streams and have a more pronounced seasonal litter contribution than coniferous-dominated forests (Hart et al. 2013). Conifers, however, play an important structural role as large wood in streams. Deciduous species like Red Alder can increase fine litter flux and



The main energy source for small headwater streams is allochthonous chemical energy provided by leaf litter/Marc Hayes, WDFW

nutrient delivery to terrestrial and aquatic food webs, thus complementing the year-round shade and wood provided by conifers (Hart et al. 2013).

Chemical energy, required by heterotrophic organisms (those that do not produce their own food from sunlight), is contained within the various C compounds of organic matter. The fundamental effects of organic matter on ecosystem composition, structure, and functions have motivated conceptual theories to describe riverine ecosystems (Pingram et al. 2012). The River Continuum Concept (RCC; Vannote et al. 1980) describes the balance of allochthonous C (produced externally to the stream) to autochthonous C (produced in-stream) in riverine ecosystems from headwaters to mainstem rivers. This balance plays a key role in structuring the invertebrate community. According

to RCC, in narrow headwater streams (first to third order), nearly all C is allochthonous produced by litter from riparian vegetation because shade severely limits the production of autochthonous C produced through in-stream photosynthesis. Because medium-sized streams (fourth to sixth order) are wider, shading decreases, in-stream photosynthesis increases, and the density of litter inputs decreases. Hence, the quantities of allochthonous and autochthonous C may be about equal. In large rivers (≥ seventh order), shading effects only a small portion of surface water, however, turbidity and water depth limit photosynthetic production. Consequently, according to RCC, the main source of energy in large rivers is allochthonous C from upstream. The RCC also posits that the quantity and quality of organic matter, which changes along the river continuum, affects the composition of the aquatic invertebrate community.

Litter from riparian areas is clearly an important source of limiting nutrients and organic matter for aquatic ecosystems. Consequently, providing adequate amounts of litter to streams is an important issue for riparian area management and addressing this issue requires an understanding of litter delivery into streams. FEMAT (1993:V-26) developed a conceptual model, known as the FEMAT curves, that depicts relationships between riparian ecological functions, including litterfall, and distance from a stream channel. Bilby and Heffner (2016) studied factors influencing litter delivery into streams in young and mature conifer forests of the western Washington Cascades and found that litter travel increased with increasing tree height, topographic slope, and wind speed. They estimated that riparian buffer widths needed to capture 95% of annual litter input from mature conifer forests to streams are between 60 to 83 ft (18 to 25 m) depending on a site's slope and wind exposure. The mean tree height of their three mature forest sites was 154 ft (47 m). Hence, riparian buffer widths needed to meet the 95% capture objective range from 39 to 54% of mean tree height. Bilby and Heffner (2016) warn that they may have underestimated litter travel distances because they released litter from only the bottom of the tree canopy, but litter travels farther with increasing height, and therefore, litter produced within the tree canopy is likely to travel farther.

While stream flows carry organic matter, insects, and other invertebrates downstream to subsidize food webs in higher order streams, there may also be upstream movement of aquatic organisms that subsidizes food webs in lower order streams. In a Welsh mountain stream, for example, amphipods *Gammarus pulex* showed net upstream movement whereas stonefly (*Trichoptera* spp.) females showed no upstream flight preference, but females moving upstream contained twice as many eggs (Dudley-Williams and Williams 1993). In many cases, however, such as with mayflies (family Baetida), seasonal upstream movements of adults via an aerial pathway are pronounced (Hershey et al. 1993). Such upstream movement of nutrients and chemical energy may be important, but has been little studied.

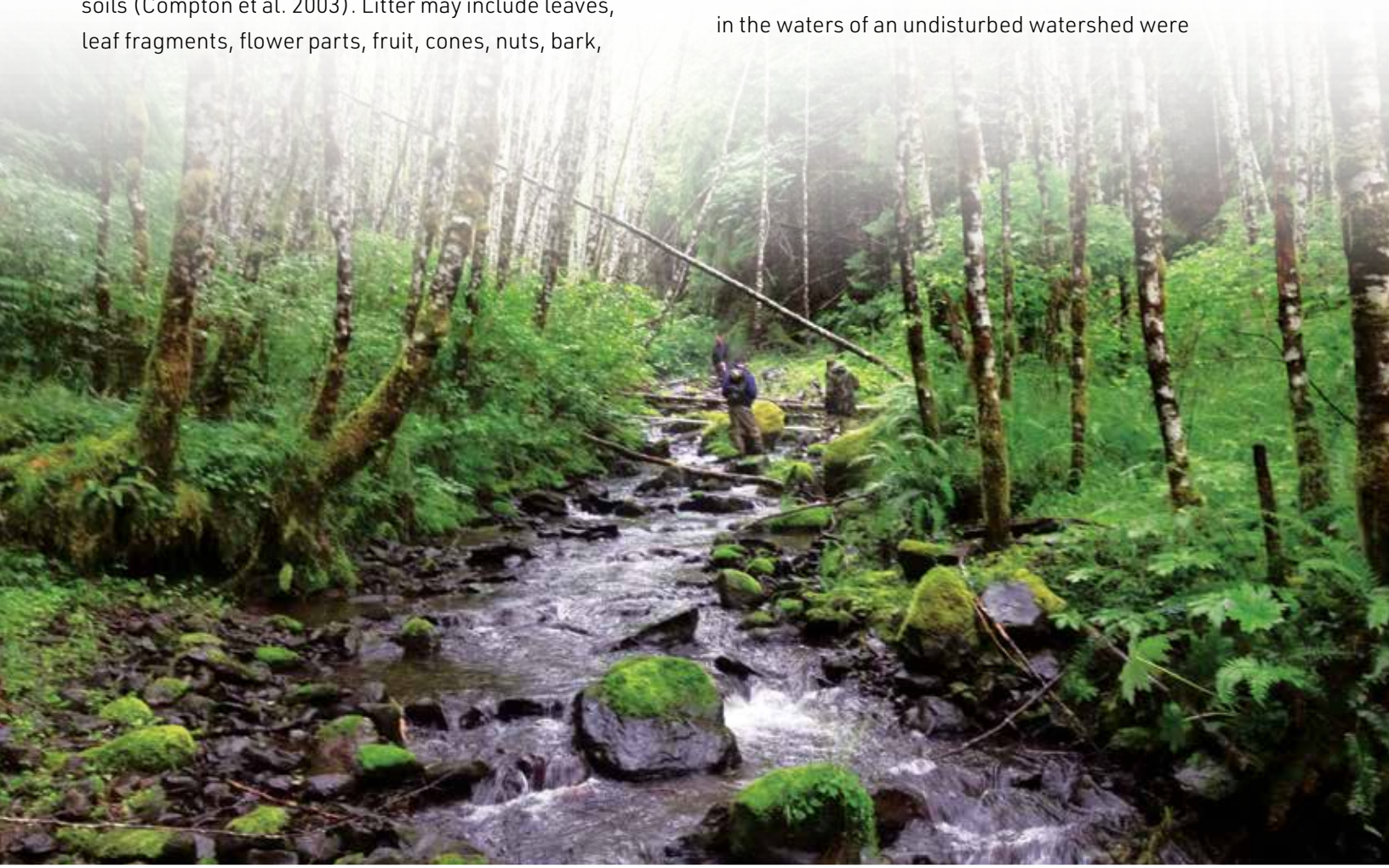
Large wood in stream channels can affect nutrient cycling by slowing the downstream transport of water, sediment, organic matter, and other materials (Chapter 3). Large wood in riparian areas ultimately decomposes, providing nutrients to the forest floor thereby increasing moisture holding capacity (Harmon et al. 1986). Woody material in streams can be a direct source of labile C to streams that can fuel microbial processes, though most C in wood is relatively recalcitrant, taking years or decades to decompose. Wood slows the flow of water thereby extending the residence time of water in the channel and facilitating accumulation of finer organic and inorganic sediments (Chapter 2) that support biofilms.

6.1.3. Nitrogen

Nitrogen is a component of proteins, necessary for all life, and often is a limiting nutrient for both terrestrial and aquatic organisms. N limitation of plant growth is common in PNW forests (Peterson and Hazard 1990). Ultimately, N comes from atmospheric N_2, which has a very strong triple bond that, aside from lightning and industrial processes, only a few specialized N-fixing organisms can break.

Nearly all N in lotic ecosystems of Washington is derived from allochthonous sources, and in undisturbed headwater watersheds, the source of nearly all N is terrestrial. Nitrogen can enter a river or stream via several pathways: litterfall, movement of soluble N from riparian soils into groundwater and hyporheic zones, and leaching and subsurface transport from upland soils (Compton et al. 2003). Litter may include leaves, leaf fragments, flower parts, fruit, cones, nuts, bark, branches and twigs (Benfield 1997), however, leaves account for 72% of total litter in broad-leafed forests and 80% in needle-leaved forests (Xiong and Nilsson 1997). Litter may enter surface waters through direct fall, lateral movement along the ground, or mobilization during floods.

For a headwater stream in the western Cascades of Oregon, Triska et al. (1984) found that more than 90% of annual N inputs to the stream were derived from biotic processes in the adjacent forest. Seventy-three percent of N entering the stream was dissolved organic N in water flowing through the subsurface from forest to stream and 21% was contained in organic matter (e.g., leaf litter, needles, and coarse woody debris) from the riparian forest. The headwater stream exported 74% of its annual N inputs to downstream waters; 22% of the exported N was contained in particulate organic matter. Edmonds et al. (1995) found that nitrate concentrations in the waters of an undisturbed watershed were



N-fixation by Red Alder is an important component of nutrient cycling in forests of western Washington and Oregon/Ned Pittman, WDFW

seasonal, with in-stream concentrations being highest in the fall and lowest in the summer when N uptake by terrestrial vegetation was greatest.

Red Alder fixes N_2 and enriches soil with N compounds through root and nodule secretions. Red Alder leaves contain N concentrations roughly 2 to 3.5 times greater than leaves or needles of other tree species (Tarrant et al. 1951). Because aquatic ecosystems in undisturbed watersheds are often N-limited, Red Alder can be a major source of allochthonous N to aquatic ecosystems, and more Red Alder litter can increase ecosystem productivity. For example, Wipfli and Musslewhite (2004) found that headwater streams with more Red Alder canopy cover exported greater biomass of both terrestrial and aquatic invertebrates to fish-bearing waters than riparian areas with less alder. This subsidy of prey from headwaters to fish-bearing streams is needed to maintain fish productivity (Wipfli and Baxter 2010).

Nitrogen cycles in the environment through multiple redox states, in solid, dissolved, and gaseous forms, and originates from multiple sources, making for one of the most challenging biogeochemical cycles to monitor and characterize (Figure 6.3). Shallow groundwater adjacent to stream channels often is a hot spot for N removal processes and a storage zone for other solutes (Hinkle et al. 2001; Zarnetske et al. 2011). The groundwater–surface water interface is characterized by dynamic gradients of dissolved oxygen, N, and organic C concentrations where biogeochemical reactions take place, including metabolism of organic C, denitrification, and nitrification (Sobczak et al. 2003). Denitrification is generally considered the most important biological process through which ecosystems lose N. Denitrification, and disturbances like tree harvest and fire, remove N from an ecosystem, whereas N uptake by plants eventually returns N to the system through litterfall or senescence and subsequent microbial decay. Organic C is required as an energy source for denitrification. Small streams can lose nitrate

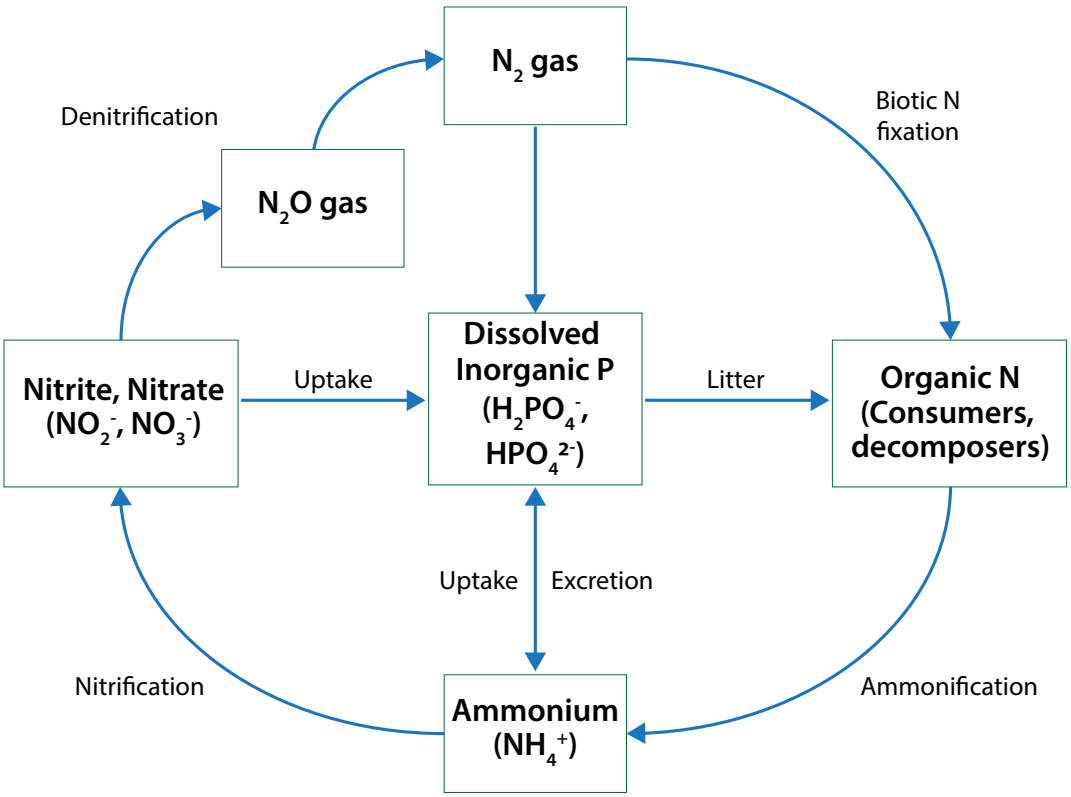


Figure 6.3. Nitrogen cycle pools and processes in ecosystems.

N efficiently because of their high ratio of streambed area to water volume, which brings more surface water in contact with the hyporheic zone. Small streams have a large cumulative influence on N transformation and loss because they account for most of the stream length within a network (Alexander et al. 2000; Peterson et al. 2001). Larger streams lose nitrate N because of longer transport distances over which more biological reactions can occur that consume N coupled with longer water residence times and higher N concentration which fuels the denitrification along with organic C (Mulholland et al. 2008).

Increased groundwater–surface water interaction can alter dissolved oxygen concentrations and redox conditions (Striz and Mayer 2008; Zarnetske et al. 2012), transporting N- and C-containing organic matter to microbes in subsurface sediments, leading to N loss via denitrification under favorable oxidation–reduction conditions (Hedin et al. 1998). The conditions that favor denitrification may change rapidly over time and space. Therefore, "hot spots" may form where denitrification occurs in small patches of the stream (e.g. under leaf packs) or "hot moments" where denitrification rates are high but for short periods of time due to rapid dynamic water movement (McClain et al. 2003; Vidon et al. 2010). However, biochemical processes in urban riparian soils such as denitrification may be impaired because of increased rates of erosion and limited groundwater–surface water interaction due to high proportions of impervious surfaces (Groffman et al. 2002).

The importance of riparian vegetation on transforming N inputs has been examined (Sweeney et al. 2004; Mayer et al. 2007; Sweeney and Newbold 2014). Riparian area characteristics such as width of vegetation, soil carbon, and hydrologic flowpaths, can influence the amount of N removed. Mayer et al. (2007) surveyed the available scientific literature containing data on riparian management and N concentration in streams and groundwater to identify relations between N uptake and riparian width, hydrological flow path, and vegetative cover. Removal efficiencies ranged from <0 (i.e., where the riparian ecosystem appeared to be a N source) to 100%, with a median removal rate of 91%. Wide vegetated riparian areas (>165 ft; 50 m) more consistently removed significantly higher proportions of N entering riparian areas than narrow bands of vegetation (0 - 82 ft; 0 - 25 m). The critical conclusions from this review were that riparian areas were effective at trapping and removing N when they were vegetated, wider, and allowed for subsurface movement of water where the interaction of nutrients dissolved in the water had prolonged contact with soils. Therefore, the hydrologic connection of riparian areas and streams is key to effective nutrient capture. Where channels are incised, riparian areas tiled for drainage, or where floodplains are disconnected via reinforced banks or channelization, nutrients will flow downstream with little interaction with riparian areas.

Subsurface hydrology (saturated vs. unsaturated soil conditions) and redox condition appear to be significant determinants of N-removal efficiency, regardless of vegetation (Mayer et al. 2007; Mayer et al. 2010b). When the water table fluctuates in response to precipitation events, buried relict hydric soil may become saturated, producing sub-oxic or anoxic conditions (Hefting et al. 2004; Weitzman et al. 2014), facilitating N removal. Where flow paths move through wetland riparian soils, great potential exists to remove large quantities of N in proportion to the loads (Jordan et al. 2011); where flows occur via deeper groundwater dynamics or via tile



Riparian vegetation: Red Elderberry Sambucus racemosa*/ Ned Pittman, WDFW*

drainage, N in solution may bypass the C-rich riparian soils and flow through zones where less potential exists for nutrient removal (Wigington et al. 2005). Hydrologic connectivity between riparian areas and streams is a critical factor in determining N removal rates.

Denitrification rates in the stream channel are linked to the organic C content of benthic sediments, respiration rates, and extent of stream water interaction with the streambed (Alexander et al. 2000; Mulholland et al. 2008), conditions that can be fostered by woody material (e.g., sticks, branches or tree trunks), and debris dams in streams. Woody material may function as microsites or hotspots of elevated biogeochemical cycling including denitrification (Groffman et al. 2005), and provides substrates for bacteria and fungi, which in turn consume N in streams (Ashkenas et al. 2004).

Biofilms are a matrix of algae, bacteria, and fungi embedded in a slick polysaccharide film that coats hard substrates in streambeds. These microbial communities consume, respire, and reduce inorganic N (Mulholland et al. 1995). Physical habitat heterogeneity and the biodiversity of the biofilms influence N uptake (Cardinale et al. 2002; Cardinale 2011). Biofilm structure, composition, and capacity for biogeochemical cycling are influenced by substrate composition, light penetration, nutrient concentration, flow rates, seasonality, sediment composition, and the community of invertebrate grazers in the vicinity (Sabater et al. 2002). Biofilms formed on wood substrates have been found to have higher respiration rates and greater N demand than biofilms developed on rock substrates (Sabater et al. 1998). Lazar et al. (2014) found that biofilms on wood substrates in a forested stream had significantly higher denitrification rates than those on non-organic substrates such as stone. In an old-growth forest system in Oregon, aquatic mosses and biofilm on large wood showed the highest N uptake rates among biota while, both vertebrate and invertebrate consumers took up substantial amounts of N, especially small invertebrate grazers (Ashkenas et al. 2004).

Furthermore, N in the stream was transported to the upland through uptake by terrestrial plants, likely through long, subsurface flow paths, demonstrating a strong link between terrestrial and aquatic systems (Ashkenas et al. 2004).

In addition to the biofilms on the streambed, microbial communities within the hyporheic zone can be hotspots for N dynamics. At the HJ Andrews Experimental Forest in Oregon, Zarnetske et al. (2011) found that the hyporheic zone was an important site for N dynamics in small forested streams, with residence time determining the dominance of different N transformation processes. Water pathways with residence times of less than 7 hours tended to be dominated by DO and DOC use as well as ammonium and nitrate production, while pathways with longer residence times removed N via denitrification. Further modeling suggested that water residence times and oxygen uptake rates of microbes are important determinants of whether hyporheic zones are net sources or sinks of nitrate N (Zarnetske et al. 2012). In large rivers like the Willamette, hyporheic zones can be important areas for nitrate removal from regional groundwater prior to entry into surface flow (Hinkle et al. 2001), as well as important for N removal and cooling as water moves in and out of hyporheic areas on its path downstream (Fernald et al. 2006).

The relationships between land use and N transport and fate can be complex, and are mediated by aquatic and riparian biota. Sobota et al. (2012) showed that N uptake differs substantially across forested, agricultural, and urban streams in the Willamette River basin in Oregon. Most nitrate N in forested streams was transported downstream without being taken up. N storage was high in algal biomass in unshaded agricultural and urban streams but turnover and subsequent recycling back to the stream may ultimately be high (Sobota et al. 2012). Collectively, this work indicates that uptake via heterotrophic organisms living on large wood is critical to long-term N capture in forested streams. Once the canopy is opened up, autotrophic algal production

becomes a more important process for uptake of excess nutrients, which leads to shorter-term storage and potential for negative consequences associated with freshwater algal blooms.

6.1.4. Phosphorus

Phosphorus (P) is an important component of adenosine triphosphate (ATP) and necessary for energy transformations in plant and animal cells. Like N, low P availability often limits primary production on land and can be particularly limiting to productivity in freshwater. This is because P tends to form complexes and be retained in soils and thus does not move as readily into ground and surface waters from the landscape as does nitrate N. P cycles in the environment through multiple organic and inorganic forms (Figure 6.4). P occurs in the environment in organic forms (e.g., organo-phosphate and polyphosphates like ATP) in plant and animal biomass, sewage, and pesticides. Inorganic forms of P, such as phosphate (PO_4^{3-}), and orthophosphate, are biologically reactive and thus can be used directly by plants and microorganisms (Carpenter et al. 1998). Orthophosphate is derived from phosphate-bearing minerals, fertilizers, detergents, and industrial chemicals. In the Pacific Northwest, bedrock is the major source of stream P loads, with fertilizer, manure, and wastewater inputs important in some locations (Wise and Johnson 2011). Overabundance of P can result in abnormally high primary production in water, leading to water quality problems such as algal blooms, production of cyanotoxins, and low oxygen events (Carpenter et al. 1998; Jacoby and Kann 2007).

P is commonly a limiting nutrient in aquatic ecosystems because it is highly insoluable and has an affinity for binding to soil particles. Nevertheless, riparian areas are sources of allochthonous P to streams in undisturbed watersheds. The amount of P that is contributed by riparian areas to aquatic habitats through litterfall

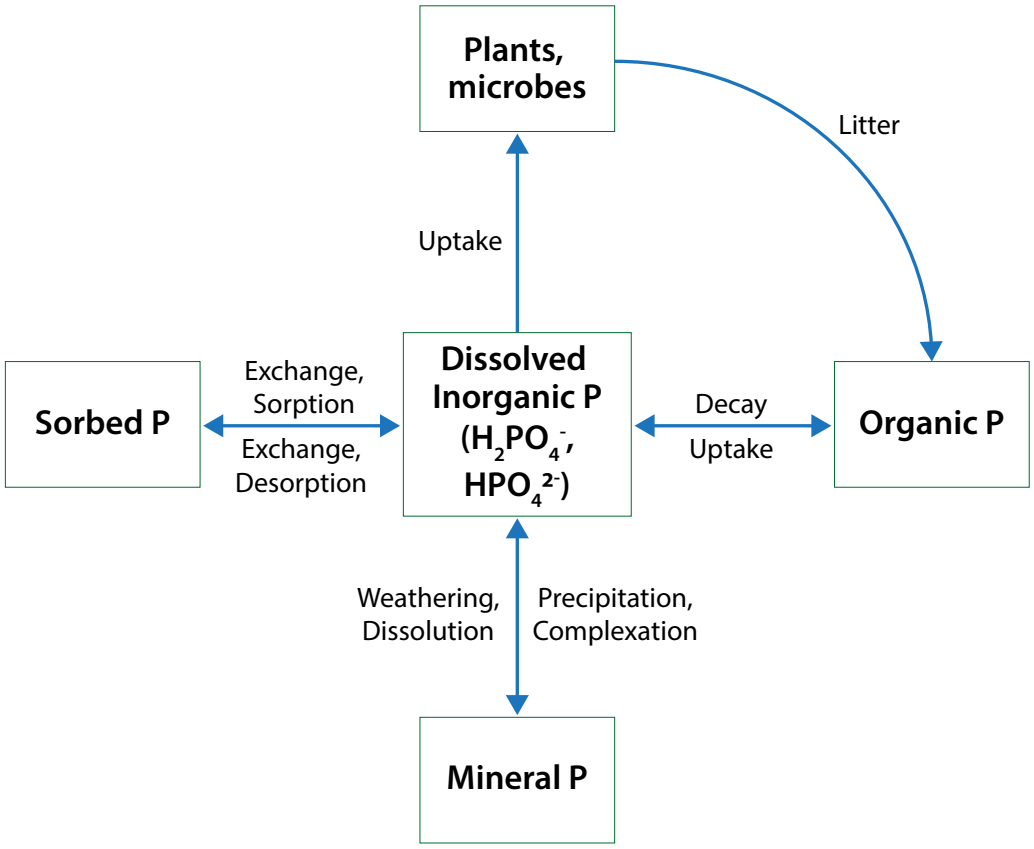


Figure 6.4. Phosphorus cycle pools and processes in ecosystems.

relative to other sources under natural, undisturbed conditions has yet to be quantified for riparian ecosystems in the Pacific Northwest.

P attenuation refers to declines in P concentration in water and soil through physical, chemical, and biological processes. Mineral content and pH are important factors determining P attenuation in soil. Because of their volcanic origins and the weathering environments, many soils in the PNW can bind tightly to large quantities of anions like phosphate, replacing reactive soluble P forms for particulate P forms, which are less biologically reactive (Johnson and Cole 1980; Bohn et al. 1985). Sorption, the chemical attachment of molecules to soil particles, may occur quickly (e.g., days) and includes adsorption and substitution between P and other anions on mineral surfaces. Sorption may also occur slowly (e.g., weeks), such as mineral dissolution and precipitation reactions between P and soil cations such as Ca and Mg or Al, Fe, and Mn oxide compounds depending on soil pH (Bohn et al. 1985). Phosphate is most soluble in slightly acid to neutral pH soils. Under reducing conditions, Fe is reduced and the P-Fe oxide compounds may dissolve, thereby releasing P (Denver et al. 2010). Minimally disturbed forests have a relatively tight P cycle, with low inputs from precipitation, and even lower leaching rates (Yanai 1992; Compton and Cole 1998). In the volcanically influenced soils of the Cascades, most of the ecosystem P is contained in soil, and organic and inorganic forms of sorbed P are the dominant forms as opposed to primary minerals or microbial P (Compton and Cole 1998). There is substantial recycling of P by plants and soil and biotic release of organic P via phosphatase enzyme activities is an important component of this cycle (Giardina et al. 1995). Several studies have shown that Red Alder increases rates of P cycling (Giardina et al. 1995; Zou et al. 1995), further supporting the important role that Red Alder plays in regulating both N and P nutrient cycles of the PNW. Vegetated riparian areas generally are expected to retain P by slowing water flow and by plant and microbial uptake.

Unlike N, which is ultimately constrained by atmospheric fixation and regulated by biologic cycling, P availability is controlled by weathering and a complex set of chemical and biological processes. P retention is regulated by the equilibrium P concentration (EPC), the concentration at which P sorption equals desorption (Hoffmann et al. 2009). Once soil P has reached its sorption capacity, excess P may be exported in water (Domagalski and Johnson 2012). Biological processes also play a role in P attenuation and release (Schechter et al. 2013). Bacteria, fungi, algae, and plants incorporate P into biomass; however, plants vary in P demand and uptake effectiveness, exhibiting numerous strategies for sustaining growth and maintenance (Shen et al. 2011). P is released from organic matter through decomposition, which is dependent on pH, litter quality (C:N:P ratios), Ca content, redox potential, soil moisture, and temperature (Schechter et al. 2013). Increases in P loading as well as soil disturbance and erosion have the potential to reduce this generally tight P cycle and increase transfer to aquatic ecosystems (Figure 6.2).

Microbial and plant uptake represent short-term, transient P pools (Richardson and Marshall 1986). Phosphate may be assimilated into plant tissues or in microorganisms but released upon death and senescence. Peat accumulation and P sorption and precipitation are important long-term P sequestration mechanisms (Richardson and Marshall 1986; Reddy et al. 1995). Long-term storage of P depends on sorption to inorganic sorbents; P sequestration is mainly associated with adsorption to Fe and Al oxides in acidic soils or precipitation of Ca phosphates in alkaline soils (Giesler et al. 2005). Phosphorus retention mechanisms differ widely depending on hydrological pathway through the riparian area. Sorption and desorption reactions are more important during subsurface flow, while sedimentation of particulate P may be the major retention mechanism during overland flow. Significant amounts of P can be stored in stream sediments and may be resuspended and released during storms. Retention of total P in riparian areas is controlled

mainly by sedimentation processes, dependent on morphology (e.g., width) and vegetation characteristics. However, riparian areas can become a net source of dissolved P released from soil or from plant material (Hoffman et al. 2009). Retention of dissolved P in riparian areas is often not as significant as retention of particulate P (Hoffman et al. 2009). Inundation of riparian areas or floodplains can deposit particulate P whereas plant uptake may temporarily immobilize P (Hoffman et al. 2009). Overall, riparian ecosystem retention efficiency varies widely and some riparian areas may become sources of P, especially ortho-phosphate (Schechter et al. 2013). Total P moving through the soil is not necessarily related to the width of the riparian area but rather on flow path and soil types (Hoffman et al. 2009; Schechter et al. 2013).

6.2. Hydrologic Connectivity and Nutrient Dynamics

Nutrients cycle at various spatial and temporal scales. Soils, vegetation, and water flows largely dictate the sources and processing of nutrients. Nutrients may enter the riparian ecosystem from the atmosphere (e.g., nitrogen oxides produced from fossil fuel combustion or ammonia released from agricultural areas), from terrestrial sources when rainwater flushes nutrients from upland soils and vegetation, or from floods that

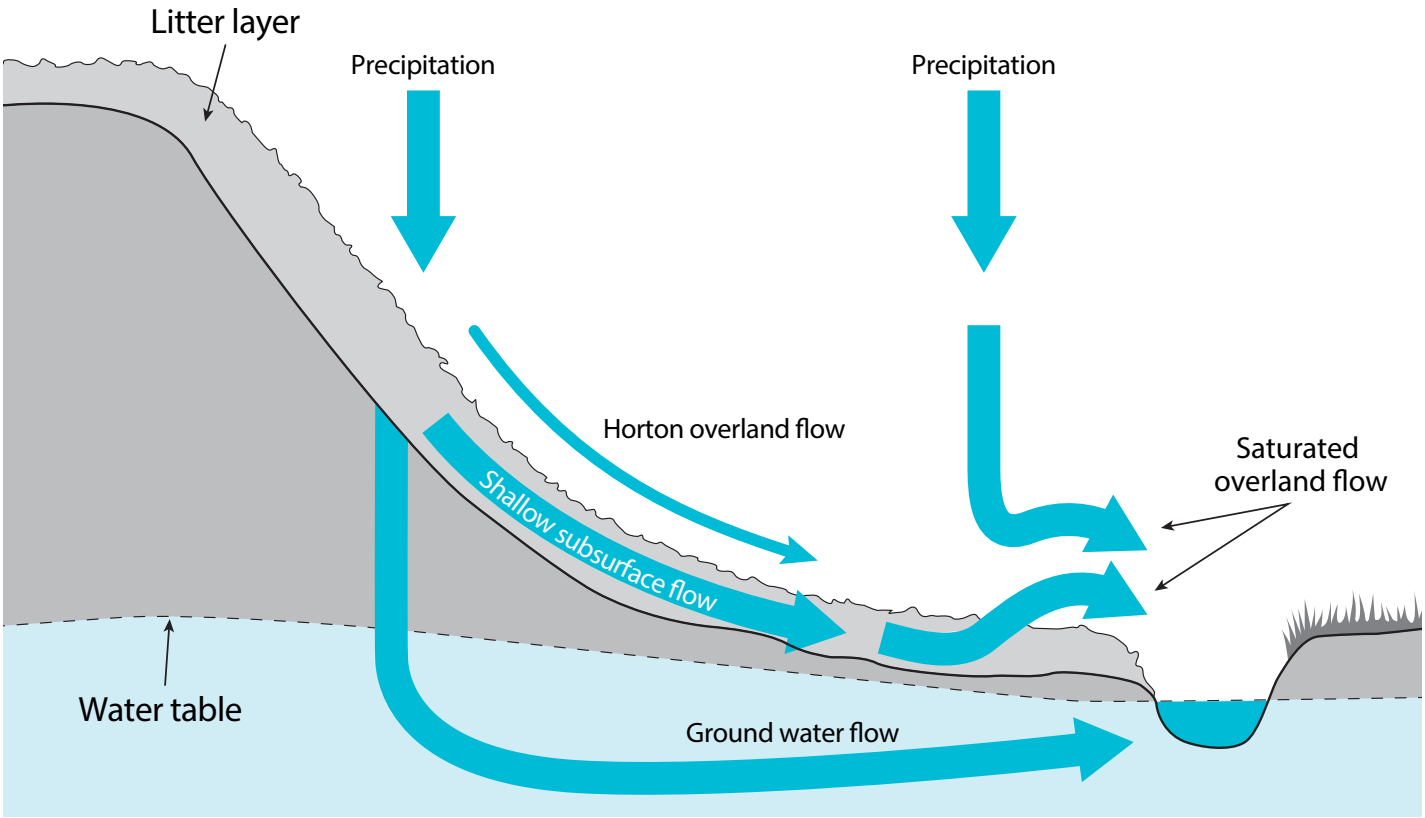


Figure 6.5. Water flow paths. Precipitation reaches a stream as surface runoff and by infiltration into the ground where it contributes to groundwater flow. The amount of water following each flow path depends on the capacity of the soil to absorb water, the amount of storage in surface depressions, and the amount, intensity, and duration of precipitation (image adapted from Stream Corridor Restoration Handbook; FISWRG, 1998).

bring in nutrients from upstream areas (Figure 6.5). As water moves downstream, it moves into and out of the hyporheic zone, carrying with it dissolved nutrients that react with the sediments and biota living in the interstitial spaces of the sediments (Fernald et al. 2006). Wondzell (2011) suggests that hyporheic exchange is likely to be most important in small streams but that hyporheic exchange through sand-bedded streams is substantial and may have an important influence on nutrient loads of large rivers. Regardless, large fractions of N are removed via denitrification in hyporheic sediments at all scales from headwater streams to large rivers (Peterson et al. 2001; Mulholland et al. 2004; Alexander et al. 2007).

Hydrology is the driving force for a range of physical and biogeochemical processes controlling retention and flux of nutrients entering the riparian ecosystem (Chapter 2). Nutrients may originate from neighboring areas via local flow systems throughout the riverscape, from regional groundwater flow systems, especially along reaches of the higher stream orders, or from a recirculation of river water in riparian areas during flooding (Dahl et al. 2007). Depending on flood intensity and frequency, water may overflow the streambanks and move into the floodplain where sediments may be deposited or, conversely, litter, woody material, and sediments may be mobilized and transported into the main channel.

Many floodplains in the Pacific Northwest are highly altered by human activities and are often artificially disconnected from stream channels by levees. Subsequently, natural flooding processes and nutrient exchange, both deposition and production, are severely altered often with negative consequences to riparian habitat.

Discharge volume, stream flow velocity, and temporal variability in flow, coupled with nutrient concentrations dictate the mass loading of each nutrient flowing downstream. Headwater streams commonly make up 75% or more of the total stream channel length in drainage basins (Benda et al. 2004) and have a disproportionately profound influence on the water quality and quantity for downstream ecosystems (Peterson et al. 2001). Alexander et al. (2007) found that fluxes from first-order headwater streams accounted for 70% of water volume and 65% of the N flux occurring from second-order streams. Research comparing perennial, intermittent, and ephemeral stream nutrient cycling processes indicates that flow intermittency can affect the concentrations, fluxes, and forms of nutrients moving from streams into downstream ecosystems (Von Schiller et al. 2011).

In western Oregon and Washington, floodplains experience extremes in water and sediment flux (Naiman et al. 2010). Floodplains often have saturated soils and shallow, upwelling groundwater. Such wet conditions influence N processing by creating anoxic, denitrifying conditions in organic soil horizons (Burt et al. 2002). However, many floodplains of the PNW are highly altered by human activities and are often artificially disconnected from the stream channel via levees constructed to convert lands to agriculture or other uses. Subsequently, nutrient exchange during flood events between aquatic and riparian ecosystems, via both mobilization and deposition of dissolved and suspended organic matter, is severely altered. River restoration often focuses on reconnecting floodplains and associated riparian areas to stream channels in order to restore natural hydrology and re-establish nutrient cycling functions (Bernhardt et al. 2005; Craig et al. 2008). The hydrologic interactions of uplands and

riparian soils control nutrient cycling and transport (Mayer et al. 2007; Weitzman et al. 2014). Therefore, it is critical to maintain riparian vegetation and to control soil erosion and nutrient runoff from uplands (Mayer et al. 2007; Hoffman et al. 2009; Zhang et al. 2010; Sweeney and Newbold 2014).

Impacts to riparian ecosystems may include historic events not well documented and not easily recognized today. Such impacts may lead to erroneous understanding of baseline conditions or misidentification of pristine areas. For example, recent research suggests that legacy sediments, referring to sediments deposited in floodplains from historic upland erosion in response to deforestation and construction of milldams and ponds, have altered nutrient cycling in riparian ecosystems throughout the mid-Atlantic region of the US (Walter and Merritts 2008; Merritts et al. 2011). Much of the fine sediment carried by these streams during storms is from streambank erosion, which often includes legacy sediments, thereby contributing substantially to sediment and nutrient loads in streams (Gellis and Noe 2013). While milldams may not have been as common in the Pacific Northwest, splash dams created to move logs downstream were common throughout the region historically until the mid-20th century (Phelps 2011). These dams and other historic logging activities may have altered riparian systems in ways not easily recognized today but which may have had a significant legacy effect on sediment deposition in floodplains. For example, splash dam releases exceeded the effects of 100-year flood events in headwater regions and were comparable to 100-year flows in lower reaches (Phelps 2011). Splash dams also may have contributed to simplification of stream channels when rocks and debris jams were removed to facilitate log transport (Sedell and Luchessa 1981; Wohl 2000). Overall, the long-term effects of splash dams are not well documented nor are they accounted for in current riparian assessments.



South Fork Sauk River/Wendy Cole, WDFW

Precipitation and runoff are master variables regulating transport and transformation of C, N, and P in watersheds (Dosskey et al. 2010; Vidon et al. 2010). The interaction between land use and climate variability can increase the amplitude and frequency of nutrient pulses, effecting rapid and large changes in concentrations and fluxes of materials (Kaushal et al. 2014). Shifting patterns in runoff and temperature due to land use and climate variability can amplify pulses of greenhouse gases (GHG) such as CO_2, CH_4, and N_2O emanating from watersheds (Kaushal et al. 2014). For example, Vidon et al. (2014) showed strong N_2O pulses in response to storm events in a riparian wetland. Warming increases production of some GHGs in wetlands (Inglett et al. 2012) because temperature affects reaction kinetics and equilibria. Higher stream temperatures may increase rates of both bacterial consumption of nutrients and production of GHGs in streams and rivers (Kaushal et al. 2014). Recent research shows that groundwater may also warm in response to climate (Menberg et al. 2014).

Most N and P enters receiving waterbodies during storm events and during cooler seasons when temperatures are lower than optimal for microbial activity (Kaushal et al. 2010) or when plants are senescent. During drought, residence times may be long, leading to more denitrification in riparian soils, however N loads may be small overall because stream flow may be much lower than normal (Mayer et al. 2010b; Filoso and Palmer 2011). However, drought may also lower moisture levels in riparian soils, potentially reducing the occurrence of anoxic conditions required for denitrification (Groffman et al. 2003). Conversely, high flow conditions during "flashy" storm events may greatly compromise nutrient retention processes (Booth 2005) flushing far more solutes downstream including N and P (Cooper et al. 2014). Consequently, high flows are also responsible for the vast majority of particulate C, N, and P transport in most streams (Alexander et al. 2000; Moore and Wondzell 2005).

Stream channel geomorphology and geologic setting, especially stream channel width, depth, and sediment lithology strongly influence groundwater behavior. In turn, nutrient movement in riparian ecosystems is dependent upon groundwater, which can be highly variable and follow preferential flow paths. Striz and Mayer (2008) showed that groundwater movement may shift considerably depending on seasonal precipitation trends. Streams may be gaining, that is, receiving water from the uplands when precipitation is high, or losing surface water to the ground when soils are dry and drought conditions prevail. Water movement through deep groundwater flow paths back to the stream can take years or decades (Hinkle 2009) and in some cases there is very little exchange with regional deep groundwater (Vaccaro 2011).

Mass removal of nutrients and contaminants in streambed sediments is dependent upon residence times because microbial processes, such as denitrification, require time for complete reaction (Zarnetske et al. 2012). Nutrient concentrations in soils and water may vary on time scales across minutes and hours as plants or algae take up nutrients. Yet, seasonal and annual cycles are also evident based on flow and temperatures. Nutrients may also vary on spatial scales of millimeters to meters depending on plant distribution or litter deposition, and can also vary at regional and global scales depending on land use, geomorphology, and precipitation patterns.

A better understanding of the role hyporheic connections play in the processing of nutrients will improve our ability to design riparian management strategies that protect water quality.

6.3. State of Riparian Nutrient Dynamics Science

Recent advances in stream nutrient research reveal spatially and temporally variable processes and resulting pulses of nutrient transformation, storage, and release that can differ among locations and through time at the same locations. We also know that freshwater and riparian ecosystems vary tremendously across the PNW based on soils, climate, organisms, and human activity. Because most stream nutrient research originates from case studies, the application of case study results to novel conditions should be done cautiously.

Most studies of riparian nutrient dynamics have been conducted in forested watersheds; grassland and desert ecosystems in our region are less well studied but share some common processes and dynamics. Much of the information provided here demonstrates that riparian areas can have important effects on nutrient transfer from land to water, which subsequently have implications for ecosystem goods and services (e.g., water for drinking, swimming, fishing, boating, etc.) and habitat conditions for aquatic species.

Generally, if the goal of riparian management involves nutrients, management should include efforts to shorten nutrient spiraling lengths, increase nutrient retention, provide substrates to support riparian food webs, and maintain natural shading in order to minimize algal blooms. However, stimulating algal and plant growth is one way to shorten nutrient spiraling lengths by enhancing nutrient uptake, at least temporarily as nutrients will be returned after senescence. A longer-term goal of riparian management is to avoid excessive nutrient delivery to streams. Maintaining riparian



The larvae of many caddisfly species use silk to make protective cases, which are often strengthened with gravel, sand, and twigs/ Ned Pittman, WDFW

vegetation, soil conditions, and flowpaths, etc. will fascilitate the removal of nutrients from surface and subsurface flow before entering the channel. If nutrient input is successfully controlled, light levels promoting algal blooms become much less of an issue.

Some of the critical gaps in our understanding occur where physical sampling for detecting water and material movement is most difficult. This occurs in the soil subsurface, the streambed, and hyporheic zones where determining flow dynamics requires multiple sampling wells (Striz and Mayer 2008) or surrogate measures such as stream temperature (Stonestrom and Constantz 2003). A better understanding of the role hyporheic connections play in the processing of nutrients will improve our ability to design riparian management strategies that protect water quality (Hinkle et al. 2001; Zarnetske et al. 2011, 2012), particularly by expanding these studies to better

represent the range of conditions in Washington. However, the use of stable isotopes of N, P, C, and also O and H in water have helped to illuminate some of the more obscure processes like water movement into and out of trees (Brooks et al. 2010) and the uptake of N along entire stream reaches (Ashkenas et al. 2004). Satellite monitoring data (e.g. GRACE) and lidar imaging, which can provide high-resolution topographic data for inaccessible areas, are proving to be valuable tools for the study of nutrient dynamics at the watershed scale. Drone technology may eventually further provide local and current information on condition and environmental variables. Coupling these new data sources with the development of powerful computer models (e.g., VELMA) that predict watershed-scale nutrient movement (Abdelnour et al. 2011; Abdelnour et al. 2013) will greatly enhance our ability to extrapolate field level data to watershed scales and to test land use riparian management scenarios and climate change impacts on nutrient cycling behavior.

6.4. The Role of Management

Litter from riparian areas is clearly an important source of limiting nutrients and chemical energy for aquatic ecosystems. Inorganic nutrients, such as those in artificial fertilizers, do not mimic the foodweb role of litter because inorganic nutrients feed the autotrophic components of foodwebs, such as algae. Litter feeds heterotrophic components of foodwebs, such as benthic macroinvertebrates, many of which are prey for resident salmonids and juvenile salmon. Consequently, providing adequate amounts of litter to streams is an important issue for riparian area management. The results of Bilby and Heffner (2016) suggest that 95% of full litter delivery to streams can be achieved with buffer widths between 40 to 60% of site-potential tree height, depending on site conditions. Numerous factors dictate the transport and fate of nutrients through riparian systems. Managing riparian systems to limit negative impacts of nutrients on downstream resources is inherently complex. The role of management is largely to offset the impacts of human activities that increase nutrient loads and runoff, exacerbate the impacts of nutrients, and/or alter the fluxes of nutrients. Table 6.1 identifies impacts of human activities in the context of factors influencing riparian areas and describes practical management and restoration approaches that are known to mitigate nutrient impacts. The primary objective with respect to offsetting nutrient impacts among all categories of land use is to maintain existing riparian systems, restore degraded systems, and plant riparian buffers where they do not currently exist. Overall, management should focus on where in the watershed important nutrient dynamics that affect aquatic system integrity (or fish life) occur, and how to reduce or ameliorate various human disturbances that can affect nutrient dynamics at those places.

Although salmon runs and associated nutrient fluxes have declined over time in Oregon, Washington, Idaho, and California (Gresh et al. 2000), salmon could still play an important role in stream ecosystems by greatly increasing the quantity of salmon carcasses planted in streams or by greatly increasing harvest escapement (Gende et al. 2002). Addition of inorganic nutrients will not mimic the food web role of salmon in PNW watersheds because they do not directly mimic the complex organic matter from salmon carcasses supplied to heterotrophs such as aquatic insects and juvenile salmonids (Compton et al. 2006). Maintaining structures, such as large wood, and processes that retain nutrients are expected to allow greater utilization of salmon-derived nutrients in aquatic food webs.

Table 6.1. Major factors influencing nutrient dynamics in riparian ecosystems and the role of management in reducing impacts

Factors influencing riparian areas	Impacts of human activities	Role of management in reducing impacts
Land use - agriculture	Excess nutrient application and leaching into groundwater and surface water	Improve nutrient management to reduce nutrient loading - right time, right place, right source, right rate (4Rs)
	Compaction and vegetation damage from poor livestock management near streams	Protect and restore riparian areas to attenuate sediment and nutrient loads
	Riparian disturbance or lack of natural vegetation in riparian area	Protect and restore riparian areas to reduce light inputs that drive algal overproduction and eutrophication
Land use - urbanization	Impervious surfaces increase nutrients and sediment transfer to surface waters	Disconnect direct runoff from impervious surfaces to streams to control nutrient and sediment inputs
	Increased nutrient application via yard fertilizer and pet waste	Educate the public and incentivize behaviors to reduce nutrient loads
	Leaky and ineffective sewer and septic systems	Improve sewer systems, sewage treatment, storm drainage, and septic systems
Land use - forestry (harvest and road building)	Small increase in nutrient loadings	Seek alternatives to clear cutting and protect riparian areas
	Small to moderate increase in sediment transport	Seek alternatives to clear cutting; improve harvest practices, slope and soil management, and road construction; and protect riparian areas
Forest age and composition	Recent clear-cuts may lose the most nutrients	Extend harvest rotations because mature forests likely retain more nutrients than young forests
	Red Alder fixes large amounts of N, which remains in the system and contributes to productive soils of the Coast Range and western Cascades mountains	Recognize the role that Red Alder forests can play in stream nutrient levels
Climate and seasonality	Rapid movement of water during fall and winter rains, sometimes bypass riparian zones	Slow water movement across the landscape
	Rapid N cycling during the summer but low flows mean this inorganic nitrogen accumulates in the soil, fall rains displace this N and transport it to streams	Consider timing of fertilizer applications
	Spring season usually has peak algal blooms because nutrient supplies are high as is light availability before full leaf out.	
	Slower processing of nutrients in cold weather, although conifer trees take up nurients year round	
Elevation and topography	Steep slopes lead to higher rates of runoff and sediment transport	Minimize disturbance to vegetation and soils on steeper slopes through forest and pasture management

Table 6.1. CONTINUED
Major factors influencing nutrient dynamics in riparian ecosystems and the role of management in reducing impacts

Factors influencing riparian areas	Impacts of human activities	Role of management in reducing impacts
Hydrology	Reduced connection between the channel and floodplain can limit nutrient uptake	Reconnect flood plains to increase water residence times, which can increase ground water-surface interactions and nutrient uptake
Nutrient concentrations, forms, and inputs	High concentration and multiple sources of bioavailable nutrient forms may overload capacity of riparian systems to process nutrient loads	Consider terrestrial versus atmospheric sources; carefully manage synthetic fertilizer and manure applications, and balance N and P
Soil properties and geology	Low permeability reduces infiltration and interaction with soils	Practice good soil management because rich, fertile soils can contribute organic carbon for denitrification
	Sandy soils can transmit more water and nutrients (e.g., pumice soils and septic systems)	Recognize that some soils are better at adsorbing P (e.g., volcanic and highly weathered soils)
Biota	Declines in salmon runs reduces supply of nutrients and organic matter for invertebrates, birds, mammals, and other fish	Restore salmon populations, which increases nutrients in ecosystem: nutrients are assimilated by vegetation, consumed by animals, and converted by microbial processes

6.5. Conclusions

Riparian areas are important sources and sinks of organic matter and nutrients for streams. Numerous sources of C, N, and P exist, each taking various organic and inorganic forms, and each moving through the environment continuously along multiple paths at various temporal and spatial scales. Transfers may be via subsurface flow, direct input of materials via litterfall, treefall, or animal movement. Nutrient and energy subsidies from riparian areas to streams and rivers have profound effects on the composition, structure, and functions of aquatic ecosystems.

In watersheds where excess nutrients are polluting surface waters, hydrology and flow paths are critically important when considering potential for nutrient removal by riparian areas. If a riparian area is physically disconnected from the stream, flow paths may not carry materials through the riparian area, particularly into the hotspots with appropriate conditions for denitrification, and thus N removal will not occur as readily. Thus, maintaining hydrologic connections between riparian areas and stream channels are critical. This includes allowing natural seasonal patterns of flow including flooding.

Historically, many watersheds in Washington have seen substantial inputs of salmon-derived N, P, and organic matter. Riparian areas serve as the critical connection for transferring these nutrients to uplands via animal consumption, plant uptake, and biogeochemical cycling.

Results of a large review of riparian ecosystem studies across the globe indicated that vegetated riparian areas were more effective in trapping N than unvegetated ecosystems, but that the type of vegetation did not matter tremendously. Wider riparian areas were more effective in N removal across studies (see Chapter 5).

N-fixation by Red Alder is an important component of nutrient cycling in forests of western Washington and

Oregon. In the PNW, deciduous riparian forests tend to produce more litter with higher nutrient content and nutritional quality for stream food webs than conifer riparian areas. However, conifers have a longer lifespan, produce larger wood and are a more consistent source of shade. In riparian areas with a mixture of deciduous and conifer trees, deciduous species enhance litter flux and nutrient delivery to terrestrial and aquatic food webs, thus, complementing the provision of shade and large wood by conifers. Both the food web and structural roles of tree species should be considered in riparian management plans in order to support aquatic production.

Structurally diverse habitats with variability in geomorphology and soils are likely to support correspondingly diverse biota including vegetation, animals, and microbial communities that will be best able to process and assimilate nutrient loads. Headwaters are especially controlled by riparian processes and thus, are important zones of active nutrient processing that can significantly affect downstream transport of nutrients. Therefore, maintaining riparian areas in headwater systems may be disproportionately important to stream function. Similarly, maintaining hydrologic connection of streams with their floodplains is important because rich, organic sediments are deposited on floodplains during flood events. Conversely, channelization and stream incision from erosion disconnects streams from their floodplains, causes flashy flows, further incises stream channels while starving floodplains of regular resupply of organic matter, and can lower groundwater tables below the rooting zone thereby contributing to the reduction of riparian vegetation in arid climates.

While more research will be necessary to answer important questions about nutrients in riparian ecosystems, the science is very clear about the importance of the condition of riparian areas on the flows of nutrients through stream systems. Riparian areas and their streams are much more than conduits for nutrients from the uplands to downstream systems; they are vitally important locations for the short- and long-term supply, storage, and transformation of nutrients.



Perennial fruiting bodies, or conks, of a polypore fungi/Ned Pittman, WDFW

6.6. Literature Cited[2]

Abdelnour, A., M. Stieglitz, F. Pan, and R. McKane. 2011. Catchment hydrological responses to forest harvest amount and spatial pattern. Water Resources Research 47: W09521 (i).

Abdelnour, A., R. McKane, M. Stieglitz, F. Pan, and Y. Cheng. 2013. Effects of harvest on carbon and nitrogen dynamics in a Pacific Northwest forest catchment. Water Resources Research 49:1292-1313. (i)

Alexander, R.B., R. A. Smith, and G.E. Schwartz. 2000. Effect of stream channel size on the delivery of nitrogen to the Gulf of Mexico. Nature 403:758–761. (i)

Alexander, R.B., E.W. Boyer, R.A. Smith, G.E. Schwarz, and R.B. Moore. 2007. The role of headwater streams in downstream water quality. Journal of the American Water Resources Association 43:41-59. (i)

Ashkenas, L.R., S.L. Johnson, S.V. Gregory, J.L. Tank, and W.M. Wollheim. 2004. A stable isotope tracer study of nitrogen uptake and transformation in an old-growth forest stream. Ecology 85:1725-1739. (i)

Beechie, T., and T.H. Sibley. 1997. Relationships between channel characteristics, woody debris and fish habitat in northwestern Washington streams. Transactions of the American Fisheries Society 126:217-229. (i)

Benda, L., N.L. Poff, D. Miller, T. Dunne, G. Reeves, G. Pess, and M. Pollock. 2004. The network dynamics hypothesis: how channel networks structure riverine habitats. BioScience 54:413-427. (i)

Benda, L., M.A. Hassan, M. Church, and C.L. May. 2005. Geomorphology of steepland headwaters: the transition from hillslopes to channels. Journal of the American Water Resources Association 41:835-851. (i)

Ben-David, M., T.A. Hanley, and D.M. Schell. 1998. Fertilization of terrestrial vegetation by spawning Pacific salmon: the role of flooding and predator activity. Oikos 83:47-55. (i)

Benfield, E.F. 1997. Comparisons of litterfall input to streams. Journal of the North American Benthological Society 16:104-108. (i)

Bernhardt, E.S., M.A. Palmer, J.D. Allan, G. Alexander, K. Barnas, S. Brooks, J. Carr, S. Clayton, C. Dahm, J. Follstad-Shah, D. Galat, S. Gloss, P. Goodwin, D. Hart, B. Hassett, R. Jenkinson, S. Katz, G.M. Kondolf, P.S. Lake, R. Lave, J.L. Meyer, T.K. O'Donnell, L. Pagano, B. Powell, and E. Sudduth. 2005. Synthesizing U.S. river restoration efforts. Science 308:636-637. (i)

Bilby, R.E., R.R. Fransen, and P.A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning Coho Salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164–173. (i)

Bilby, R.E., and J.T. Heffner. 2016. Factors influencing litter delivery to streams. Forest Ecology and Management 369:29-37. (i)

Bisson, P.A., and R.E. Bilby. 1998. Organic matter and trophic dynamics. Page 373-398 *in* R.J. Naiman and R.E. Bilby, editors. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. (i)

Bohn, H.L., B.L. McNeal, and G.A O'Connor. 1985. Soil chemistry. John Wiley and Sons, New York. (i)

Booth, D.B. 2005. Challenges and prospects for restoring urban streams: a perspective from the Pacific Northwest of North America. Journal of North American Benthological Society 24:724–737. (i)

Brooks, J.R., H. Barnard, R. Coulombe, and J.J. McDonnell. 2010. Ecohydrologic separation of water between trees and streams in a Mediterranean climate. Nature Geoscience 3:100-104. (i)

Brown G.W., A.R. Gahler, and R.B Marston. 1973. Nutrient losses after clear-cut logging and slash burning in the Oregon Coast Range. Water Resources Research 9:1450-1453. (i)

2 References are classified according to RCW 34.05.271 (see Appendix 1) denoted by a lower case roman numeral (i – viii) in parentheses at the end of the citation.

Burt, T.P., G. Pinay, F.E. Matheson, N.E. Haycock, A. Butturini, J.C. Clement, S. Danielescu, D.J. Dowrick, M.M. Hefting, A. Hillbricht-Ilkowska, and V. Maitre. 2002. Water table fluctuations in the riparian zone: comparative results from a pan-European experiment. Journal of Hydrology 265:129–148. (i)

Cardinale, B.J., M.A. Palmer, C.M. Swan, S. Brooks, and N.L. Poff. 2002. The influence of substrate heterogeneity on biofilm metabolism in a stream ecosystem. Ecology 83:412–422. (i)

Cardinale, B.J. 2011. Biodiversity improves water quality through niche partitioning. Nature 472:86-89. (i)

Carpenter, S., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. Issues in Ecology No. 3, Ecological Society of America, Washington, D.C. (i)

Cederholm, C.J., D.B. Houston, D.I. Cole, and W.J. Scarlett. 1989. Fate of Coho Salmon *Oncorhynchus kisutch* carcasses in spawning streams. Canadian Journal of Fisheries and Aquatic Sciences 46:1347–55. (i)

Cederholm, C.J., M.D. Kunze, T. Murota, and A. Sibatani. 1999. Pacific salmon carcasses: essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. Fisheries 24:6–15. (i)

Chappell, H.N., D.W. Cole, S.P. Gessel, and R.B. Walker. 1991. Forest fertilization research and practice in the Pacific Northwest. Fertilizer Research 27:129-140. (i)

Compton, J.E., M.R. Church, S.T. Larned, and W.E. Hogsett. 2003. Nitrogen export from forested watersheds of the Oregon Coast Range: the role of N_2-fixing Red Alder. Ecosystems 6:773–85. (i)

Compton, J.E., and D.W. Cole. 1998. Phosphorus cycling and soil P fractions in Douglas-fir and Red Alder stands. Forest Ecology and Management 110:101-112. (i)

Compton, J.E., C.P. Andersen, D.L. Phillips, J.R. Brooks, M.G. Johnson, M.R. Church, W.E. Hogsett, M.A. Cairns, P.T. Rygiewicz, B.C. McComb, and C.D. Shaff. 2006. Ecological and water quality consequences of nutrient addition for salmon restoration in the Pacific Northwest. Frontiers in Ecology and the Environment 4:18–26. (i)

Cooper, C.A., P.M. Mayer, and B.R. Faulkner. 2014. Effects of road salts on groundwater and surface water dynamics of sodium and chloride in an urban restored stream. Biogeochemistry 121:149-166. (i)

Craig, L.S., M.A. Palmer, D.C Richardson, S. Filoso, E.S. Bernhardt, B.P. Bledsoe, M.W. Doyle, P.M. Groffman, B.A. Hassett, S.S. Kaushal, P.M. Mayer, S.M. Smith, and P.R. Wilcock. 2008. Stream restoration strategies for reducing river nitrogen loads. Frontiers in Ecology and the Environment 6:529-538. (i)

Dahl, M., B. Nilsson, J.H. Langhoff, and J.C. Refsgaard. 2007. Review of classification systems and new multi-scale typology of groundwater–surface water interaction. Journal of Hydrology 344:1–16. (i)

Denver, J.M., C.A. Cravotta III, S.W. Altor, and B.D. Lindsey. 2010. Contributions of phosphorus from groundwater to streams in the Piedmont, Blue Ridge, and Valley and Ridge Physiographic Provinces, Eastern United States. Scientific Investigations Report 2010–5176. U.S. Geological Survey, Reston, Virginia. (viii)

Domagalski J.L., and H. Johnson. 2012. Phosphorus and groundwater: establishing links between agricultural use and transport to streams. U.S. Geological Survey, California Water Science Center, Sacramento. (viii)

Dosskey, M.G., P. Vidon, N.P. Gurwick, C.J. Allan, T.P. Duval, and R. Lowrance. 2010. The role of riparian vegetation in protecting and improving chemical water quality in streams. Journal of the American Water Resources Association 46:261-277. (i)

Dudley-Williams, D., and N.E. Williams. 1993. The upstream/downstream movement paradox of lotic invertebrates: quantitative evidence from a Welsh mountain stream. Freshwater Biology 30:199-218. (i)

Edmonds, R.L., T.B. Thomas, and R.D. Blew. 1995. Biogeochemistry of an old-growth forested watershed, Olympic National Park, Washington. Water Resources Bulletin 31:409-419. (i)

FISRWG (Federal Interagency Stream Restoration Working Group). 1998. Stream corridor restoration: principles, processes, and practices. NEH-653. Natural Resources Conservation Service, Washington, D.C. (viii)

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic and social assessment. U.S. Department of Agriculture and U.S. Department of the Interior, Portland, Oregon. (viii)

Fernald, A.G., D.H. Landers, and P.J. Wigington. 2006. Water quality changes in hyporheic flow paths between a large gravel bed river and off-channel alcoves in Oregon, USA. River Research and Applications 22:1111-24. (i)

Filoso, S., and M.A. Palmer. 2011. Assessing stream restoration effectiveness at reducing nitrogen export to downstream waters. Ecological Applications 21:1989–2006. (i)

Gellis, A.C., and G.B. Noe. 2013. Sediment source analysis in Linganore Creek watershed, Maryland, USA, using the sediment fingerprinting approach: 2008 to 2010. Journal of Soils and Sediments 13:1735–1753. (i)

Gende, S.M., R.T. Edwards, M.F. Willson, and M.S. Wipfli. 2002. Pacific salmon in aquatic and terrestrial ecosystems. BioScience 52:917-28. (i)

Giardina, C., S. Huffman, D. Binkley, and B. Caldwell. 1995. Alders increase phosphorus supply in a Douglas-fir plantation. Canadian Journal of Forest Research 25:1652-1657. (i)

Giesler, R., T. Andersson, L. Lövgren, and P. Persson. 2005. Phosphate sorption in aluminum- and iron-rich humus soils. Soil Science Society of America 69:77–86. (i)

Greathouse, E.A., J.E. Compton, and J. Van Sickle. 2014. Linking landscape characteristics and high stream nitrogen in the Oregon Coast Range: Red Alder complicates use of nutrient criteria. Journal of the American Water Resources Association 50:1383-1400. (i)

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the Northeast Pacific Ecosystem: evidence of a nutrient deficit in the freshwater systems of the Pacific Northwest. Fisheries 25:15-21. (i)

Groffman, P.M., N.J. Boulware, W.C. Zipperer, R.V. Pouyat, L.E. Band, and M.F. Colosimo. 2002. Soil nitrogen cycling processes in urban riparian zones. Environmental Science & Technology 36:4547-4552. (i)

Groffman, P.M., D.J. Bain, L.E. Band, K.T. Belt, G.S. Brush, J.M. Grove, R.V. Pouyat, I.C. Yesilonis, and W.C. Zipperer. 2003. Down by the riverside: urban riparian ecology. Frontiers in Ecology and the Environment 1:315–321. (i)

Groffman, P.M., A.M. Dorsey, and P.M. Mayer. 2005. Nitrogen processing within geomorphic features in urban streams. Journal of North American Benthological Society 24:613-625. (i)

Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkaemper, K. Cromack, Jr., and K.W. Cummins, 1986. Ecology of coarse woody debris in temperate ecosystems. Advances in Ecological Research 15:133-302. (i)

Hart, S.K., D.E. Hibbs and S.S. Perakis. 2013. Riparian litter inputs to streams in the central Oregon Coast Range. Freshwater Science 32:343-358. (i)

Hedin, L.O., J.C. von Fischer, N.E. Ostrom, B.P. Kennedy, M.G. Brownand, and G.P. Robertson. 1998. Thermodynamic constraints on nitrogen transformations and other biogeochemical processes at soil-stream interfaces. Ecology 79:684-703. (i)

Hefting, M., J.C. Clement, D. Dowrick, A.C. Cosandey, S. Bernal, C. Cimpian, A. Tatur, T. P. Burt, and G. Pinay. 2004. Water table elevation controls on soil nitrogen cycling in riparian wetlands along a European climatic gradient. Biogeochemistry 67:113-134. (i)

Helfield J.M., and R. Naiman. 2001. Effects of salmon-derived nitrogen on riparian forest growth and implications for stream productivity. Ecology 82:2403-2409. (i)

Hershey, A.E., J. Pastor, B.J. Peterson, and G.W. Kling. 1993. Stable isotopes resolve the drift paradox for Baetis mayflies in an arctic river. Ecology 74:2315-2325. (i)

Hinkle, S.R., J.H. Duff, F.J. Triska, A. Laenen, E.B. Gates, K.E. Bencala, D.A. Wentz, and S.R. Silva. 2001. Linking hyporheic flow and nitrogen cycling near the Willamette River–a large river in Oregon, USA. Journal of Hydrology 244:157-80. (i)

Hinkle, S.R. 2009. Tritium/helium-3 apparent ages of shallow ground water, Portland basin, Oregon, 1997–98: Scientific Investigations Report 2009-5057. U.S. Geological Survey, Reston, Virginia. (viii)

Hoffmann, C.C., C. Kjaergaard, J. Uusi-Kämppä, H.C. Bruun, and B. Kronvang. 2009. Phosphorus retention in riparian buffers: review of their efficiency. Journal of Environmental Quality 38:1942–1955. (i)

Ice, G., and D. Binkley. 2003. Forest streamwater concentrations of nitrogen and phosphorus: comparison with EPA's proposed water quality criteria. Journal of Forestry 101:21–28. (i)

Inglett K.S., P.W. Inglett, K.R. Reddy, and T.Z. Osborne. 2012. Temperature sensitivity of greenhouse gas production in wetland soils of different vegetation. Biogeochemistry 108:77-90. (i)

Jacoby J.M., and J. Kann. 2007. The occurrence and response to toxic cyanobacteria in the Pacific Northwest, North America. Lake Reservoir Management 23:123–143. (i)

Johnson, D.W., and D.W. Cole. 1980. Anion mobility in soils: relevance to nutrient transport from forest ecosystems. Environment International 3:79-90. (i)

Jordan, S.J., J. Stoffer, and J.A. Nestlerode. 2011. Wetlands as sinks for reactive nitrogen at continental and global scales: a meta-analysis. Ecosystems 14:144-155. (i)

Kaushal, S.S., M. Pace, P. Groffman, L. Band, K. Belt, P. Mayer, and C. Welty. 2010. Land use and climate variability amplify contaminant pulses. EOS Transactions of the American Geophysical Union 91:221-222. (i)

Kaushal, S.S., and W.M. Lewis Jr. 2005. Fate and transport of dissolved organic nitrogen in minimally disturbed streams of Colorado, USA. Biogeochemistry 74:303–321. (i)

Kaushal, S.S., P.M. Mayer, P.G. Vidon, R.M. Smith, M.J. Pennino, S. Duan, T.A. Newcomer, C. Welty, and K. Belt. 2014. Land use and climate variability amplify carbon, nutrient, and contaminant pulses: a review with management implications. Journal of the American Water Resources Association 50:585-614. (i)

Lazar, J.G., A.J. Gold, K. Addy, P.M. Mayer, K.J. Forshay, and P.M. Groffman. 2014. Instream large wood: denitrification hotspots with low N_2O production. Journal of the American Water Resources Association 50:615-625.

Martin, C.W., and R.D. Harr. 1989. Logging of mature Douglas-fir in western Oregon has little effect on nutrient output budgets. Canadian Journal of Forest Research 19:35-43. (i)

Masese, F.O., K.G. Abrantes, G.M. Gettel, S. Bouillon, K. Irvine, and M.E. McClain. 2015. Are large herbivores vectors of terrestrial subsidies for riverine food webs? Ecosystems 18:686-706. (i)

Mayer, P.M., A.H. Todd, J.A. Okay, and K.A. Dwire. 2010a. Introduction to the featured collection on riparian ecosystems and buffers. Journal of the American Water Resources Association 46:207-210. (i)

Mayer, P.M., P.M. Groffman, E. Striz, and S.S. Kaushal. 2010b. Nitrogen dynamics at the groundwater-surface water interface of a degraded urban stream. Journal of Environmental Quality 39:810–823. (i)

Mayer, P.M., K.A. Dwire, J.A. Okay, and P. Vidon. 2014. Introduction to the featured collection on riparian ecosystems. Journal of the American Water Resources Association 50:529-532. (i)

Mayer, P.M., S.K. Reynolds, M.D. McMutchen, and T.J. Canfield. 2007. Meta-analysis of nitrogen removal in riparian buffers. Journal of Environmental Quality 36:1172-1180. (i)

McClain, M.E., R.E. Bilby, and F.J. Triska. 1998. Biogeochemistry of N, P, and S in Northwest rivers: natural distributions and responses to disturbance. Pages 347-372 *in* R.J Naiman and R.E. Bilby, editors. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. (i)

McClain, M.E., E.W. Boyer, C.L. Dent, S.E. Gergel, N.B. Grimm, P.M. Groffman, S.C. Hart, J.W. Harvey, C.A. Johnston, E. Mayorga, W.H. McDowel,l and G. Pinay. 2003. Biogeochemical hot spots and hot moments at the interface of terrestrial and aquatic ecosystems. Ecosystems 6:301–312. (i)

McDowell, W.H., and G.E. Likens. 1988. Origin, composition, and flux of dissolved organic carbon in the Hubbard Brook Valley. Ecological Monographs 58:177-195. (i)

Menberg, K., P. Blum, B.L. Kurylyk, and P. Bayer. 2014. Observed groundwater temperature response to recent climate change. Hydrology and Earth System Sciences 18:4453–4466. (i)

Merritts, D., R. Walter, M. Rahnis, J. Hartranft, S. Cox, A. Gellis, N. Potter, W. Hilgartner, M. Langland, L. Manion, C. Lippincott, S. Siddiqui, Z. Rehman, C. Scheid, L. Kratz, A. Shilling, M. Jenschke, K. Datin, E. Cranmer, A. Reed, D. Matuszewski, M. Voli, E. Ohlson, A. Neugebauer, A. Ahamed, C. Neal, A. Winter, and S. Becker S. 2011. Anthropocene streams and base-level controls from historic dams in the unglaciated mid-Atlantic region, USA. Philosophical Transactions of the Royal Society A 369:976–1009. (i)

Moore, R.D., and S.M. Wondzell. 2005. Physical hydrology and the effects of forest harvesting in the Pacific Northwest: a review. Journal of the American Water Resources Association 41:763-784. (i)

Moyle, P., A. Engilis, M. Escobar, C.M. Mosser, D. Purkey, L.C., and M.L. Truan. 2009. Progress report: innovative management options to prevent loss of ecosystem services provided by Chinook Salmon in California: overcoming the effects of climate change. US EPA NCER program. Available: http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/9070/-report/2009. (January 2019). (viii).

Mulholland, P.J., E.R. Marzolf, S.P. Hendricks, R.V. Wilkerson, and A.K. Baybayan. 1995. Longitudinal patterns of nutrient cycling and periphyton characteristics in streams: a test of upstream-downstream linkage. Journal of North American Benthological Society 14:357-370. (i)

Mulholland, P.J., A.M. Helton, G.C. Poole, R.O. Hall Jr., S.K. Hamilton, B.J. Peterson, J.L. Tank, L.R. Ashkenas, L.W. Cooper, C.N. Dahm, W.K. Dodds, S.E.G. Findlay, S.V. Gregory, N.B. Grimm, S.L. Johnson, W.H. McDowell, J.L. Meyer, H.M. Valett, J.R. Webster, C.P. Arango, J.J. Beaulieu, M.J. Bernot, A.J. Burgin, C.L. Crenshaw, L.T. Johnson, B.R. Niederlehner, J.M. O'Brien, J.D. Potter, R.W. Sheibley, D.J. Sobota, and S.M. Thomas. 2008. Stream denitrification across biomes and its response to anthropogenic nitrate loading. Nature 452:202-206. (i)

Murphy, M.L. 1998. Primary productivity. Pages 144-168 *in* R.J. Naiman and R.E. Bilby, editors. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York (i)

Naiman, R.J., J.S. Bechtold, T.J. Beechie, J.J. Latterell, and R. Van Pelt. 2010. A process-based view of floodplain forest patterns in coastal river valleys of the Pacific Northwest. Ecosystems 13:1-31. (i)

Naiman, R.J., and K.H. Rogers. 1997. Large animals and system level characteristics in river corridors. BioScience 47:521–9. (i)

Naiman, R.J., C.A. Johnston, and J.C. Kelley. 1988. Alteration of North American streams by Beaver. BioScience 38:753-762. (i)

Naiman, R.J., G. Pinay, C.A. Johnson, and J. Pastor. 1994. Beaver-induced influences on the long-term biogeochemical characteristics of boreal forest drainage networks. Ecology 75:905-921. (i)

Naiman, R.J., R.E. Bilby, D.E. Schindler, and J.M. Helfield. 2002. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. Ecosystems 5:399-417. (i)

Newbold, J.D., R.V. O'Neill, J.W. Elwood, and W. Van Winkle. 1982. Nutrient spiralling in streams: implications for nutrient limitation and invertebrate activity. The American Naturalist 120:628-652. (i)

Newcomer, T.A., S.S. Kaushal, P.M. Mayer, A.R. Shields, E.A. Canuel, P.M. Groffman, and A.J. Gold. 2012. Influence of natural and novel organic carbon sources on denitrification in forested, degraded-urban, and restored streams. Ecological Monographs 82:449–466. (i)

Perakis, S.S., D.A. Maguire, T.D. Bullen, K. Cromack, R.H. Waring, and J.R. Boyle. 2006. Coupled nitrogen and calcium cycles in forests of the Oregon Coast Range. Ecosystems 9:63-74. (i)

Peterson, B.J., W.M. Wollheim, P.J. Mulholland, J.R. Webster, J.L. Meyer, J.L. Tank, E. Marti, W.B. Bowden, H.M. Valett, A.E. Hershey, W.H. McDowell, W.K. Dodds, S.K. Hamilton, S. Gregory, and D.D. Morrall. 2001. Control of nitrogen export from watersheds by headwater streams. Science 292:86-90. (i)

Peterson, C.E., and J.W. Hazard. 1990. Regional variation in growth response of coastal Douglas-fir to nitrogen fertilizer in the Pacific Northwest. Forest Science 36:625–640. (i)

Phelps, J.D. 2011. The geomorphic legacy of splash dams in the southern Oregon Coast Range. Master's thesis. University of Oregon. Eugene. (i)

Pingram M.A., K.J. Collier, D.P. Hamilton, B.O. David, and B.J. Hicks. 2012. Carbon sources supporting large river food webs: a review of ecological theories and evidence from stable isotopes. Freshwater Reviews 5:85–103. (i)

Pollock, M.M., T.J. Beechie, and C.E. Jordan. 2007. Geomorphic changes upstream of Beaver dams in Bridge Creek, an incised stream channel in the interior Columbia River basin, eastern Oregon. Earth Surface Processes and Landforms 32:1174-1185. (i)

Reddy K.R., O.A. Diaz, L.J. Scinto, and M. Agami. 1995. Phosphorus dynamics in selected wetlands and streams of the Lake Okeechobee basin. Ecological Engineering 5:183–207. (i)

Richardson, C.J., and P.E. Marshall. 1986. Processes controlling movement, storage and export of phosphorus in a fen peatland. Ecological Monographs 56:279–302. (i)

Richardson, J.S., and R.J. Danehy. 2007. A synthesis of the ecology of headwater streams and their riparian zones in temperate forests. Forest Science 53:131-147. (i)

Royer, T.V., and M.B. David. 2005. Export of dissolved organic carbon from agricultural streams in Illinois, USA. Aquatic Sciences 67:465–471. (i)

Sabater, S., H. Guasch, A. Roman, and I. Munoz. 2002. The effect of biological factors on the efficiency of river biofilms in improving water quality. Hydrobiologia 469:149-156. (i)

Sabater S., S.V. Gregory, and J.R. Sedell. 1998. Community dynamics and metabolism of benthic algae colonizing wood and rock substrata in forest stream. Journal of Phycology 34:561-567. (i)

Schechter, S.P., T.J. Canfield, and P.M. Mayer. 2013. A meta-analysis of phosphorus attenuation in best management practices (BMP) and low impact development (LID) practices in urban and agricultural areas. EPA 600/R-13/208. National Risk Management Research Laboratory, Ada, Oklahoma. (viii)

Scrivener, J.C. 1975. Water, water chemistry, and hydrochemical balance of dissolved ions in Carnation Creek watershed, Vancouver Island, July 1971 - May 1974. Technical Report 564. Canadian Fisheries and Marine Service, Vancouver, British Columbia. (viii)

Sedell, J.R., and K.J. Luchessa. 1981. Using the historical record as an aid to salmonid enhancement. Pages 210-223 *in* N.B. Armantrout, editor. Acquisition and utilization of aquatic habitat inventory information. Western Division, American Fisheries Society, Portland, Oregon. (viii)

Shen, J., L. Yuan, J. Zhang, H. Li, Z. Bai, X. Chen, W. Zhang, and F. Zhang. 2011. Phosphorus dynamics: from soil to plant. Plant Physiology 156:997-1005. (i)

Silvester, W.B. 1989. Molybdenum limitation of asymbiotic nitrogen fixation in forests of Pacific Northwest America. Soil Biology and Biochemistry 21:283-289. (i)

Sobczak, W.V., S.E.G. Findlay, and S. Dye. 2003. Relationships between DOC bioavailability and nitrate removal in an upland stream: an experimental approach. Biogeochemistry 62:309–327. (i)

Sobota, D.J., S. Johnson, S.V. Gregory, and L.R. Ashkenas, LR. 2012. A stable isotope tracer study of the influences of adjacent land use and riparian condition on fates of nitrate in streams. Ecosystems 15:1-17. (i)

Sollins, P., C.C. Grier, F.M. McCorison, K. Cromack Jr., R. Fogel, and R.L. Fredriksen. 1980. The internal element cycles of an old-growth Douglas-fir ecosystem in western Oregon. Ecological Monographs 50:261-285. (i)

Stanley, E.H., S.M. Powers, N.R. Lottig, I. Buffam, and J.T. Crawford. 2012. Contemporary changes in dissolved organic carbon (DOC) in human-dominated rivers: is there a role for DOC management? Freshwater Biology 57:26-42. (i)

Stonestrom, D.A., and J. Constantz. 2003. Heat as a tool for studying the movement of groundwater near streams. Circular 1260. U.S. Geological Survey, Denver, Colorado. (viii)

Striz, E.A., and P.M. Mayer. 2008. Assessment of near-stream groundwater-surface water interaction (GSI) of a degraded stream before restoration. EPA/600/R-07/058, National Risk Management Research Laboratory, Ada, Oklahoma. (viii)

Swain, N.R., and J.D. Reynolds. 2015. Effects of salmon-derived nutrients and habitat characteristics on population densities of stream-resident sculpins. PLOS ONE 10(6): e0116090. (i)

Sweeney, B.W., and J.D. Newbold. 2014. Streamside forest buffer width needed to protect stream water quality, habitat, and organisms: a literature review. Journal of the American Water Resources Association 50:560-584. (i)

Sweeney, B.W., T.L. Bott, J.K. Jackson, L.A. Kaplan, J.D. Newbold, L.J. Standley, W.C. Hession, and R.J. Horwitz. 2004. Riparian deforestation, stream narrowing, and loss of stream ecosystem services. Proceedings of the National Academy of Sciences 101:14132-14137. (i)

Tague, C., and G.E. Grant. 2004. A geological framework for interpreting the low-flow regimes of Cascade streams, Willamette River Basin, Oregon. Water Resources Research 40:W04303. (i)

Tarrant, R.F., L.A. Issac, and R.F. Chandler. 1951. Observations on litter fall and foliage nutrient content of some Pacific Northwest tree species. Journal of Forestry 49:914-915. (i)

Triska, F.J., J.R. Sedell, K. Cromack Jr., S.V. Gregory, and F.M. McCorison. 1984. Nitrogen budget for a small coniferous forest stream. Ecological Monographs 54:119-40. (i)

USEPA ATTAINS database. Available: http://www2.epa.gov/nutrient-policy-data/waters-assessed-impaired-due-nutrient-related-causes. (June 2015). (vi)

Vaccaro, J.J. 2011. River-aquifer exchanges in the Yakima River basin, Washington: U.S. Geological Survey Scientific Investigations Report 2011-5026. U.S. Geological Survey, Reston, Virginia. (viii)

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fish and Aquatic Science 37:130-137. (i)

Vidon, P., C. Allan, D. Burns, T.P. Duval, N. Gurwick, S. Inamdar, R. Lowrance, J. Okay, D. Scott, and S. Sebestyen. 2010. Hot spots and hot moments in riparian zones: potential for improved water quality. Journal of the American Water Resources Association 46:278-298. (i)

Vidon, P., P.A. Jacinthe, X. Liu, K. Fisher, and M. Baker. 2014. Hydrobiogeochemical controls on riparian nutrient and greenhouse gas dynamics: 10 Years post-restoration. Journal of the American Water Resources Association 50:639-652. (i)

Von Schiller, D., V. Acuña, D. Graeber, E. Martí, M. Ribot, S. Sabater, X. Timoner, and K. Tockner. 2011. Contraction, fragmentation and expansion dynamics determine nutrient availability in a Mediterranean forest stream. Aquatic Sciences 73:485-497. (i)

Wallace, J.B., S.L. Eggert, J.L. Meyer, and J.R. Webster. 1997. Multiple trophic levels of a forest stream linked to terrestrial litter inputs. Science 277:102-104. (i)

Walter, R.C., and D.J. Merritts. 2008. Natural streams and the legacy of water-powered mills. Science 319:299–304. (i)

Weitzman, J.N., K.J. Forshay, J.P. Kaye, P.M. Mayer, J. Koval, and R.C. Walter. 2014. Potential nitrogen and carbon processing in a landscape rich in mill-dam legacy sediments. Biogeochemistry 120:337-357. (i)

Welch, E.B., J.M. Jacoby and C.W. May. 1998. Stream quality. Pages 69-94 *in* R.J. Naiman, and R.E. Bilby, editors. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. (i)

Wigington, P.J. Jr., T.J. Moser, and D.R. Lindeman. 2005. Stream network expansion: a riparian water quality factor. Hydrological Processes 19:1715–1721. (i)

Wigington, P.J., M.R. Church, T.C. Strickland, K.N. Eshleman, and J. Van Sickle. 1998. Autumn chemistry of Oregon Coast Range streams. Journal of the American Water Resources Association 34:1035-49. (i)

Willson, M.F., and K.C. Halupka. 1995. Anadromous fish as keystone species in vertebrate communities. Conservation Biology 9:489–97. (i)

Wilzbach, M.A., B.C. Harvey, J.L. White, and R.J. Nakamoto. 2005. Effects of riparian canopy opening and salmon carcass addition on the abundance and growth of resident salmonids. Canadian Journal of Fisheries and Aquatic Sciences 62:58–67. (i)

Wipfli, M.S. 2005. Trophic linkages between headwater forests and downstream fish habitats: implications for forest and fish management. Landscape and Urban Planning 72:205-213. (i)

Wipfli, M.S., and C.V. Baxter. 2010. Linking ecosystems, food webs, and fish production: subsidies in salmonid watersheds. Fisheries 35:373-387. (i)

Wipfli, M.S., and J. Musslewhite. 2004. Density of Red Alder (*Alnus rubra*) in headwaters influences invertebrate and detritus subsidies to downstream fish habitats in Alaska. Hydrobiologia 520:153-163.

Wise, D.R., and H.M. Johnson. 2013. Application of the SPARROW model to assess surface-water nutrient conditions and sources in the United States Pacific Northwest. Scientific Investigations Report 2013–5103. U.S. Geological Survey, Reston, Virginia. Available: **http://pubs.usgs.gov/sir/2013/5103/.** (Januray 2019) (viii)

Wise, D.R., and H.M. Johnson. 2011. Surface-water nutrient conditions and sources in the United States Pacific Northwest. Journal of the American Water Resources Association 47:1110-1135. (i)

Wohl, E.E. 2000. Mountain Rivers. The American Geophysical Union, Washington, D.C. (viii)

Wondzell, S.M. 2011. The role of the hyporheic zone across stream networks. Hydrological Processes 25:3525-3532. (i)

Xiong, S., and C. Nilsson. 1997. Dynamics of leaf litter accumulation and its effects on riparian vegetation: a review. Botanical Review 63:240–264. (i)

Yanai, R.D. 1992. Phosphorus budget of a 70-yr-old northern hardwood forest. Biogeochemistry 17:1-22. (i)

Zarnetske, J.P., R. Haggerty, S.M. Wondzell, V.A. Bokil, and R. González-Pinzón. 2012. Coupled transport and reaction kinetics control the nitrate source-sink function of hyporheic zones. Water Resources Research 48: W11508. (i)

Zarnetske, J.P., R. Haggerty, S.M. Wondzell, and M.A. Baker. 2011. Dynamics of nitrate production and removal as a function of residence time in the hyporheic zone. Journal of Geophysical Research 116:G01025. (i)

Zhang, X., X. Liu, M. Zhang, R.A. Dahlgren, and M. Eitzel. 2010. A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution. Journal of Environmental Quality 39:76-84. (i)

Zou, X., D. Binkley, and B.A. Caldwell. 1995. Effects of dinitrogen-fixing trees on phosphorus biogeochemical cycling in contrasting forests. Soil Science Society of America Journal 59:1452-1458. (i)



Big Creek Trail/Rachel Blomker, WDFW



Chapter 7. Riparian Areas of the Columbia Plateau

By: George F. Wilhere

This chapter is dedicated Karin Divens who passed away unexpectedly on 12 October 2017. Karin made a significant contribution to this chapter by organizing a two-day, multi-disciplinary workshop that advanced our scientific understanding of riparian areas in the Columbia Plateau Ecoregion. Karin was an effective and well-respected habitat biologist at WDFW, who brought not only science to her work but a full heart.

7.1. Introduction

The Columbia Plateau Ecoregion (sensu Omernick 1987),[1] is classified as a cold desert (Sleeter 2012), and covers about one-third of Washington State (Figure 7.1). In the driest parts of the ecoregion, a rain shadow cast by the Cascades Mountains limits precipitation to 6 to 9 in (15 to 23 cm) per year, and even wettest parts of the ecoregion, the Palouse Hills Subregion, receive only 18 to 23 in (46 to 58 cm) per year (Bryce and Omernik 1997). Uplands of the Columbia Plateau are covered by either shrub-steppe or steppe[2] vegetation (i.e., sagebrush and bunchgrass communities, respectively), and, most notably, lack trees (Franklin and Dyrness 1988). The ecoregion's desert climate confines nearly all trees to riparian areas.[3]

Seventy-five years ago Daubenmire (1942) wrote, "The vegetation of the unforested regions in the Pacific Northwest has been less thoroughly studied and is consequently less perfectly understood than is that of the forested areas." The situation has not changed. Most of what is known about riparian areas in the Pacific Northwest is based on research conducted in forested ecoregions. During my review of the scientific literature, I found far less information about the composition, structure, and functions of riparian ecosystems in unforested ecoregions, such as the Columbia Plateau, than I found for forested ecoregions. However, many of the basic principles and qualitative relationships that have emerged from research in forested ecoregions are also valid in unforested ecoregions. For instance, while there are significant quantitative differences among ecoregions in the amount of wood or shade provided by riparian areas, the physical processes of large wood recruitment and stream shading should be very nearly the same. On the other hand, processes that are strongly affected by groundwater, such as nutrient dynamics and pollutant removal, should be different. To clarify current

[1] There are several different delineations of ecoregions (e.g., USFWS 1994; Bailey 1995; Olson et al. 2001). For this report WDFW used the ecoregions of Omernick (1987). The only non-forested ecoregion in Washington is the Columbia Plateau. Forested ecoregions surrounding the Columbia Plateau in Washington are the Eastern Cascades, North Cascades, Okanogan, Northern Rockies, and Blue Mountains.

[2] Steppe is also referred to as grassland or prairie. The steppe region of southeastern Washington is called the Palouse.

[3] A notable exception is the Juniper Dunes Wilderness Area, which preserves the northernmost Western Juniper Trees *Juniperus occidentalis* in North America. This 7100-acre area contains no surface water.



The amount of rain received by the Columbia Plateau Ecoregion each year is insufficient to support trees in the uplands/Justin Haug, WDFW

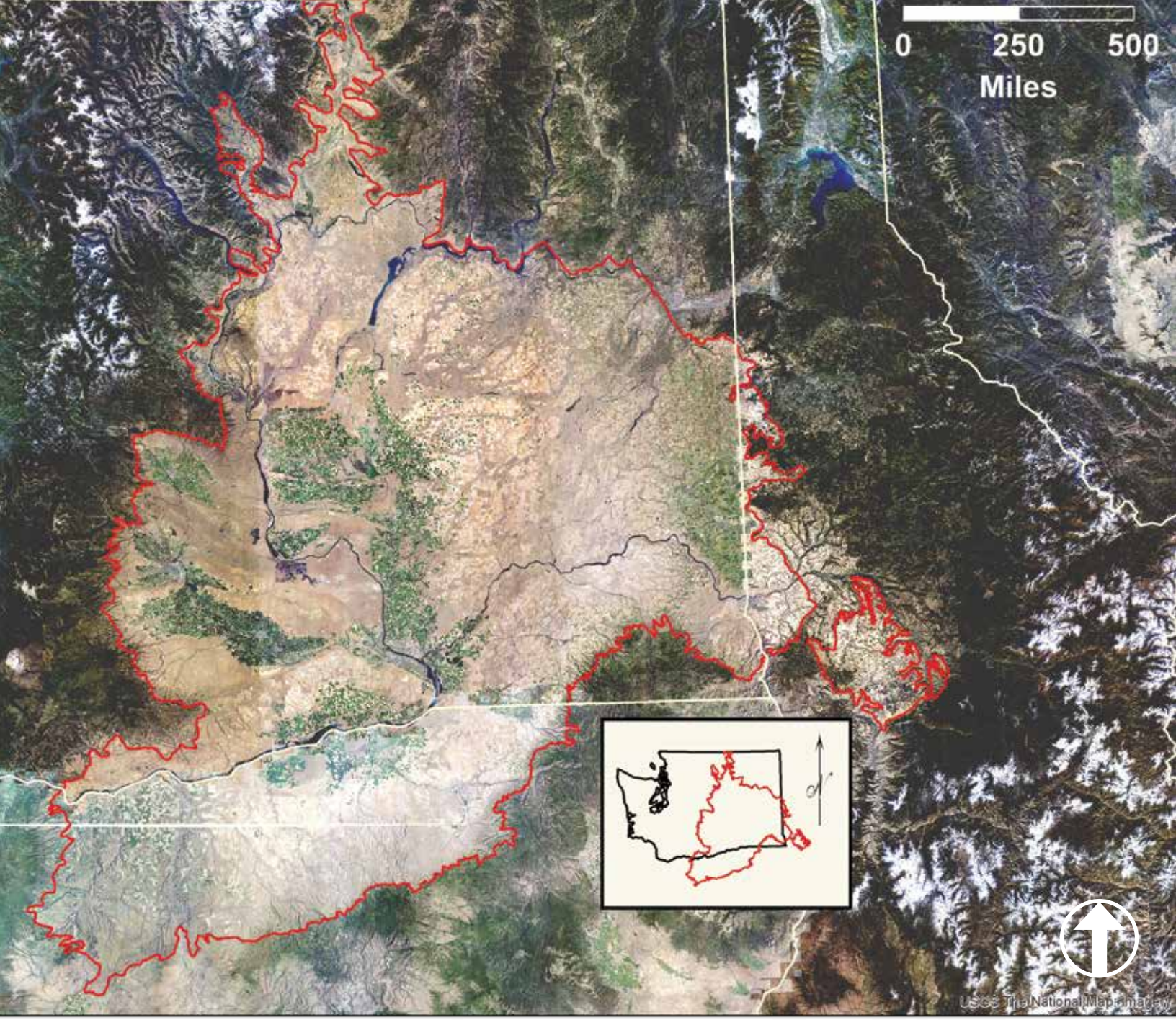


Figure 7.1. Boundary (in red) of the Columbia Plateau Ecoregion. State boundaries are white. Aerial photography for Washington State done in 2015 by the National Agriculture Imagery Program.

scientific understanding, throughout this chapter I point out differences between riparian areas in forested and unforested ecoregions.

The Columbia Plateau Ecoregion is comprised of both arid and semi-arid subregions (hereafter collectively known as drylands). Due to lack of information, I make few subregional distinctions regarding riparian areas. Most of what is known about the ecology of dryland riparian areas is based on research conducted in desert ecoregions of the southwestern United States (Patten 1998). Although these ecoregions have climate, hydrology, soils, and vegetation different from the Columbia Plateau, many of the basic principles and qualitative relationships that have emerged from research in other desert ecoregions should be valid for the Columbia Plateau.

7.1.1. Dryland Riparian Areas

Decades ago, the term "riparian" referred exclusively to areas adjacent to surface waters with moist soils that support distinctive vegetation (e.g., Thomas et al. 1979, Anderson 1987). Later definitions expanded the meaning of riparian. Sedell et al. (1989) and Naiman et al. (1992), for example, divided the "riparian ecosystem" or "riparian area" into two zones: a "riparian zone" with moist soils supporting wetland and riparian-dependent vegetation, and an upland "zone of influence" that significantly influences the exchanges of energy and matter between terrestrial and aquatic ecosystems (Figure 7.2). In forested ecoregions, the potential vegetation of both zones is commonly forest, and the ecological functions of the zones are similar. In the Columbia Plateau, vegetation within riparian ecosystems often exhibits an abrupt demarcation between the two zones. Phreatophytic[4] trees and shrubs and hydrophytic[5] herbaceous plants are confined to moist streamside areas, but the upland zone of influence may consist of sagebrush or bunchgrass communities. Consequently, the functions of the two zones may be quite different. Along some reaches, the riparian zone and zone of influence may both reside within a floodplain and exhibit similar composition and structure. For our purposes, the phrases riparian ecosystem and riparian area are synonymous.

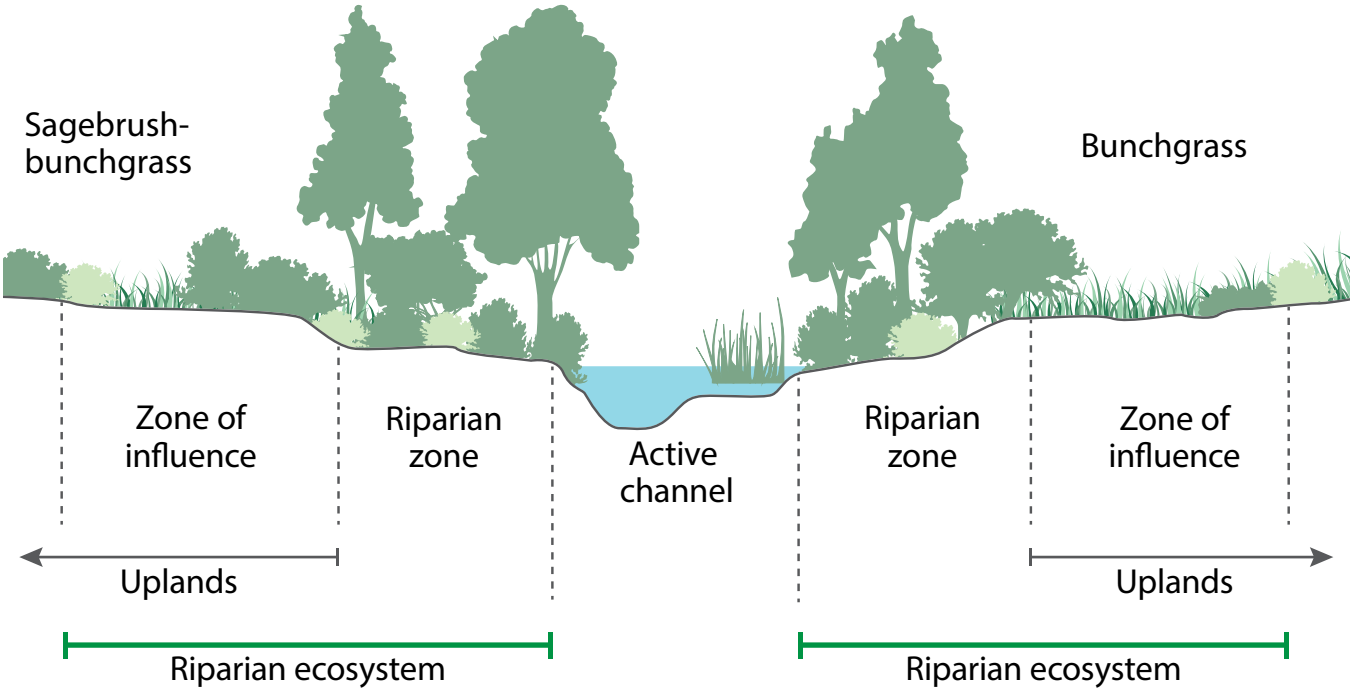


Figure 7.2. Dryland Riparian Ecosystem. The riparian ecosystem consists of two zones: riparian and zone of influence. The riparian zone extends from the edge of the active channel towards the uplands. This zone includes areas where terrestrial biota are influenced, at least periodically, by surface or subsurface waters. Beyond this is the riparian "zone of influence." This includes areas where ecological functions significantly influence the stream (diagram modified from USFS 2004).

[4] A phreatopyhtic plant is a species that obtains water from the subsurface zone of saturation either directly or through the capillary fringe (Thomas 2014).
[5] Hydrophytic plants are those that are adapted to growing conditions associated with periodically saturated soils. They include obligate wetland plants that almost always occur in wetlands under natural conditions, facultative wetland plants that usually occur in wetlands but are occasionally found in non-wetlands, and facultative plants that equally likely to occur in wetlands or non-wetlands (Lichvar et al. 2012).



In the semi-arid Columbia Plateau Ecoregion, trees are generally confined to riparian areas/Scott Fitkin, WDFW

In dryland ecoregions, riparian ecosystems are the ultimate expression of groundwater and surface-water interactions (Webb and Leake 2006). Soil moisture and water table elevation are key variables in the survival of riparian-dependent plants. Stream discharge affects soil moisture by saturating soils and recharging the alluvial aquifer during overbank flooding, and stream stage (i.e., surface elevation) directly affects water table elevation.

In dryland ecoregions, trees and dense shrubs exist only near surface water, such as a river, stream, or lake. In the Columbia Plateau, surface streamflow is highly dependent on its source. Rivers and perennial[6] streams generally originate in the adjacent mountainous ecoregions (Omernik and Gallen 1986), and their peak flows, if unaffected by dams, generally occur during fall or winter storms and/or during spring snowmelt (Reidy Liermann et al. 2012). Within the Columbia Basin, the flow source of most streams is groundwater (Reidy Liermann et al. 2012), and consequently, during the hot, dry summer, many streams originating within the ecoregion are intermittent (Daubenmire 1942; Bryce and Omernik 1997). This spatial and temporal variability in local hydrology affects the distribution, abundance, and species of plants in dryland riparian areas.

[6] A perennial stream is one which flows continuously. An ephemeral stream, or section of stream, is one that flows only in direct response to precipitation. It receives no water from springs and no long-continued supply from melting snow or other surface source. An intermittent stream is one that flows during protracted periods when it receives water from some surface or subsurface source, such as melting snow or a spring (Meinzer 1923).

The diversity[7] of riparian climax plant communities in the Columbia Plateau Ecoregion is greater than the diversity in surrounding forested ecoregions. In forested ecoregions, the potential natural vegetation of nearly all riparian areas along rivers and streams is forest. The species composition may vary, but the climax community's structure ultimately attains a closed-canopy of trees, with the upland zone of influence most often dominated by conifer species. In the Columbia Plateau, differences in hydrology and geomorphology manifest substantial site-level differences in composition and structure of riparian vegetation (Hough-Snee et al. 2015). A rudimentary classification system based on overstory conveys obvious differences in vertical structure: tall tree, short tree, tall shrub, shrub, grass-like, grass, and forb (Figure 7.3; Crawford 2003). The main tall tree types have an overstory consisting of Black Cottonwood *Populus trichocarpa*, White Alder *Alnus rhombifolia*, or Quaking Aspen *Populus tremuloides*. Short tree types have an overstory of Thinleaf Alder *Alnus incana*, Water Birch *Betula occidentalis*, or Black Hawthorn *Crataegus douglasii*.[8] Tree vegetation types are usually multi-layered with shrub and herbaceous layers under the tree canopy. Common shrubs are Redosier Dogwood *Cornus sericea*, Common Snowberry *Symphoicarpos albus*, Lewis' Mockorange *Philadelphus lewisii*, and Woods' Rose *Rosa woodsii*. Tall shrub vegetation types include those dominated by willow species (e.g., Yellow *Salix lutea*, Sandbar *S. exigua*) which can be up to 20 ft (6 m) tall.

The structural diversity of riparian vegetation in the Columbia Plateau causes differences in site-level functions. Large wood recruitment, for instance, cannot occur in all riparian areas, and the amount of stream shading will vary considerably due to site-to-site variation in vertical structure.



The most diverse and productive biological communities of the Columbia Plateau are riparian areas/Rex Crawford, WNHP



Nearly all woody vegetation in riparian areas of the Columbia Plateau consists of deciduous shrubs and trees/Scott Fitkin, WDFW

[7] Measures of biological diversity take into account two factors: species richness (i.e., the number of different types) and evenness (i.e., the relative abundance of different types). While the richness of riparian climax plant communities in forested ecoregions may be comparable to that of dryland ecoregions, the relative abundance of different riparian climax plant communities is more even in dryland ecoregions. This results in a greater diversity of types.

[8] Black Hawthorn might also be considered a tall shrub. Crawford (2003) reported Black Hawthorn in riparian areas to be 6 to 20 ft (2 to 6 m) tall, and Daubenmire (1970) found Black Hawthorn up to 27 ft (8 m) tall.

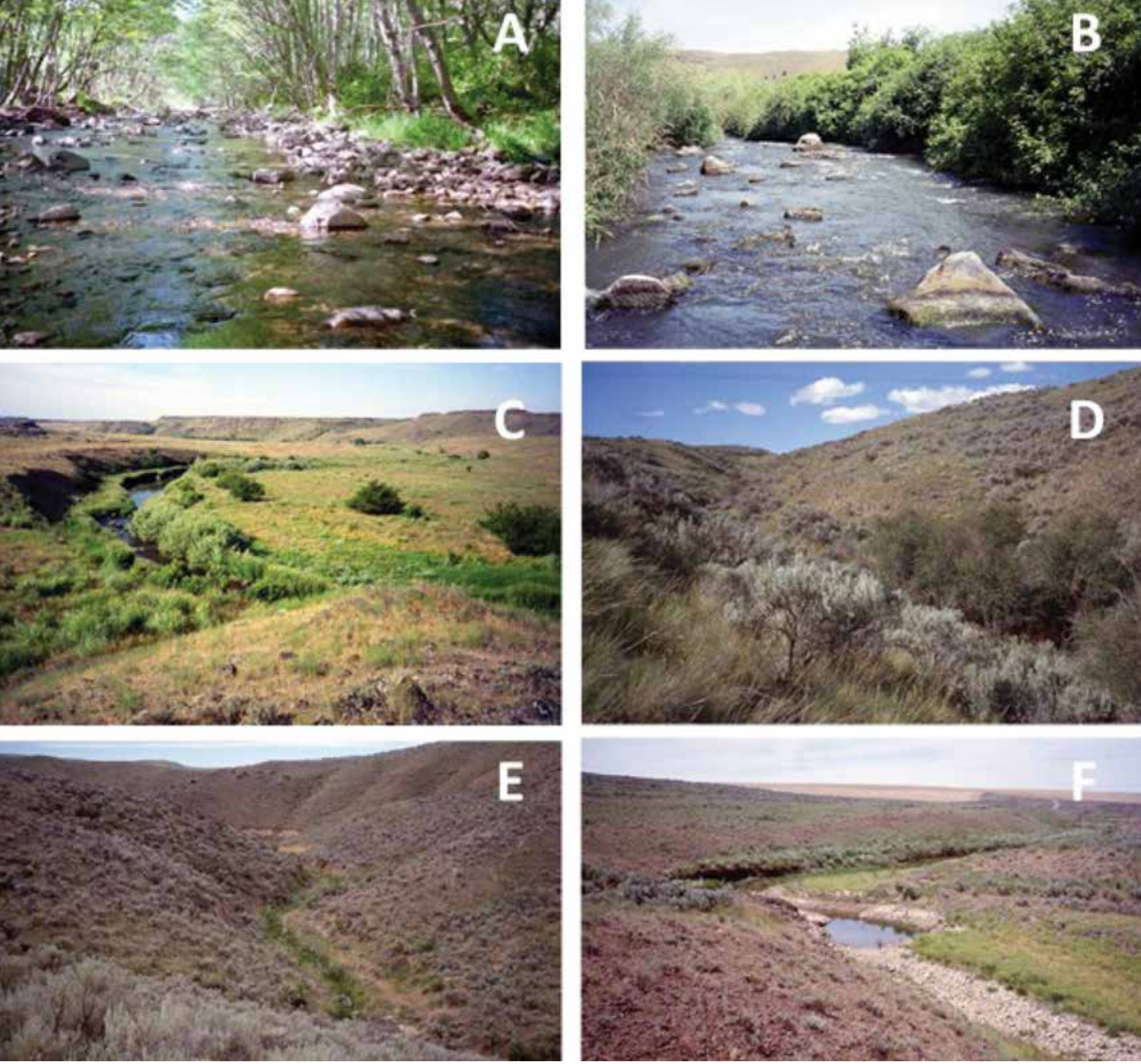


Figure 7.3. Different riparian vegetation structure types: A) tall tree, B) short tree, C) tall shrub, D) shrub on an intermittent stream, E) grass-like, F) forb/Rex Crawford, WNHP

7.2. Historical Context

Because western Washington and Oregon have a substantial amount of national park, wilderness, and roadless areas, the scientific literature contains many descriptions of unmanaged, natural riparian areas within forested ecoregions (e.g., Fonda 1974; Campbell and Franklin 1979; McKee et al. 1982; Sedell and Swanson 1984; Pabst and Spies 1999; Latterell and Naiman 2007; Fox and Bolton 2007). In the Columbia Plateau Ecoregion, however, nearly all riparian areas have been significantly impacted by human land use (grazing, intensive agriculture), resource exploitation (Beaver *Castor canadensis* trapping, timber harvest), water management (dams, diversions, reservoirs), or invasive species (Reed Canary Grass *Phalaris arundinacea*, Russian Olive *Elaeagnus angustifolia*). Daubenmire wrote in 1942, "few typical remnants of the original prairie and desert remain. These relics of the primeval vegetation likewise seem to be heading toward nearly complete extermination within a few years . . ." In short, the conditions of natural riparian areas in the Columbia Plateau Ecoregion are effectively unknown to science.

7.2.1. Beaver Trapping

The first major ecological impacts of Europeans on riparian areas in the Columbia Plateau Ecoregion were due to American Beaver (hereafter Beaver) trapping. In the early 1800s, Beaver hats were very fashionable and in high demand across Europe. The Hudson's Bay Company was determined to profit from that demand, and to obtain Beaver skins it managed a network of forts or trading posts throughout the Pacific Northwest (and throughout western North America). Several were established in and around the Columbia Plateau: Spokane House at the mouth of the Little Spokane River in 1810; Fort Okanagan at the confluence of Okanogan and Columbia rivers in 1811; a temporary post from 1812 to 1813 near confluence of Snake and Clearwater rivers; Fort Nez Perces[9] near the Walla Walla and Columbia rivers' confluence in 1818; and a temporary post at The Dalles from 1829 to 1830 (Meinig 1968). Most Beaver skins traded at these forts were obtained from the surrounding forested ecoregions.

Fort Nez Perces was situated near the center of the Columbia Plateau, and its district, which was delineated by The Dalles to the west, Priest Rapids to the north, and the Deschutes, John Day, and Grande Ronde watersheds to the south, was considered poor "fur country." Nevertheless, between 1827 and 1831 about 1,150 Beaver skins per year were traded at Fort Nez Perces (Meinig 1968). During that period, the number of Beaver skins traded per year at Fort Nez Perces dropped by 50%. Given the locations of trading posts and the high demand for Beaver skins, if Beaver could be trapped profitably in the Columbia Plateau, then they probably were. North of the Columbia Plateau, Beaver were also heavily exploited, and impacts to Beaver populations are indicated by trends in Beaver skins. The number of Beaver skins traded at the Hudson's Bay Company's Fort Colville (founded in 1825) dropped precipitously from 3600 per year in 1826 to 438 per year in 1850 (Johnson and Chance 1974).

The Hudson's Bay Company's annual Snake Country Expeditions operated out of Fort Walla Walla (formerly Fort Nez Perces). One goal of these expeditions was to create a "fur desert" which was intended to discourage America's westward expansion into lands controlled by Great Britain (Lorne 1993). George Simpson, the Hudson's Bay Company's governor at Fort Walla Walla, wrote in 1824, ". . . we have convincing proof that the country is a rich preserve of Beaver and which for

[9] In 1818 the North West Company opened a fur-trading post near the mouth of the Walla Walla River at the current location of Wallula, Washington. Originally called Fort Nez Perces, it was renamed Fort Walla Walla when the North West Company and the Hudson's Bay Company merged in 1821 (Denfeld 2011).

political reasons we should endeavor to destroy as fast as possible" (Ott 2003). In 1825 the trapper Peter Ogden and his party collected 3,577 Beaver skins in the Crooked River watershed, a semi-arid portion of the neighboring Blue Mountains Ecoregion, and on two subsequent expeditions trapped more Beaver in this area (Buckley 1993). During the 1825 expedition, Odgen noted that the Crooked River's tributaries were well lined with willows and aspen. By 1910, if not sooner, Beaver had been eliminated from some tributaries of the Crooked River, and the willow and aspen had vanished (Buckley 1993). The eradication of Beaver from dryland riparian areas is thought to have caused a cascade of adverse effects upon riparian ecosystems that I discuss in Section 7.3.

7.2.2. Open Range Grazing by Livestock

Open-range grazing by livestock was the next major ecological impact of Europeans in the Columbia Plateau Ecoregion. Around 1730, Native Americans on the Columbia Plateau acquired horses descended from those brought by Spanish explorers (Carlson 1940). In 1805, Lewis and Clark saw about 700 horses in one Indian village and thousands more in the nearby hills (Galbraith and Anderson 1971). Daubenmire (1970) believed that while most villages were on rivers, the impacts to riparian vegetation by horses were probably not extensive. A few cattle were brought to the Okanogan Valley in 1825 and to the Walla Walla Valley in 1834 (Carlson 1940). By 1855, roughly 200,000 cattle inhabited the Columbia Plateau of Washington (Daubenmire 1970). Sheep herding developed in the 1880s (Daubenmire 1970), and great numbers of sheep were brought to eastern Washington in 1892 (Galbraith and Anderson 1971). By the late 1800s, damage to rangeland from overgrazing was evident. Based on his 1893 expedition from Spokane to Steven's Pass, the botanist John Leiberg wrote, "We will never know the complete flora of these regions. Sheep and cattle are rapidly destroying the native plants and by the time private explorations reach these regions the flora will have been totally exterminated by such agencies" (as cited in Mack 1988; Weddell 2001).

Open-range management of livestock invariably results in excessive utilization of riparian areas (Ohmart 1996), and the destructive impacts of unmanaged grazing in riparian areas are well-documented (Kauffman and Krueger 1984; Ohmart 1996, Belsky et al. 1999). Riparian areas in arid and semi-arid lands of the western United States cover only 1 to 2% of land area, but produce 20% of available forage and nearly 80% of forage actually consumed by cattle (Fisher 1995). Therefore, it is reasonable to assume that the damage observed by Leiberg was greatest in riparian areas.

Restoration projects can indicate the density of woody plants that existed historically in riparian areas prior to intensive livestock grazing. For example, two years after the cessation of grazing within riparian areas in northeastern Oregon, the mean crown volume of willows and Thinleaf Alder tripled in size and that of Black Cottonwood increased nine-fold (Case and Kauffman 1997). Furthermore, shrub density increased by 50%. One possible reason for the severe impacts of grazing in the Columbia Plateau is that, unlike the Great Plains, Bison (*Bison bison*) have been rare or absent from the Columbia Plateau for close to 10,000 years (Jones 2000). According to Daubenmire (1970) and also Mack and Thompson (1982), ungulates played no significant role in the evolution of plant species in steppe and shrub-steppe communities of the Columbia Plateau, and consequently present-day vegetation cannot endure intensive grazing by livestock.

The impacts of both Beaver trapping and open-range livestock grazing may have acted synergistically to degrade riparian areas. Baker et al. (2005) suggest that Beaver and willow (*Salix* spp.) are mutualists because willow is an important food source for Beaver, and Beaver create environmental conditions suitable

as willow habitat. Baker et al. (2005) believed this relationship can persist indefinitely within a given area. They also speculated that heavy browsing by native ungulates or livestock disrupt the Beaver-willow mutualism, thus leading to degradation of the riparian ecosystem. Ohmart (1996), based on personal observation, suggested that overgrazing by livestock causes an imbalance in the Beaver-vegetation relationship that leads to collapse of riparian forests. A similar relationship has also been observed in Yellowstone National Park (Beschta and Ripple 2016) where decades of intensive grazing by Elk *Cervus canadensis* during the absence of Wolves *Canis lupus* resulted in riparian plant communities that could no longer support Beaver. The reintroduction of Wolves has led to a recovery of Beaver in Yellowstone (Beschta and Ripple 2016).

Today in the Columbia Plateau Ecoregion, the most severe impacts from grazing are caused by wild or feral horses (hereafter collectively known as wild horses). Until the mid-1900s, wild horses inhabited open rangelands in various parts of the Columbia Plateau. Today wild horses are confined to Native American reservations where the number of wild horses has fluctuated greatly over the past 140 years. The reservation of the Yakama Nation, for instance, supported roughly 16,000 horses in 1878, but a round up in 1957 left 300 horses on the reservation (Adams 2004). By 2010, the number of horses had rebounded to 12,000 (YN 2010), but the current carrying capacity of the Yakama Nation's reservation is only about 1,000 horses (Mapes 2010). Consequently, wild horses have destroyed rangelands, cultural resources, and wildlife habitats, including riparian areas (NTHC, no date). Wild horse populations also exceeded the carrying capacities of the Colville and Umatilla reservations (AP 2012; Tribal Tribune 2013). Effective management of wild horses on Native American reservations has been hampered by continual controversy regarding the most practical and ethical means of reducing their population sizes.

7.2.3. Wood Harvest and Wheat

The Donation Land Claim Act of 1850 and Homestead Act in 1862 were major impetuses for settlement of Oregon and Washington states. Settlers needed wood for fuel and construction. On the Columbia Plateau the closest source of wood, and in some places the only practical source, was riparian areas. Historians have little information on wood harvest in riparian areas by early settlers on the Columbia Plateau, however, the practices of pioneers and settlers on the Great Plains, as described by West and Ruark (2004), are likely to be similar to their practices on the Columbia Plateau. West and Ruark (2004) state that pioneers on their way west stripped virtually all trees from the Platte River valley, that riparian areas on the Great Plains were an important source of winter fuel for settlers, and that by 1900 most of the trees in riparian areas of the Great Plains had been harvested. Daubenmire (1970) speculated that Black Cottonwood, the largest tree species in the Columbia Plateau, was much more abundant before the arrival of settlers.

Impacts of Beaver trapping and open-range livestock grazing may have acted synergistically to degrade riparian areas. Baker et al. (2005) suggest that Beaver and willow are mutualists because willow is an important food source for Beaver, and Beaver create environmental conditions suitable as willow habitat.

River commerce on the Columbia and Snake rivers may have also impacted riparian areas. By 1859, steamboats were travelling upriver as far as Wallula, Washington and could reach Lewiston, Idaho at high water (Meinig 1968, cited in Evans 1989). HIstorians do not know how much wood was burned to power steamboats in the Columbia Basin, but estimates from other western watersheds suggest severe impacts to riparian forests along the Columbia and Snake. On the upper Missouri River in Montana, for instance, riparian forests along its banks were denuded of usable trees by the turn of the century (Evans 1989).

The soils and climate of the Palouse Hills subregion are suitable for dryland wheat agriculture. Consequently, the next major impact to riparian areas was converting native vegetation to wheat. The first wheat was planted in 1877, by 1895 most of the tillable land in the subregion had been plowed (Kaiser 1961), and during the 1970s industrial agriculture expedited the destruction of the last refugia for native plant communities (Black et al. 1998). Agriculture in the Palouse Hills had four major impacts on riparian areas, which were all poorly documented: 1) fields were plowed to the very edge of streambanks, thereby destroying riparian vegetation, 2) many ephemeral channels were plowed through and filled (Kaiser 1961; Bryce and Omernik 1997), 3) perennial and intermittent stream channels became deeply incised (Rockie 1939), and 4) some channels were filled with sediment from soil erosion (Rockie 1939; Bryce and Omernik 1997). Rockie (1939) reported a Nez Percé Indian telling him that some dry channels in the Palouse Hills were once perennial streams containing trout. According to Bryce and Omernik (1997), the original channel substrate, riparian vegetation, and flow regime (i.e., perennial or intermittent) are impossible to know in areas of intensive agriculture.



The least arid subregions of the Columbia Plateau support productive grasslands/Alan Bauer

7.2.4. Large-scale Irrigation Projects

Across the Columbia Plateau, the most obvious human impacts to native habitat types, including riparian areas, are those associated with irrigation projects. The U.S. Bureau of Reclamation manages two major projects on the Columbia Plateau, the Yakima and Columbia Basin, which service about 1,135,000 acres (459,318 ha) of farmland (USBR 2017a; 2017b). Another 37,000 acres (14,973 ha) are irrigated with water impounded by dams on the Snake River (USACE 2002). All 1.17 million acres (473,482 ha) of irrigated farmland were once shrub-steppe or steppe vegetation. However, these projects did not record how many acres of riparian area have been lost because ephemeral or intermittent stream channels were filled for agriculture or converted to irrigation ditches.

Construction of the Yakima Project began in 1906, and the last of 11 dams on the Yakima River or its tributaries was completed in 1939 (USBR 2017a). The Yakima Project's biggest impacts to riparian areas are along the Naches and Yakima rivers. Storage reservoirs and water diversions located upstream have truncated the rivers' natural hydrographs. This has substantially reduced river-floodplain interactions, such as inundation and lateral channel migration, which in turn have led to channel simplification and degraded aquatic and riparian habitats (Snyder and Stanford 2001; YSPB 2004).

Construction of the Columbia Basin Project began in 1933 with Grand Coulee Dam, and the first irrigation water was delivered in 1952 (USBR 2017b). The Columbia Basin Project includes a network of canals, drains, and wasteways over 5,800 miles (9,334 km) long. The reservoir behind Grand Coulee Dam, Lake Roosevelt, inundated roughly 84 miles (135 km) of riparian habitat within the Columbia Plateau Ecoregion along the Columbia, Spokane, and Sanpoil rivers.[10] Roughly 460 miles (740 km) of the Columbia River lie within the Columbia Plateau Ecoregion, but only 51 miles (82 km) of riparian habitat, the Hanford Reach, have not been inundated by reservoirs. When the dams were built, there was apparently some hope that vegetation would re-establish along new reservoir margins, but water level fluctuations appear to be too extreme for most plants to tolerate (Evans 1989). The other major impacts to riparian areas from the Columbia Basin Project are dramatic changes in hydrology. The groundwater table around lower Crab Creek, for instance, has risen between 50 and 150 ft (15 and 46 m) since 1952. Furthermore, the formerly intermittent lower Crab Creek is now perennial with four to five times the flow that occurred prior to irrigation (KWA 2004), and, as a consequence, willow species, which are adapted to the natural hydrologic regime, no longer regenerate along lower Crab Creek (Ortolano and Cushing 2000). In contrast, due to groundwater withdrawals, the groundwater table around upper Crab Creek (the Odessa subarea) has fallen 150 ft (46 m) (KWA 2004). I found no records on how the water table changes may have affected stream flow in upper Crab Creek.

Decades of hydrological alteration by dams and water diversions have altered vegetation composition and structure of riparian areas. Black Cottonwood and willow are successional pioneers that require barren sediments of disturbed alluvial floodplains for seedling germination (Patten 1998). Such conditions are produced by floods, but dams reduce peak flows and the erosive forces that scour sediments. Furthermore, the survival and growth of Black Cottonwood seedlings is highly dependent on water table elevation and its seasonal rate of change (Braatne et al. 1996). If the water table declines more rapidly than seedling root growth, then seedlings die. Braatne et al. (2007), for example, found that dams on the Yakima River created

[10] Estimated with Google Earth. Distance estimated along Spokane River comports with that reported by Ortolano and Cushing (2000).

hydrological conditions unsuitable for Black Cottonwood seedlings. They studied river reaches near Cle Elum, Union Gap, and Wapato and found: 1) no seedlings in any reaches, 2) Black Cottonwood stands less than 25 years old were extremely limited, 3) riparian areas were dominated by older age classes, and 4) altered hydrology promoted invasion of the floodplain by exotic tree species such as Silver Maple *Acer saccharinum*, Norway Maple *Acer platanoides*, and Chinese Elm *Ulmus parvifolia*. Hence, one could confidently infer that historical conditions have been altered by regulated flows. If artificial flow regimes are not changed, then as older individuals senesce and die, cottonwoods may be eliminated from some sections of the Yakima River. This would have adverse effects on multiple riparian area functions: streambank stability, shading, large wood recruitment, and detrital nutrients. Exotic tree species currently found along the Yakima River cannot provide the same ecological functions as Black Cottonwood because they cannot establish themselves in the barren, saturated sediments of recently disturbed floodplains.

Dams have also altered the flow of wood through watersheds. Historically, wood was transported from forested headwaters to dryland reaches of rivers and streams. This process is known to have occurred in other semi-arid and arid regions of the United States.

"We will never know the complete flora of these regions. Sheep and cattle are rapidly destroying the native plants and by the time private explorations reach these regions the flora will have been totally exterminated by such agencies."

- Botanist John Leiberg, 1893

Minckley and Rinne (1985) present historical evidence for the movement of large wood in desert rivers of the American southwest: wood originated in forested headwaters, moved sporadically through desert riparian areas during flood events, and was ultimately deposited at the mouth of the Colorado River in Mexico. Minckley and Rinne (1985) identified interception of large wood by dams as a major cause of large wood reduction in semi-arid and arid river basins. At artificial reservoirs in eastern Washington, such as Keechelus, Kachess, Cle Elum, Easton, Bumping, Clear, and Rimrock lakes, large wood that could potentially interfere with dam operations is removed and burned (W. Meyer, Washington Department of Fish and Wildlife, personal communication; B. Renfrow, Washington Department of Fish and Wildlife, personal communication). Large wood in dryland sections of the Wenatchee and Okanogan rivers may be effected in this way as well. How wood management at dams and smaller water diversions affects in-stream large wood in eastern Washington has not been investigated.

7.2.5. Invasive Non-native Plants

An ongoing historical anthropogenic impact is the introduction of exotic invasive plant species. After their botanical survey of the Columbia Plateau in 1893, Sandberg and Leiberg were not troubled by the meager abundance of exotic species at that time (Mack 1988), however, by 1929 about 200 exotic species were known to exist on the plateau (Mack 1988). Riparian areas in dryland landscapes are more vulnerable to invasion by exotic plant species than adjacent upland areas (Loope et al. 1988; Hood and Naiman 2000), and invasive plants in riparian areas can impact a variety of ecological processes: hydrology, sediment dynamics, nutrient dynamics, and species competition. Two invasive species of particular concern are Reed Canary Grass and Russian Olive.[11]

11 Other invasive species of concern in the Columbia Plateau Ecoregion are Crack Willow *Salix fragilis*, Yellow Flag Iris *Iris pseudacorus*, and Purple Loosestrife *Lythrum salicaria*.

Reed Canary Grass occurs as both exotic and indigenous strains (Tu 2006). The European cultivar has been present in the Pacific Northwest since the 1880s (Stannard and Crowder 2001), and, as of 2016, it is found in all Washington counties except Douglas (WSDA 2016). Reed Canary Grass forms dense stands that can exclude all other plant species, and such stands exhibit substantially higher transpiration per unit ground surface area than other species (Gebauer et al. 2015). This could alter water availability in riparian areas. Reed Canary Grass also has higher roughness values than native sedge species (Martinez and McDowell 2016). This could lead to greater sediment deposition and channel narrowing.

As of 2016, Russian Olive is found in most counties east of the Cascade crest and is most common in Grant County (WSDA 2016). In the late 1800s, it was introduced into the Pacific Northwest as an ornamental plant (Giblin 2006), but the species did not become prominent outside cultivated areas until two to five decades later, depending on location. Unlike many tree and shrub species in dryland riparian areas, Russian Olive does not require disturbed soils for germination. Hence, it can grow on sites where woody vegetation would not naturally occur (Katz and Shafroth 2003). It is also shade tolerant, and consequently, Russian Olive can establish beneath the canopy of native riparian trees or shrubs and compete with them for resources. Russian Olive exhibits about two times higher transpiration per unit basal area than cottonwood trees (Hultine and Bush 2011). This could alter water availability in riparian areas. The species is a nitrogen fixer that adds nitrogen to the soil. Tuttle et al. (2016) found that stands of Russian Olive had higher exotic plant ground cover than stands of native tree species, and they believed that the difference was due to higher available soil nitrogen that benefited fast growing exotics plants. Finally, according to Lesica and Miles (1999), Beaver foraging behavior indicates that Russian Olive is much less palatable than native cottonwood. They found that 77% of cottonwood trees along a river in Montana were damaged by Beaver but only 22% of Russian Olive trees were damaged. If Russian Olive replaces native cottonwood, then Beaver population density could be adversely affected.

7.2.6. Value of a Historical Perspective

Current scientific understanding of riparian ecosystems in the Columbia Plateau Ecoregion is mostly based on present-day conditions, which are unlikely to accurately represent historical composition and structure. History indicates that past human impacts in the Columbia Plateau may have erased fully functioning riparian ecosystems from many watersheds. For example, records of the U.S. Army cavalry at Fort Simcoe on the Yakama Indian Reservation from the 1850s describe small valleys with broad floodplains dissected by multi-threaded stream channels that are absent today. These valleys—such as the Wenas, Ahtanum, and Cowiche—historically contained a network of streams, wetlands, and Beaver ponds that supported extensive groves of willow, Redosier Dogwood, Black Cottonwood, and aspen. Cattle were said to be lost for weeks in these tangles (P. Harvester, Washington Department of Fish and Wildlife, personal communication). These same streams are now reduced to a single, incised channel with minimal riparian vegetation. The loss of riparian habitats indicated by the Fort Simcoe records is very likely to have occurred in other parts of the Columbia Plateau.

Rivers and streams of the Columbia Plateau Ecoregion have been degraded by a variety of human activities. This has adversely affected anadromous salmon—their populations are threatened with extinction and fisheries produce a small fraction of historical harvest. In response, salmon habitat restoration projects are occurring throughout the Columbia Plateau. Habitat restoration requires ecological reference information to determine site-level restoration potential, establish desired conditions, and formulate measures of success

(White and Walker 1997). Ecological reference information is generally based on historical conditions, natural areas, or minimally disturbed sites (White and Walker 1997; Stoddard et al. 2006; Higgs et al. 2014). In the Columbia Plateau Ecoregion, which lacks national parks, wilderness, or roadless areas containing natural reference sites, historical information may be the only basis for reference conditions (Wohl 2005).

Because the Columbia Plateau lacks undisturbed watersheds, even small ones, ecologists have a poor understanding of the composition, structure, and functions of natural riparian ecosystems. Historical reconstruction using journals of early explorers and naturalists, General Land Office survey notes, and historical drawings or photos (Figure 7.4) are ways to develop qualitative descriptions of riparian plant

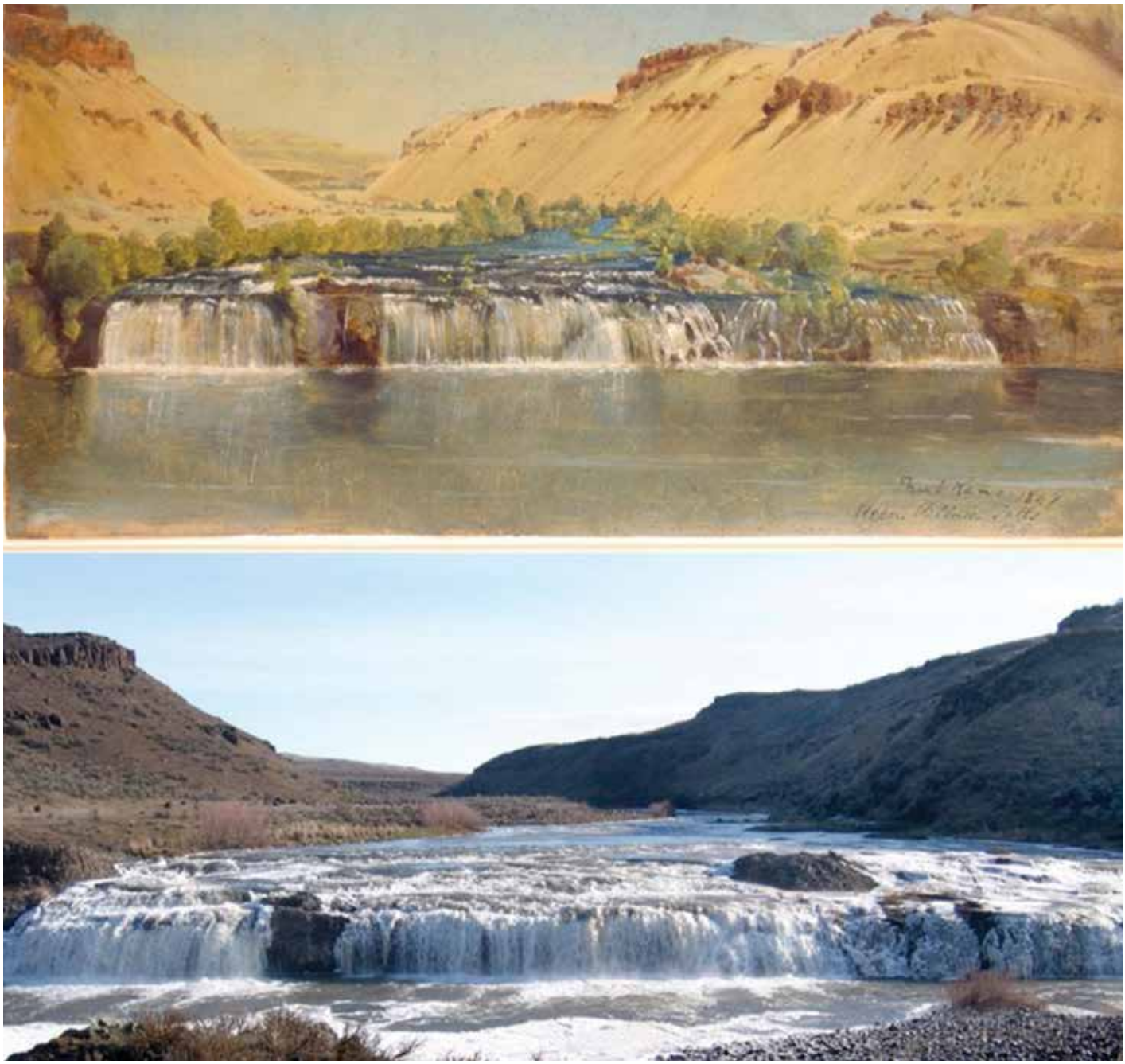


Figure 7.4. Historical drawings and paintings can provide invaluable information for riparian area restoration. A 1847 painting by Paul Kane of Upper Palouse Falls (top) shows extensive, uninterrupted small tree or tall shrub vegetation along the river banks. A recent photo by Jack Nisbet (bottom) although taken in winter, shows large gaps in small tree or tall shrub vegetation along the banks.

communities (McAllister 2008). Much work needs to be done on deducing the likely historical conditions of riparian areas in the Columbia Plateau. Studies of historical conditions in the Columbia Plateau, however, must be cognizant of one important caveat. If hydrology of a riparian area has been significantly altered by human activity, then the vegetation that site supported historically may have no relationship to the vegetation the site is capable of supporting now. Irrigation systems have altered hydrology in riparian areas throughout the Columbia Plateau, making some drier and others wetter. At such places, information on historical vegetation will often be of little value in establishing desired future conditions for restoration.

7.3. Beaver

Beaver may play an essential role in the restoration and future conservation of dryland riparian areas (Dremmer and Beschta 2008; Pollock et al. 2014). The ecosystem benefits of Beaver in dryland riparian areas have been known for over 80 years. Scheffer (1938) reported that in 1936 the Soil Conservation Service transplanted 10 Beaver to the Ahtanum Creek watershed for the purposes of increasing water storage. The Beaver constructed several large dams, one of which was 90 ft (27 m) long, 10 ft (3 m) high, and stored 5 acre-feet (6,167 m^3) of water. Scheffer (1938) implied that the dams reduced downstream flood damage and increased summer stream flows for irrigation. Finley (1937) reported the opposite situation for Silver Creek in eastern Oregon. Two trappers removed 600 Beaver in one winter. As a result, the Beaver ponds "disappeared," the water table lowered, grassy meadows "died out" and streams containing trout went dry.

The observations of Scheffer (1938) and Finley (1937) are anecdotes. More rigorous scientific research into the connections between Beaver and riparian ecosystems have found that Beaver have numerous positive effects.



Beaver viewed with night vision camera/Ned Pittman, WDFW

Beaver dams store organic nutrients and large quantities of sediment, reduce channel incision, remove excess nutrients from water, increase surface water storage and base flows, reduce peak flows, increase groundwater recharge, raise water table elevations, expand the area of riparian vegetation, and increase the salmonid habitat capacity of small streams (Naiman et al. 1988; Pollock et al. 2003; Gibson and Olden 2014). For dryland riparian areas where the extent of riparian vegetation depends on shallow groundwater, the hydrologic and geomorphic effects of Beaver dams may be necessary for the mere existence of a riparian zone at many sites. In dryland riparian areas, most ecosystem functions occur within the riparian zone.

The dramatic effects of Beaver on hydrology was shown by Westbrook et al. (2006), a multi-year study of two Beavers dams on a fourth order stream running through a dry meadow in the Rocky Mountains of Colorado. One dam diverted over half and the other diverted 70% of the stream onto the floodplain and terrace. Both dams increased substantially the area flooded by annual peak flows. One dam caused the equivalent of a 20-year flood over 30 acres (12 ha) of the valley floor during a peak flow event with a 1.6-year recurrence interval, and the other dam caused the equivalent of a 200-year flood over 21 acres (8 ha) of the valley floor during a peak flow event with a 1-year recurrence interval. One of the dams

studied by Westbrook et al. (2006) was breached by high flows. Westbrook et al. (2011) subsequently found that overbank flooding caused by that dam had deposited nutrient-rich sediments in some areas and scoured soils in other areas downstream of the dam site. These bare sediments were colonized by willow and aspen seedlings, which may eventually establish riparian plant communities.

In sagebrush steppe of Wyoming, Cooke and Zach (2008) found that the number of Beaver dams was positively associated with riparian zone width, riparian shrub height and percent cover by emergent wetland vegetation. These responses can at least partly be explained by changes in hydrology caused by Beaver dams.

Eradication of Beaver has been implicated in stream channel incision and desertification of riparian zones that has occurred throughout arid and semi-arid ecoregions of western North American (Parker et al. 1985; Pollock et al. 2003), including the Columbia Plateau (Pollock et al. 2007). According to Pollock et al. (2007), the exact mechanism that caused widespread incision of streambeds remains uncertain, however, incision almost invariably coincided with widespread trapping of Beaver and the onset of intensive livestock grazing. Channel incision, whatever the ultimate cause, occurs through an imbalance between sediment deposition and sediment mobilization. Assuming no changes in upstream sediment sources, incision is usually attributed to an increase in erosive forces or a decrease in channel resistance to erosive forces. The former can be caused by an increase in runoff, both can be caused by a decrease in channel roughness, and the latter can also be caused by loss of streamside vegetation. Therefore, channel incision can be prevented by controlling runoff caused by upstream land uses, maintaining roughness elements such as large wood, and retaining riparian vegetation. For many dryland riparian areas, Beaver are essential for the latter two. Beaver dams act as massive roughness elements that reduce flow velocities, thereby reducing hydraulic forces that cause erosion. Reducing flow velocities also results in sediment deposition, which raises the streambed elevation and creates microsites suitable for germination of riparian plants.

Several studies have suggested that reintroduction of Beaver can reverse channel incision (Pollock et al. 2007; Beechie et al. 2008), primarily by restoring sediment retention processes in the channel (Pollock et al. 2014). Sediment aggradation caused by Beaver dams fills the incision and raises the streambed elevation. As the bed elevation increases, hydrologic connectivity between the channel and former floodplain is improved both by raising the water table elevation and by reducing bank height, which allows overbank flooding to recharge the floodplain's alluvial aquifer. Increased soil moisture allows riparian plant species vegetation to re-establish. Development of a well-vegetated riparian zone provides Beaver with more food and building materials, enabling construction of more dams (Pollock et al. 2014).

The aforementioned impacts of Beaver on aquatic and riparian ecosystems are immensely beneficial to fish; however, Beaver may also have detrimental effects on fish. Sediment deposition in Beaver ponds may harm spawning beds, and Beaver dams can block upstream and downstream fish movements (Pollock et al. 2003). Water temperature in Beaver ponds can be warmer than nearby flowing waters, especially where the stream is largely under a closed canopy forest (Robison et al. 1999), but in areas with open or no canopy (such as dryland riparian areas), water temperatures tend to be similar between Beaver ponds and unimpounded reaches (Talabere 2002). Beaver ponds have also been found to provide productive habitats for non-native fish (Gibson et al. 2015) that may compete with or prey upon native fish.

7.4. Ecosystem Functions

FEMAT (1993) identified five key functions of riparian ecosystems that are important for fish habitats: streambank integrity affected by plant roots, litter fall that provides detrital nutrients, shading to limit stream temperatures, large wood recruitment, and pollution removal. Most of what is known about these key riparian functions was discovered through research conducted in forested ecoregions, in particular, the mesic forest ecoregions of the Pacific Northwest (e.g., Salo and Cundy 1987; Naiman and Bilby 1998; Richardson et al. 2005). Much of what is known about riparian areas in forested ecoregions is transferable to riparian areas in the Columbia Plateau, and therefore, where appropriate I repeat some of the knowledge and principles elucidated in chapters 1 through 6. However, as will become apparent, large gaps in knowledge remain.

In addition to FEMAT's key ecological functions, a sixth key function occurs in dryland riparian areas– alluvial water storage. Alluvial water storage occurs in riparian areas of all ecoregions, but it may be especially important in dryland ecoregions.

7.4.1. Streambank Stability

Streambank stability refers to a bank's resistance to change and its resilience after change (Bohn 1986). Streambank stability is the opposite of streambank erosion. Streambank erosion is commonly misinterpreted as a sign of adverse human impacts to riparian ecosystems, and it can be. However, a channel in dynamic equilibrium simultaneously exhibits both stable and unstable banks (Wohl et al. 2015). Streambank erosion is integral to a watershed's fluvial disturbance regime and necessary for long-term ecological sustainability (Florsheim et al. 2008) because the opposing processes of bank stability and bank erosion maintain the diversity of aquatic and riparian habitats within a watershed. Bank stability is also associated with overhanging/undercut banks which shade the water and provide cover for fish (Bohn 1986; Ohmart 1996).

The stability of streambanks is influenced by soil characteristics, groundwater, and vegetation. For the purposes of riparian area management, I focus on vegetation. Rooted vegetation is essential for streambank stability (Hupp and Osterkamp 1996; Gurnell 2014). Plants are said to provide "root strength" or "root reinforcement" along streambanks (FEMAT 1993; Pollen-Bankhead and Simon 2010). Soil is generally strong in compression, but weak in tension. Woody and herbaceous plant roots are strong in tension, but weak in compression. Consequently, the root-permeated soil of streambanks behaves as a composite material with enhanced strength (Simon and Collision 2002). Dense root networks also physically restrain or bind soil particles. Exposed roots on the bank surface increase channel roughness which dampens stream flow velocities, thereby reducing fluvial erosion (Griffin et al. 2005). Reduction of stream velocities by roots may also cause sediment deposition, which further stabilizes streambanks.

The stability provided by roots is species dependent (Polvi et al. 2014). Simon et al. (2006), for instance, found that Lemmon's Willow *Salix lemmonii* provided 10 times more root reinforcement of streambanks than Lodgepole Pine *Pinus contorta.* The difference was due to the greater root density and larger root area of Lemmon's Willow. On the southeastern slope of the Cascades Range in Washington, Liquori and Jackson (2001) found that different riparian plant communities manifested differences in bank erosion and channel form. They identified two types of riparian plant communities: a scrub-shrub community that exists within an open-canopy Ponderosa Pine *Pinus ponderosa* forest, and a dense, closed-canopy fir forest. The

Ponderosa Pine forest is maintained by regular wildfires while the fir forest was created by fire suppression. The scrub-shrub community was associated with stream channels that had less bank erosion, lower width-to-depth ratios, more pools, and more undercut banks than channels within the fir forest community. The channel morphology of scrub-shrub riparian communities also resulted in slightly lower summer stream temperatures. In the semi-arid Sierra Nevada Mountains, Micheli and Kirchner (2002) found that riparian areas comprised of sedges and/or rushes had banks five times stronger than riparian areas comprised of sagebrush and grasses, and that bank strength was correlated with the root mass to soil mass ratio. Sedges and/or rushes enabled the formation of undercut banks, and increased the width of an undercut bank by a factor of 10.

The composition and structure of riparian vegetation affects channel morphology which, in turn, affects riparian vegetation (Corenblit et al. 2007; Osterkamp and Hupp 2010). Toledo and Kauffman (2001) observed the effects of one such interactive feedback loop in semi-arid northeastern Oregon. Upland plants were found along incised channels and wetland-obligate plants (mostly sedges) were found along unincised channels, which had two times greater root biomass than incised channels. Along unincised channels, approximately 40% of root biomass was deeper than 8 in (20 cm) in the soil, but along incised channels less than 25% of root biomass was below 8 in (20 cm).

Compared to forested ecoregions, there is less large woody debris, and woody debris play a much smaller role in the fluvial processes of dryland river and streams.

Denser roots at deeper soil depths result in a larger volume of reinforced soil. According to Toledo and Kauffman (2001), the severely degraded conditions at their incised sites were caused by a positive feedback loop in which an initial channel incision led to a lower water table. The resulting reduction in soil moisture altered riparian vegetation which shifted to an upland plant community with reduced root mass. Bank erosion subsequently increased which led to channel widening and further incision.

The studies reviewed thus far have reported on the bank strength provided by hydric or wetland-obligate shrubs and herbaceous plants (sedges and rushes) in dryland riparian areas. Trees are also important for bank stability. Rood et al. (2015) studied the amount of bank erosion after major floods along Elk River in British Columbia. They found that floodplain locations occupied by grassland or small shrubs exhibited substantial erosion (>75 m of bank erosion) after major floods but locations occupied by forest, including Black Cottonwood stands, exhibited much less change (<15 m of bank erosion). Rood et al. (2015) concluded that "only big plants can resist big flows," and that other studies which demonstrated that grasses or shrubs are more erosion resistant had observed only low energy flows in smaller or shallower gradient streams.

Streambanks along incised channels of arid or semi-arid regions are particularly sensitive to changes in soil moisture. Much of the bank may be above the water table, and hence soils are unsaturated. Matric[12] suction above the water table, enhanced by transpiration of riparian vegetation, has the effect of increasing the apparent soil cohesion, and decreases in soil strength due to a loss of suction are a leading cause of bank failures in incised channels (Simon and Collison 2002).

12 Matric suction is a negative pore pressure that induces water to flow in unsaturated soil. It results from the combined effects of adsorption and capillarity of the soil matrix. Water flows from a soil with low matric suction (a wet soil) to soil with a high matric suction (a dry soil).

7.4.2. Wood

The main role of wood in aquatic ecosystems is roughness element (Bisson et al. 1987). Roughness elements are obstacles in a channel that deflect flow and change its velocity. The size, shape, and strength of large wood make it very effective at redirecting hydraulic forces and the flow of materials, such as sediment and fine organic matter. In-stream large wood increases hydraulic complexity, i.e., creates a wider range of flow velocities, which causes pool formation, streambed scour, sediment deposition, and channel migration. The net result is a diversity of aquatic habitat types.

I could find no studies conducted in the Columbia Plateau describing the density of trees or their spatial distribution in riparian areas. However, riparian areas in the Columbia Plateau certainly contain less large wood than forested ecoregions, even historically, for three reasons. First, trees are smaller in the Columbia Plateau than in forested ecoregions of Washington. Canopy dominant trees in old-growth riparian ecosystems of mesic forested ecoregions can be well over 48 in (122 cm) diameter at breast height (dbh) and over 150 ft (46 m) tall, but the maximum size of Black Cottonwood in the Columbia Plateau is much smaller (see below). Second, trees are fewer in the Columbia Plateau because in the Columbia Plateau trees inhabit the riparian zone but often do not inhabit the zone of influence. In forested ecoregions, trees inhabit both zones. Third, along some streams, particularly in the most arid subregions of the Columbia Plateau, even the riparian zone is unsuitable for tree species. At such sites, the riparian zone consists of tall shrub, shrub, grass-like, grass, and forb vegetation types. Therefore, compared to forested ecoregions, there is less large woody debris, and woody debris plays a much smaller role in the fluvial processes of dryland river and streams.

Knowledge regarding wood in aquatic and riparian ecosystems of Columbia Plateau is extremely limited at present, nevertheless, the historical abundance of woody plants in riparian areas is thought to have been much greater than it is today (Wissmar et al. 1994; Kauffman et al. 1997; Wissmar 2004). Riparian areas in the Columbia Plateau are inhabited by a variety of woody plants–Black Cottonwood, Quaking Aspen, White Alder, Thinleaf Alder, Water Birch, Black Hawthorn, and Yellow Willow (Crawford 2003). Conifer trees, including Ponderosa Pine and Douglas-fir *Pseudotsuga menziesii,* are widely scattered in eastern Washington riparian areas and were likely more common historically than at present. They are currently restricted to canyons or valleys with steep rocky walls along mid- to high-gradient streams where they are inaccessible to harvest and where microclimates are conducive to supporting trees (Evans 1989). The main causes of reduced wood are explained in Section 7.2.

The size and quantity of wood recruited to a stream depends on the size and density of woody plants, their distances from the channel, and the recruitment processes that deliver wood to the channel. Only a few tree species in riparian areas of the Columbia Plateau qualify as large wood, which is commonly defined as greater than 4 in (10 cm) in diameter and greater than 6 ft (2 m) in length.[13] Black Cottonwood is the largest riparian tree species in the Columbia Plateau Ecoregion and the largest deciduous species in western North America. The species has a typical lifespan of 100 to 200 years (Braatne et al. 1996), and can attain a dbh of about 30 to 35 in (76 to 90 cm) in the Pacific Northwest (Franklin and Dyness 1988), but sizes are smaller in the Columbia Plateau. The interior of British Columbia is less productive than the province's coastal ecoregion, and in the interior, Black Cottonwood attain an average size of 15 in (38 cm) dbh and 52 ft (16 m) tall at age 80 years, and 26 in (66 cm) dbh and 70 ft (21 m) tall at age 150 years (Roe 1958). Other tree species that might also

[13] Large wood is also known as large woody debris (LWD) or coarse woody debris. There is no universal definition of LWD. Another common definition is greater than 4 in (10 cm) in diameter and greater than 3 ft (1 m) in length. Small wood is also known as small woody debris or fine woody debris.



Large trees in riparian areas are a major source of instream large woody debris/Jim Cummins , WDFW

function as large wood are Quaking Aspen, White Alder, and Peachleaf Willow *Salix amygdaloides*. Daubenmire (1970) reported that Quaking Aspen and White Alder grow to about 8 and 23 in (10 and 58 cm) dbh, respectively, in riparian areas of the Columbia Plateau.

Substantial amounts of small wood may be recruited to and stored in stream channels through Beaver activity. Most dryland riparian areas lack large trees, but in dryland riparian areas Beaver create large roughness elements from small wood that mimic some effects of large wood (see section 7.3). In effect, Beaver convert small wood to large wood. Beaver dams consist mainly of mud and small wood. Published information on small wood sizes in dams of North American Beaver is lacking. However, Beaver most often forage on trees ranging from 1.2 to 3.2 in (3 to 8 cm) in diameter (Collen and Gibson 2001), and a large proportion of woody stems used as food are also used in dam construction (Barnes and Mallik 1996). In Maryland, Blersch and Kangas (2014) found that 98% of sticks (i.e., small wood) in a Beaver dam were less than 4 in (10 cm) in diameter and that 46% of those sticks were probably placed in the dam by Beaver. The other 54% of sticks in the dam were due to passive capture of transported wood.

Large wood recruitment processes in riparian areas of the Columbia Plateau should be very similar to those in forested ecoregions. Therefore, the main processes should be tree mortality caused by disease or senescence, bank erosion, and wind throw. Maximum recruitment distances for large wood will generally be either riparian zone width or site-potential tree height, whichever is smaller. I found no studies on recruitment mechanisms of small wood, nevertheless, the main mechanisms should be direct fall of branches into a stream channel, mobilization by overbank flooding, and Beavers. Consequently, depending on the relative distribution of small and large wood sources within a riparian area, the recruitment distance for small wood could be greater than the distance for large wood. That is, shrubs that lie farther from the stream channel than trees, could contribute small wood via flooding or Beaver.

7.4.3. Detrital Nutrients

With respect to riparian ecosystems, *detrital nutrients* most often refer to nutrients derived from terrestrial litter. Litter may consist of leaves, bark, seeds, cones, flowers, fruit, nuts, twigs, and other small plant parts (Benfield 1997). Terrestrial litter in an aquatic system is also called allochthonous nutrients.[14] Detrital nutrients are only one component of nutrient dynamics in riparian ecosystems. Riparian areas also mediate bi-directional exchange of dissolved nutrients between terrestrial and aquatic systems. Detrital nutrients in the larger context of nutrient dynamics (e.g., nitrogen cycle) are discussed in Chapter 6.

Besides research on marine derived nutrients (Naiman et al. 2002), the dynamics of macronutrients—nitrogen, phosphorus, and carbon (N, P, and C)—in riparian areas of the Pacific Northwest has been largely neglected by scientists (but see Naiman and Sedell 1980; Triska et al. 1984). I found one study related to nutrient dynamics in riparian areas that was conducted in the Columbia Plateau Ecoregion (e.g., Cushing and Wolf 1982; Cushing and Wolf 1984; Cushing 1988).

The availability of macronutrients has profound effects on the productivity, composition, and structure of ecosystems. In Washington, many streams and rivers in undisturbed watersheds are oligotrophic, i.e., exhibit low productivity associated with low N or P concentrations. Thut and Haydu reported in 1971 that roughly half of unpolluted surface waters in Washington were N-limited, and the other half were limited by P. Interestingly, N-limited waters, such as those in the Yakima River and lower Columbia River basins, most often arise from volcanic rock formations, while P-limited waters, such as those in the Okanogan River basin, flow from glacial deposits or granitic formations (Thut and Haydu 1971; Murphy 1998). Nutrient-limited waters are often sensitive to anthropogenic inputs of macronutrients, and when more N or P enters a stream than can be immediately metabolized, degradation of aquatic habitats often results. Artificial fertilizers, which are inorganic nutrients, cannot mimic the foodweb role of detrital nutrients. Artificial fertilizers are used by plants, but litter feeds heterotrophs such as macroinvertebrate detritivores (shredders and collectors), many of which are prey for salmonids. Therefore, providing adequate amounts of litter to streams is an important issue for riparian area management.

According to Xiong and Nilsson (1997), in drier and less productive grasslands, a certain amount of litter may help to conserve soil moisture and thus increase plant growth. The same effect may be obtained in dryland riparian areas. Hence, in addition to providing nutrients, litter from riparian vegetation may also retain soil moisture.

Little is known about nutrient dynamics in dryland riparian areas. Nitrogen cycling, for instance, is driven by microbes in soils, and microbial activity depends on water availability. In forested ecoregions, nitrogen cycling is rarely limited by water availability. Hence, microbial processes are active in both uplands and riparian soils, and can occur year round. In arid regions, nitrogen cycling in uplands may cease when soil moisture approaches zero. This is also true of nitrogen cycling in riparian areas, however, nitrogen dynamics are more complex in riparian areas because they are closely linked to seasonal water table elevations which are affected by site and watershed-scale hydrology (Belnap et al. 2005).

Particulate and dissolved organic carbon are important sources of energy in aquatic ecosystems. Both support organisms near the bottom of the food web. In forested ecoregions, productivity of headwater streams is typically light-limited by a closed canopy (Conners and Naiman 1984; Murphy 1998), and consequently, the main source of energy is allochthonous chemical energy

[14] Allochthonous means originating or formed in a place other than where found. In contrast, autochthonous means originating or formed in the place where found.

from riparian areas. In arid and semi-arid regions, the canopy over headwater streams tends to be more open, which allows more light to reach the aquatic ecosystem. Cushing and Wolf (1982) found that chemical energy for a small spring-fed stream in central Washington, Rattlesnake Springs, was predominantly autochthonous, i.e., produced within the stream by Watercress *Rorippa nasturtium-aquatica,*[15] Cattail *Typha latifolia*, and algae. Direct allochthonous inputs contributed 11% of total energy inputs, and all of it was consumed. Consequently, Cushing and Wolf (1982) concluded that the aquatic community exhibited both autotrophic and heterotrophic traits.

The amount of allochthonous carbon produced by dryland riparian areas varies considerably. The input rates of allochthonous organic matter (specifically, leaf litter from shrubs) in two dryland riparian areas were 1.1 oz/ft^2/yr (350 g/m^2/yr) at Rattlesnake Springs and 0.54 oz/ft^2/yr (165 g/m^2/yr) at Snively Springs (Fisher 1995). The former is about 1.2 to 2.1 times greater than the amount of leaf litter produced by riparian areas in mesic forests (Gregory et al. 1991; cited in Fisher 1995).

Nearly all N in lotic ecosystems in forested ecoregions of the Pacific Northwest is derived from allochthonous sources. Headwater streams in the western Cascades of Oregon, for instance, obtain more than 90% of annual nitrogen inputs from biotic processes in the adjacent forest (Triska et al. 1984). An important source of N in forests of western Oregon and Washington is N_2-fixing Red Alder *Alnus rubra*, which contributes both litter and dissolved organic N to streams (Compton et al. 2003). Small streams in the Columbia Plateau Ecoregion must also obtain N from allochthonous sources. The overstory of some riparian plant communities in that ecoregion consists of N_2-fixing White Alder *Alnus rhombifolia* or Thinleaf Alder *Alnus incana*. Evidence suggests that Black Cottonwood and willow species contain mutualistic organisms that fix nitrogen (Doty et al. 2009, Wuehlissch 2011). This helps to explain how these species can survive and grow on recently disturbed, barren, floodplain sediments. Litter from these pioneering plants also provides nitrogen for other plant species in subsequent successional stages and deliver allochthonous nitrogen to the aquatic ecosystem.

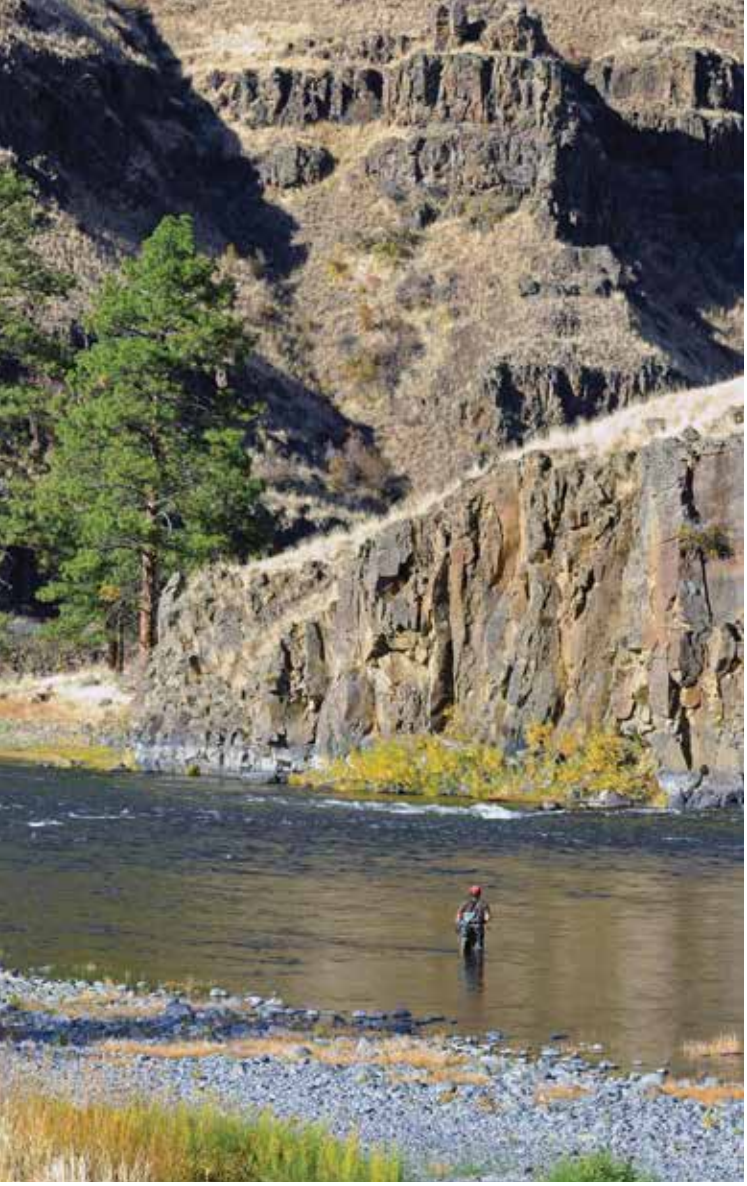
The only study I could find on litter source distances was conducted in mature conifer forest in western Washington. Bilby and Heffner (2016) found that about 95% of litter delivered to streams comes from distances between 39 and 54% of mean tree height, depending upon forest type, topography, and wind. For Snively Springs, a spring-fed small stream with a riparian area comprised of dense willow and wild rose in central Washington, Cushing (1988) found that roughly 40% of litter fell directly into the stream from overhanging vegetation and 60% was blown laterally from plants some distance from the streambank. He did not measure distances. These proportions were affected by factors that influence wind, such as vegetation density and topography.

7.4.4. Shade

For an in-depth discussion of shade and water temperature refer to Chapter 4.

Numerous studies in dryland riparian areas have shown that salmonid species abundance is negatively correlated with stream temperature (Platts and Nelson 1989; Li et al. 1994; Ebersole et al. 2003a; Zoellick 2004). Even when primary and secondary production increase in response to reduced shading, salmonid populations often respond negatively to high temperatures (Tait et al. 1994). Shade is important because it directly affects stream temperatures. Other factors can significantly affect stream temperature, such as topographic shading, channel azimuth, channel form, groundwater flow, and hyporheic exchange, but for the purposes of riparian area management, I focus on shade provided by vegetation. Vegetation also affects local air temperature,

15 Watercress (*Rorippa nasturtium-aquaticum*) is an exotic plant in Washington State.



In the Columbia Plateau, some stream reaches have no shade from vegetation/Alan Bauer

humidity, and air movement, which all affect stream temperature (Cristea and Janisch 2007).

Shading of a stream is affected by the vegetation's height and foliage density and by the stand's depth (or width) and stem density. In general, a taller, denser, or wider strip of vegetation will shade a larger proportion of a channel for a longer time, at both daily and annual time scales. Riparian vegetation also enables the formation of undercut banks, which provide shade along streambanks that has been shown to lower water temperatures of individual pools (Ebersole et al. 2003a; Ebersole et al. 2003b).

The classification system based on overstory underscores the substantial differences in shading provided by riparian vegetation types: tall tree, short tree, tall shrub, shrub, grass-like, grass, and forb (Crawford 2003). The obvious implication of these vegetation types is that some stream channels in the Columbia Plateau receive little or no shade from vegetation, even historically. However, the actual historical condition of many riparian areas is unknown. Studies show that restoration of riparian areas, especially restoration of incised channels, can alter vegetation type, increase shading, and reduce water temperatures. How spatial variation in vegetation type and consequent shading currently affects salmonid habitat regionally is also unknown. Ecologists lack a map of current and potential riparian vegetation types across the Columbia Plateau that would enable managers to assess impacts on fish-bearing streams from insolation (see Macfarlane et al. 2017 for a first approximation).

7.4.5. Pollutant Removal

For an in-depth discussion of pollutant removal by riparian areas refer to Chapter 5.

The capability of riparian areas to remove certain pollutants from runoff is well documented (Barling and Moore 1994; Hickey and Doran 2004; Polyakov et al. 2005; Dosskey et al. 2010). Management of riparian areas for pollutant removal differs from the other ecological functions discussed in this document in that the primary focus is on mitigating activities occurring outside the riparian area. The pollutant removal function is unique in that it only exists in the presence of human activities that generate polluted runoff, and it is only necessary when runoff from upland activities threatens to degrade in-stream water quality. Major nonpoint-source pollutants removed with riparian "buffers"[16] are sediments, excess nutrients (nitrogen or phosphorus), pesticides, and pathogens.

16 Riparian buffers are also known as riparian management zones (RMZs). "Buffer" refers to its purpose, which is to reduce or prevent adverse impacts to water quality, fisheries, and aquatic biodiversity from human activities occurring upslope of the buffer. Riparian buffers managed specifically for pollutant removal may also be called vegetated filter strips.

The processes in riparian areas affecting pollutant transport and fate are complex and often interrelated. Riparian areas can slow surface runoff and increase infiltration of water into the soil, thereby enhancing both deposition of solids and filtration of water-borne pollutants. Riparian areas also intercept and act on contaminants in subsurface flow through dilution, sorption, physical transformation, chemical degradation by various biogeochemical processes, and through uptake and assimilation by plants, fungi, and microbes. Hydrology, soils, and vegetation all affect pollutant transport and fate, but for the purposes of riparian area management I focus on vegetation.

Research on pollutant removal by riparian buffers conducted in arid or semi-arid ecoregions is very limited (Hook 2003). I could locate only three such studies (Tate et al. 2000; Fasching and Bauder 2001; Hook 2003), but all three have significant shortcomings. Hook (2003), for instance, simulated sediment-laden run-off from rangeland in western Montana. He reported that 20 ft (6 m) buffers removed at least 94% of sediment regardless of vegetation type in the buffer, but whether these simulations are realistic is unknown because he did not compare his run-off flow volumes and sediment concentrations to values from actual rangeland. Fasching and Bauder (2001), simulated sediment-laden run-off from tilled, bare cropland in central Montana. They found that 40 ft (12 m) wide buffers removed 75 to 80% of sediment during a simulated 50-year 24-hour storm event. However, while the buffer was 40 ft (12 m) wide, the bare cropland was only 15 ft (3 m) wide, which is certainly an unrealistic size for cropland. Tate et al. (2000) measured nitrate-nitrogen, total phosphorus, and suspended solids in run-off from irrigated pastures in the Central Valley of California. They reported that 33 ft (10 m) wide buffers did not significantly reduce nitrate-nitrogen concentration, total phosphorus concentration, or total suspended solid load. However, the strength of their inferences was compromised by extreme variability. Some buffered plots yielded higher concentrations of all three pollutants than unbuffered plots, which they attributed to differences in soil and microtopography among plots.

Despite the large quantity of research conducted around the world, no widely accepted recommendations have emerged on minimum buffer widths needed to protect water quality. The lack of agreement amongst scientists is due, in part, to the surprising complexity of the biogeochemical processes that remove pollutants from surface and subsurface flows, the many different environmental conditions among research sites, the variety of methods used to study pollutant removal, and the shortcomings of some research (as described above). One way to cut through this variability and develop quantitative relationships between buffer width and pollutant removal efficacy is meta-analysis.[17] I found five such meta-analyses in the literature (Mayer et al. 2007; Liu et al. 2008; Yuan et al. 2009; Zhang et al. 2010; Sweeney and Newbold 2014).

The number of studies in the five meta-analyses ranged from to 52 to 88. I could determine the geographic locations of all studies included in four of the meta-analyses; only one study was conducted in an arid or semi-arid region (i.e., Tate et al. 2000, cited in Zhang et al. 2010). Four meta-analyses analyzed sediment studies, three meta-analyses analyzed nitrogen studies, and 1 one meta-analysis (Zhang et al. 2010) analyzed phosphorus and pesticide studies. All meta-analyses show that: 1) removal efficacy increases as buffer width increases, 2) removal efficacy varies among pollutants, and 3) relationships between buffer width and removal efficacy follow a nonlinear law of diminishing returns. In other words, the marginal removal efficacy decreases as buffer width increases. Comparing the four pollutants, buffer width that resulted in 90% removal was narrowest for sediment and widest for nitrogen (surface and subsurface combined). See Chapter 5 for a complete summary of their results.

17 Meta-analysis refers to various approaches for drawing statistical inferences from many separate but similar experiments (Mann 1990).

Only one study from arid or semi-arid ecoregions was included in the meta-analyses. Therefore, actual removal efficacy versus buffer width relationships may be quite different for riparian buffers in the Columbia Plateau. Differences in soil, hydrology, and vegetation between arid or semi-arid ecoregions and other ecoregions are significant, and are likely to affect pollutant removal. Because soils in arid ecoregions with biological crusts may be less permeable (Warren 2014) and vegetation tends to be less dense, especially in the upland zone of influence, the meta-analyses may underestimate buffer widths needed for a given level of removal efficacy. This issue can only be resolved through research on pollutant removal by dryland riparian areas.

7.4.6. Alluvial Water Storage

Alluvial water storage, also known as bank storage, is an ecological function of riparian areas that is thought to be especially important for small streams in dryland ecoregions (Pollock et al. 2003). However, the idea that alluvium can supply enough water to maintain base flows is controversial because empirical data to support it are lacking (S. Wondzell, U.S. Forest Service, personal communication).

Alluvial water storage is thought to be part of a cyclic process. During annual floods, stream stage exceeds water table elevation, and surface waters flow into shallow alluvial aquifers (Winter et al. 1998). During the dry season, as stream stage declines, water flow reverses from aquifers to surface water, and the released water may comprise a substantial portion of the stream's base flow (Brunke and Gonser 1997; Whiting and Pomerants 1997). By absorbing some floodwaters, alluvial aquifers may also reduce the impacts of flood events (Whiting and Pomerants 1997). The water volume in bank storage depends on the duration of flooding, the area of inundated floodplain, hydraulic gradients between surface water and the aquifer, soil infiltration rate, the permeability and porosity of alluvial sediments, floodplain width, and thickness of the bank storage layer (Whiting and Pomerants 1997; Chen and Chen 2003).



Autumn foliage, brown grass, and low flows annually coincide in Columbia Plateau Ecoregion/Scott Fitkin, WDFW



Alluvial fans, such as these emanating from side canyons, store water from spring snow melt that contributes to a river's base flow during the dry season/Scott Fitkin, WDFW

On the semi-arid plains of Alberta, Meyboom (1961) found that groundwater released from bank storage is a substantial portion of dry-season stream flow in the Elbow River. Bank storage was 73% of total groundwater discharge during normal base-flow recession, and during late summer, discharge from bank storage comprised 50 to 70% of the river's daily mean discharge. On the eastern edge of the Great Plains in central Iowa, Kunkle (1968) determined that base flow characteristics of Four Mile Creek were related mainly to the adjacent alluvial sand reservoir. Bank storage discharge accounted for 37 to 42% of the annual base flow.

Hydrological studies in the Yakima River basin (Synder and Stanford 2001, and studies cited therein) have suggested that prior to irrigation projects extensive exchange between surface and ground waters occurred in riparian areas and floodplains. Annual inundation of floodplains, including riparian areas, would recharge shallow surficial aquifers, including the alluvial aquifer. Synder and Stanford (2001) asserted for the Yakima River, "Based on fundamental hydrologic principles, there is no question that groundwater recharge of this nature would not only have maintained base flows, but would have provided areas of cooler thermal refugia." A salient characteristic of alluvial water

storage is residence time, which can vary from days to years, depending upon floodplain width and hydraulic connectivity of alluvial sediments (Whiting and Pomereants 1997). The historical hydrology of rivers in the Columbia Plateau was water entered alluvial aquifers during spring peak flows and exited the aquifer weeks later during the low flows of late summer and fall of that same year (Synder and Stanford 2001). The historical timing and magnitudes of aquifer recharge and discharge may have been altered by dams, diversions, and levees.

Riparian and floodplain vegetation affect alluvial water storage in four ways. First, vegetation may reduce water storage through evapotranspiration. In fact, removing riparian vegetation can increase annual water yield from a watershed (Salemi et al. 2012). However, the timing of the additional surface water may not coincide with annual low flows when it is most needed. Second, through root growth and decay, vegetation creates soil macropores that increase soil permeability (Fisher and Binkley 2000) and thus enhance infiltration of floodwaters. Third, vegetation increases the residence time of floodwaters in floodplains by increasing surface roughness (Thomas and Nisbet 2007). The increased residence time provides more time for floodwaters to percolate through soils and into the alluvial aquifer. Vegetation increases surface roughness through stems, organic litter, large woody debris, and by altering micro-topography. Fourth, riparian vegetation helps to maintain cooler temperatures of shallow groundwater. Heat conduction from the soil surface into groundwater affects groundwater temperatures. Consequently, shallow groundwater temperatures are cooler in winter and warmer in summer. During the summer, shade from riparian vegetation and the riparian microclimate, which is cooler than adjacent uplands, may result in cooler groundwater. Stanford et al. (2002), for example, collected data suggesting that intact riparian forest moderated the rate of increase in groundwater temperatures along several reaches of the Yakima River.

Alluvial aquifers typically underlie floodplains (Vaccaro 2011), including riparian areas. The alluvial water storage function of floodplains has been degraded by dams that reduce flood magnitudes, levees that reduce the area of flooding, and the channelization or loss of distributary channels across alluvial fans. To replace natural recharge pathways, water managers are trying artificial recharge of shallow alluvial aquifers (USBR & WDOE 2012; WWBWC 2013). While artificial recharge may replace the aquifer recharge function of floods, it cannot replace the fluvial disturbances caused by flooding that are needed to maintain riparian vegetation and aquatic habitats.

7.5. Conclusions

The goal for riparian areas of the Columbia Plateau Ecoregion is the same as the goal for forested ecoregions—maintain or restore key ecological functions. However, management to achieve that goal is more complicated in dryland riparian areas for three reasons. First, there is a greater diversity of plant communities within riparian ecosystems of the Columbia Plateau than in the surrounding forested ecoregions—the vegetation heights of dryland riparian ecosystems range from sedges to tall trees. Several key ecological functions of riparian areas—namely, shade, wood, and detrital nutrients for aquatic habitats—are dependent on vegetation height. The other three functions—bank stability, pollutant removal, and alluvial water storage—are largely dependent on processes occurring at or below the soil surface. In forested ecoregions, the total capacity of a riparian area to provide five of the key functions typically occurs within a site-potential tree height (FEMAT 1993). In other words, with respect to aquatic habitats, full function for five of the key riparian ecological functions is typically provided by an area that is one site-potential tree height wide.[18]

[18] Site-potential" is a concept related to forest productivity. A site's productivity is often expressed as the height a particular tree species growing on that site is expected to attain by a specified age. FEMAT (1993) defined site-potential tree height as the average maximum height of the tallest dominant trees (200 years old or greater).

In dryland ecoregions, the width of the riparian ecosystem is based on the ecological function that creates the widest zone of influence. At most sites, this will be either the wood (large and small) or pollutant removal functions. For grass, herb, shrub, and small tree vegetation types, the zone of influence based on wood, which depends on vegetation height, will be narrower than the zone of influence based on pollutant removal. Therefore, if pollutants, including sediments due to ground disturbance, are a concern at a particular site, then riparian ecosystem width should be based on the desired removal efficacy for pollutants created at that site. If, for instance, surface run-off containing excess nitrogen is a concern and a 95% removal is desired, then the zone of influence is 170 ft (52 m) wide, measured from the active channel, see Table 5.4. If pollutant removal is not a concern, then riparian ecosystem width should be based on site-potential vegetation height (i.e., trees or shrubs), which should provide maximum wood and shade for aquatic habitats.



Some trees (Pinus ponderosa) *have all the luck/Scott Fitkin, WDFW*

The second reason management of riparian ecosystems is more complicated in the Columbia Plateau Ecoregion is water. The existence of dryland riparian areas depends on soil moisture and water table elevations. Many dryland riparian plant communities evolved under an annual hydrological cycle of flooding followed by gradual recession of stream flows. This cycle has been disrupted by dams and water diversions. The consequences of water management on riparian areas were documented by Braatne et al. (2007) who found an unsustainable age-class distribution of cottonwoods along the Yakima River. Two long-term impacts for these reaches of the Yakima could be reductions in shade and large wood for aquatic habitats. Water management is likely to have caused adverse changes to riparian plant communities along other rivers and streams in the Columbia Plateau. Under state law (RCW 90.03), in-stream flows are managed only to maintain flows above a specified minimum flow. Little consideration is given to mimicking the natural seasonal hydrograph for the sake of riparian ecosystems. To restore riparian ecosystems and aquatic habitats in the Columbia Plateau, that may need to change.

Third, management will be more complicated because many riparian areas in the Columbia Plateau have been highly altered by human activities, and ecologists do not know their historical or "properly functioning" conditions. Lacking such information will hamper the success of site-scale riparian restoration projects and regional restoration plans. An initial step toward grappling with this issue might be a subregional or WRIA-level mapping of potential riparian vegetation types. The mapping could include the capacity to support Beaver (e.g., Macfarlane et al. 2017) and the vegetation that would develop in the presence of Beaver. The map would serve three purposes: 1) a vegetation guide for riparian restoration projects, 2) a historical baseline for fish habitat conditions in the Columbia Plateau, and 3) habitat restoration objectives for the recovery of salmon and other aquatic species.

Historical information on riparian areas will serve three other purposes. First, knowledge of historical conditions will enable an accounting of lost ecosystem services. The losses incurred by fisheries are well recognized, but losses of wildlife, both game and nongame species, due to altered riparian areas have not been rigorously evaluated. Another major ecosystem service is the contribution to perennial stream flow from short-term storage of water in shallow alluvial aquifers that lie beneath floodplains (USBR & WDOE 2012; WWBWC 2013). Losses of this ecosystem service caused by disconnecting floodplains from streams also have not been rigorously evaluated. Second, knowledge of historical conditions may enable an estimate of the past quantity and quality of salmon habitats. Historical knowledge of past salmon habitats can be used in salmon recovery plans to establish habitat restoration objectives and priorities. The third purpose is partly political. Knowledge of past habitat loss can influence policy decisions to conserve remaining habitats or to restore habitats where practicable.

7.6. Acknowledgements

In May 2017, WDFW held a two-day workshop in Yakima, Washington on dryland riparian areas. WDFW thanks the following experts for participating: Tim Beechie, Rebecca Brown, Rex Crawford, Ben Floyd, Alex Fremier, Nate Hough-Snee, Thomas Hruby, Duncan Patten, Joe Rocchio, and Steve Wondzell. We are also very grateful to Tim Beechie, Alex Fremier, Perry Harvester, Nate Hough-Snee, Tom Hruby, Duncan Patten, Joe Rocchio, Amanda Stahl, Steve Wondzell, and four anonymous reviewers from the Washington Academy of Sciences for reviewing this chapter.

7.7. Literature Cited[19]

Adam, S. 2004. Appendix E *in* B.E. Jamison and M.F. Livingston. Sage-Grouse habitat evaluation in the shrub-steppe ecosystem of the Yakama Reservation. Project final report. Wildlife, Range & Vegetation Resources Management Program, Confederated Tribes and Bands of the Yakama Nation, Toppenish, Washington. (vii)

AP (Associated Press). 2012. Umatilla tribes hope to trim wild horse numbers without slaughtering any. Available: http://www.oregonlive.com/pacific-northwest-news/index.ssf/2012/10/umatilla_tribes_hope_to_trim_w.html. (February 2018). (vii)

Anderson, E.W. 1987. Riparian area definition – a viewpoint. Rangelands 9(2):70. (i)

Bailey, R.G. 1995. Description of the ecoregions of the United States (2nd ed.). Misc. Pub. No. 1391. U.S. Forest Service, Washington, D.C. (viii)

Baker, B.W., H.C. Ducharme, D.C.S. Mitchell, T.R. Stanley, and H.R. Peinetti. 2005. Interaction of Beaver and Elk herbivory reduces standing crop of willow. Ecological Applications 15:110–118. (i)

Barling, R.D., and I.D. Moore. 1994. Role of buffer strips in management of waterway pollution: a review. Environmental Management 18:543-558. (i)

Barnes, D.M., and A.U. Mallik. 1996. Use of woody plants in construction of Beaver dams in northern Ontario. Canadian Journal of Zoology 74:1781-1786. (i)

Beechie, T.J., M.M. Pollock, and S. Baker. 2008. Channel incision, evolution and potential recovery in the Walla Walla and Tucannon River basins, northwestern USA. Earth Surface Processes and Landforms 33:784–800. (i)

Belnap, J., J.R. Welter, N.B. Grimm, N.N. Barger, and J.A. Ludwig. 2005. Linkages between microbial and hydrologic processes in arid and semi-arid watersheds. Ecology 86:298–307. (i)

Belsky, A.J., A. Matzkem, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54:419-431. (i)

Benfield, E.F. 1997. Comparisons of litterfall input to streams. Journal of the North American Benthological Society 16:104-108. (i)

Beschta, R.L., and W.J. Ripple. 2016. Riparian vegetation recovery in Yellowstone: the first two decades after Wolf reintroduction. Biological Conservation 198:93-103. (i)

Bilby, R.E., and J.T. Heffner. 2016. Factors influencing litter delivery to streams. Forest Ecology and Management 369:29-37. (i)

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dollof, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present, and future. Pages 143-190 *in* E.O. Salo and T.W. Cundy, editors. Streamside management: forestry and fishery interactions. Contribution No. 57. Institute of Forest Resources, University of Washington, Seattle. (i)

Black, A.E., E. Strand, P. Morgan, J.M. Scott, R.G. Wright, and E. Watson. 1998. Biodiversity and land-use history of the Palouse bioregion: pre-European to present. Pages 85-99 *in* T.D. Sisk, editor. Perspectives on the land use history of North America: a context for understanding our changing environment. Biological Science Report USGS/BRD/BSR-1998-0003. U.S. Geological Survey, Reston, Virginia. (viii)

Blersch, D.M., and P.C. Kangas. 2014. Signatures of self-assembly in size distributions of wood members in dam structures of *Castor Canadensis*. Global Ecology and Conservation 2:204-213. (i)

Bohn, C. 1986. Biological importance of streambank stability. Rangelands 8(2):55-56. (i)

Braatne, J.H., R. Jamieson, K.M. Gill, and S.B. Rood. 2007. Instream flows and the decline of riparian cottonwoods along the Yakima River, Washington, USA. River Research and Applications 23:247–267. (i)

[19] References are classified according to RCW 34.05.271 (see Appendix 1) denoted by a lower case roman numeral (i – viii) in parentheses at the end of the citation.

Braatne, J.H., S.B. Rood, and R.E. Heilman. 1996. Life history, ecology and conservation of riparian cottonwoods in North America. Pages 57-85 *in* R.F. Stettler, H.D. Bradshaw, P.E. Heilman, and T.M. Hinckley, editors. Biology of *Populus* and its implications for management and conservation. NRC Research Press, Ottawa, Ontario. (i)

Brunke. M., and T. Gonser. 1997. The ecological significance of exchange processes between rivers and groundwater. Freshwater Biology 37:1-33. (i)

Bryce, S.A., and J.M. Omernik. 1997. Level IV ecoregions of the Columbia Plateau Ecoregion of Oregon, Washington, and Idaho. Pages 11-22 *in* S.E. Clark and S.A. Bryce, editors. Hierarchical subdivisions of the Columbia Plateau and Blue Mountains ecoregions. PNW-GTR-395. U.S. Forest Service, Pacific Northwest Forest Station, Portland, Oregon. (viii)

Buckley, G.L. 1993. Desertification of the Camp Creek drainage in central Oregon. Yearbook of the Association of Pacific Coast Geographers 55:91-126. (i)

Campbell, A.G., and J.F. Franklin. 1979. Riparian vegetation in Oregon's western Cascade Mountains: composition, biomass, and autumn phenology. Bulletin No. 14. Coniferous Forest Biome Ecosystem Analysis Studies, University of Washington, Seattle. (i)

Carlson, N.K. 1940. The history of grazing and livestock development in the Pacific Northwest. Range Division, Region 9, Soil Conservation Service. (viii)

Case, T.L., and J.B. Kauffman. 1997. Wild ungulate influence on the recovery of willows, Black Cottonwood, and Thin-Leaf Alder following cessation of cattle grazing in northeastern Oregon. Northwest Science 71:115-126. (i)

Chen, X., and X. Chen. 2003. Stream water infiltration, bank storage, and storage zone changes due to stream fluctuations. Journal of Hydrology 280:246-264. (i)

Collen, P., and R.J. Gibson. 2001. The general ecology of beavers (*Castor* spp.), as related to their influence in stream ecosystems and riparian habitats, and the subsequent effects on fish – a review. Reviews in Fish Biology and Fisheries 10:439–461. (i)

Compton, J.E., M.R. Church, S.T. Larned, and W.E. Hogsett. 2003. Nitrogen export from forested watersheds of the Oregon Coast Range: the role of N_2-fixing Red Alder. Ecosystems 6:773–85. (i)

Conners, M.E., and R.J. Naiman. 1984. Particulate allochthonous inputs: Relationships with stream size in an undisturbed watershed. Canadian Journal of Fisheries and Aquatic Sciences 41:1473–1488. (i)

Cooke, H.A., and S. Zack. 2008. Influence of Beaver dam density on riparian areas and riparian birds in shrubsteppe of Wyoming. Western North American Naturalist 68:365-373. (i)

Corenblit, D., E. Tabacchi, J. Steiger, and A.M. Gurnell. 2007. Reciprocal interactions and adjustments between fluvial landforms and vegetation dynamics in river corridors: a review of complementary approaches. Earth-Science Reviews 84: 56-86. (i)

Crawford, R.C. 2003. Riparian vegetation classification of the Columbia Basin, Washington. Natural Heritage Program Report 2003-03. Washington Department Natural Resources. Olympia, Washington. (viii)

Cristea, N., and J. Janisch. 2007. Modeling the effects of riparian buffer width on effective shade and stream temperature. Ecology Publication No. 07-03-028. Environmental Assessment Program, Washington State Department of Ecology, Olympia, Washington. (viii)

Cushing, C.E. 1988. Allochthonous detritus inputs to a small, cold desert spring-stream. Vereinigung fur Theoretische und Angewandte Limnologie 23:1107-1113. (i)

Cushing, C.E., and E.G. Wolf. 1982. Organic energy budget of Rattlesnake Springs, Washington. American Midland Naturalist 107:404-407. (i)

Cushing, C.E., and E.G. Wolf. 1984. Primary production on Rattlesnake Springs, a cold desert spring-stream. Hydrobiologica 114:229-236. (i)

Daubenmire, R.F. 1942. An ecological study of the vegetation of southeastern Washington and adjacent Idaho. Ecological Monographs 12:53-79. (i)

Daubenmire, R.F. 1970. Steppe vegetation of Washington. Washington State Experimental Station Technical Bulletin 62. Washington State University Cooperative Extension, Pullman, Washington. (viii)

Denfeld, D.C. 2011. Fort Walla Walla. Essay 9649, HistoryLink.org. Available: http://www.historylink.org/File/9649. (January 2019). (viii)

Dosskey, M.G., P. Vidon, N.P. Gurwick, C.J. Allan, T.P. Duval, and R. Lowrance. 2010. The role of riparian vegetation in protecting and improving chemical water quality in streams. Journal of the American Water Resources Association 46:261-277. (i)

Doty, S.L., B. Oakley, G. Xin, J.W. Kang, G.L. Singleton, Z. Khan, A. Vajzovic, and J.T. Staley. 2009. Diazotrophic endophytes of native Black Cottonwood and willow. Symbiosis 47:23–33. (i)

Dremmer, R., and R.L. Beschta. 2008. Recent history (1988-2004) of Beaver dams along Bridge Creek in central Oregon. Northwest Science 82:309-318. (i)

Ebersole, J. L., W.J. Liss, and C.A. Frissell. 2003a. Thermal heterogeneity, stream channel morphology, and salmonid abundance in northeastern Oregon streams. Canadian Journal of Fisheries and Aquatic Sciences 60:1266-1280. (i)

Ebersole, J. L., W.J. Liss, and C.A. Frissell. 2003b. Cold water patches in warm streams: physicochemical characteristics and the influence of shading. Journal of the American Water Resources Association 39:355-368. (i)

Evans, S. 1989. Provisional riparian and aquatic wetland plant communities on the Columbia Plateau. Report prepared under contract No. C0089098. Report to Washington Department of Ecology. Natural Heritage Program, Washington Department of Natural Resources, Olympia, Washington. (viii)

Fasching, R.A., and J.W. Bauder. 2001. Evaluation of agricultural sediment load reductions using vegetative filter strips of cool season grasses. Water Environment Research 73:590-596.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment. United States Department of Agriculture and United States Department of Interior, Portland, Oregon. (viii)

Finley, W.L. 1937. The Beaver – conserver of soil and water. Pages 295-297 *in* Transactions of the Second North American Wildlife Conference. American Wildlife Institute, Washington, D.C. (viii)

Fisher, S.G. 1995. Stream ecosystems of the western United States. Pages 61-87 *in* C.E. Cushing, K.W. Cummins, and G.W. Minshall, editors. River and stream ecosystems of the world. University of California Press, Berkley, California. (i)

Fisher, R.F., and D. Binkley. 2000. Ecology and management of forest soils. Wiley, New York.

Florsheim, J.L., J.F. Mount, and A. Chin. 2008. Bank erosion as a desirable attribute of rivers. BioScience 58:519-529. (i)

Fonda, R.W. 1974. Forest succession in relation to river terrace development in Olympic National Park, Washington. Ecology 55:927-942. (i)

Fox, M., and S. Bolton. 2007. A regional and geomorphic reference for quantities and volumes of instream wood in unmanaged forested basins of Washington State. North American Journal of Fisheries Management 27:342-359. (i)

Franklin, J.F., and C.T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Oregon State University Press, Corvallis, Oregon. (i)

Galbraith, W.A., and E.W. Anderson. 1971. Grazing history of the Northwest. Journal of Rangeland Management 24:6-12. (i)

Gebauer, A.D., R. Brown, S. Schwab, C. Nezat, and C. McNeely. 2015. Effects of an invasive grass (*Phalaris Arundinacea*) on water availability in semi-arid riparian zones. Wetlands 36:59–72. (i)

Giblin, D. 2006. Russian Olive, *Elaeagnus angustifolia*. Pages 78–79 *in* P.D. Boersma, S.H. Reichard, and

A.V. van Buren, editors. Invasive species in the Pacific Northwest. University of Washington Press, Seattle. (i)

Gibson, P.P., and J.D. Olden. 2014. Ecology, management, and conservation implications of North American Beaver (*Castor canadensis*) in dryland streams. Aquatic Conservation: Marine and Freshwater Ecosystems 24:391-409. (i)

Gibson, P.P., J.D. Olden, and M.W. O'Neill. 2015. Beaver dams shift desert fish assemblages toward dominance by non-native species (Verde River, Arizona, USA). Ecology of Freshwater Fish 24:355–372. (i)

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones. Bioscience 41: 540–551. (i)

Griffin, E., J. Kean, K. Vincent, J. Smith, and J. Friedman. 2005. Modeling effects of bank friction and woody bank vegetation on channel flow and boundary shear stress in the Rio Puerco, New Mexico. Journal of Geophysical Research 110:F04023. (i)

Gurnell, A. 2014. Plants as river system engineers. Earth Surface Processes and Landforms 39:4-25. (i)

Hickey, M.B., and B. Doran. 2004. A review of efficiency of buffer strips for the maintenance and enhancement of riparian ecosystems. Water Quality Research Journal of Canada 39:311-317. (i)

Higgs, E., D.A. Falk, A. Guerrini, M. Hall, J. Harris, R.J. Hobbs, S.T. Jackson, J.M. Rhemtulla, and W. Throop. 2014. The changing role of history in restoration ecology. Frontiers in Ecology and the Environment 12:499–506. (i)

Hood, W.G., and R.J. Naiman. 2000. Vulnerability of riparian zones to invasion by exotic vascular plants. Plant Ecology 148:105-114. (i)

Hook, P.B. 2003. Sediment retention in rangeland riparian buffers. Journal of Environmental Quality 32:1130-1137. (i)

Hough-Snee, N., B.B. Roper, J.M. Wheaton, and R.L. Lokteff. 2015. Riparian vegetation communities of the American Pacific Northwest are tied to multi-scale environmental filters. River Research and Applications 31:1151-1165. (i)

Hultine, K.R., and S.E. Bush. 2011. Ecohydrological consequences of non-native riparian vegetation in the southwestern United States: A review from an ecophysiological perspective. Water Resources Research 47: W07542. (i)

Hupp, C.R., and W.R. Osterkamp. 1996. Riparian vegetation and fluvial geomorphic processes. Geomorphology 14:277-295. (i)

Johnson, D.R., and D.H. Chance. 1974. Presettlement overharvest of upper Columbia River Beaver populations. Canadian Journal of Zoology 52:1519-1521. (i)

Jones, A. 2000. Effects of cattle grazing on North American arid ecosystems: a quantitative review. Western North American Naturalist 60:155-164. (i)

Kaiser, V.G. 1961. Historical land use and erosion in the Palouse – a reappraisal. Northwest Science 35:139-153. (i)

Katz, G.L., and P.B. Shafroth. 2003. Biology, ecology and management of *Elaeagnus angustifolia* L. (Russian Olive) in western North America. Wetlands 23:763-777. (i)

Kauffman, J.B., R.L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries 22:12-24. (i)

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications: a review. Journal of Range Management 37:430-438. (i)

Kunkle, G.R. 1968. A hydrogeologic study of the ground-water reservoirs contributing base runoff to Four Mile Creek, east-central Iowa. Geological Survey Water-Supply Paper 1839-O. U.S. Geological Survey, Washington, D.C. (i)

KWA. 2004. Crab Creek subbasin plan. KWA Ecological Sciences Inc., Duvall, Washington. (viii)

Latterell, J.J., and R.J. Naiman. 2007. Sources and dynamics of large logs in a temperate floodplain river. Ecological Applications 17:1127-1141. (i)

Lesica, P., and S. Miles. 1999. Russian olive invasion into cottonwood forests along a regulated river in north-central Montana. Canadian Journal of Botany 77: 1077-1083. (i)

Li, H.W., G.A. Lamberti, T.N. Pearsons, C.K. Tait, and J.L. Li. 1994. Cumulative effects of riparian disturbance along high desert trout streams of the John Day Basin, Oregon. Transactions of the American Fisheries Society 123:627-640. (i)

Lichvar, R.W., N.C. Melvin, M.L. Butterwick, and W.N. Kirchner. 2012. National wetland plant list indicator rating definitions. ERDC/CRREL TN-12-1. U.S. Army Corps of Engineers, Washington, D.C. (viii)

Liu, X., X. Zhan, and M. Zhang. 2008. Majors factors influencing the efficacy of vegetated buffers on sediment trapping: a review and analysis. Journal of Environmental Quality 37:1667-1674. (i)

Liquori, M., and C.R. Jackson. 2001. Channel response from shrub dominated riparian communities and associated effects on salmonid habitat. Journal of the American Water Resources Association 37:1639-1651. (i)

Loope, L.L., P.G. Sanchez, P.W. Tarr, W.L. Loope, and R.L. Anderson. 1988. Biological invasions of arid land nature reserves. Biological Conservation 44:95-118. (i)

Lorne, L. 1993. Marketing wildlife: the Hudson's Bay Company and the Pacific Northwest, 1821-1849. Forest & Conservation History 37(January):14-24. (i)

Macfarlane, W.W., J.T. Gilbert, M.L. Jensen, J.D. Gilbert, N. Hough-Snee, P.A. McHugh, J.M. Wheaton, and S.N. Bennett. 2017. Riparian vegetation as an indicator of riparian condition: detecting departures from historic condition across the North American West. Journal of Environmental Management 202:447-460. (i)

Macfarlane, W.W., J.M. Wheaton, N. Bouwes, M.L. Jensen, J.T. Gilbert, N. Hough-Snee, and J.A. Shivik. 2017. Modeling the capacity of riverscapes to support Beaver dams. Geomorphology 277:72-99. (i)

Mack, R.N. 1988. First comprehensive botanical survey of the Columbia Plateau, Washington: the Sandberg and Leiberg Expedition of 1893. Northwest Science 62:118-128. (i)

Mack, R.N., and J.N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. American Naturalist 119:757-773. (i)

Mann, C. 1990. Meta-analysis in the breech. Science 249:476-480. (i)

Mapes, L.V. 2010. Northwest tribes seek solutions to unwanted horses. The Seattle Times. Available: **https://www.seattletimes.com/seattle-news/northwest-tribes-seek-solutions-to-unwanted-horses/**. (February 2018). (viii)

Martinez, A.E., and P.F. McDowell. 2016. Invasive Reed Canarygrass (*Phalaris arundinacea*) and native vegetation roughness. Invasive Plant Science and Management 9:12-21. (i)

Mayer, P.M., S.K. Reynolds, M.D. Marshall, D. McCutchen, and T.J. Canfield. 2007. Meta-analysis of nitrogen removal in riparian buffers. Journal of Environmental Quality 36:1172-1180. (i)

McAllister, L.S. 2008. Reconstructing historical riparian conditions for two river basins in eastern Oregon, USA. Environmental Management 42:412-425. (i)

McKee, A., G. LaRoi, and J.F. Franklin. 1982. Structure, composition, and reproductive behavior of terrace forests, South Fork Hoh River, Olympic National Park. Pages 22-29 *in* E.E. Starkey, J.F. Franklin, and J.W. Matthews, technical coordinators. Ecological Research in National Parks of the Pacific Northwest. Oregon State University Research Laboratory Publication, Corvallis, Oregon. (i)

Meinig, D.W. 1968. The great Columbia Plain: a historical geography. University of Washington Press, Seattle, Washington. (i)

Meinzer, O.E. 1923. Outline of ground-water hydrology. Water Supply Paper 494. U.S. Geological Survey, Washington, D.C. (i)

Meyboom, P. 1961. Estimating ground-water recharge from stream hydrographs. Journal of Geophysical Research 66:1203-1214. (i)

Micheli, E.R., and J.W. Kirchner. 2002. Effects of wet meadow riparian vegetation on streambank erosion. 2. Measurements of vegetated bank strength and consequences for failure mechanics. Earth Surface Processes and Landforms 27:687–697. (i)

Minckley, W.L., and J.N. Rinne. 1985. Large woody debris in hot-desert streams: an historical overview. Desert Plants 7(3):142-153. (i)

Murphy, M.L. 1998. Primary productivity. Pages 144-168 *in* R.J. Naiman and R.E. Bilby, editors. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. (i)

Naiman, R.J., and R.E. Bilby, editors. 1998. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. (i)

Naiman, R.J., R.E. Bilby, D.E. Schindler, and J.M. Helfield. 2002. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. Ecosystems 5:399-417. (i)

Naiman, R.J., T.J. Beechie, L.E. Benda, D.R. Berg, P.A. Bisson, L.H. MacDonald, M.D. O'Conner, P.L. Olsen, and E.A. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest Coastal Ecoregion. Pages 127-188 *in* R.J. Naiman, editor. Watershed management: balancing sustainability and environmental change. Springer, New York. (i)

Naiman, R.J., C.A. Johnston, and J.C. Kelley. 1988. Alteration of North American streams by Beaver. BioScience 38:753-762. (i)

Naiman, R.J., and J.R. Sedell. 1980. Relationships between metabolic parameters and stream order in Oregon. Canadian Journal of Fisheries and Aquatic Sciences 37:834-847. (i)

NTHC (Northwest Tribal Horse Coalition). no date. Managing excess feral horses in the Inland Northwest. Available: **https://www.ynwildlife.org/Wildhorsecoalition.php.** (February 2018). (viii)

Ohmart, R.D. 1996. Historical and present impacts of livestock grazing on fish and wildlife resources in western riparian habitats. Pages 245-279 in P.R. Krausman, editor. Rangeland wildlife. Society for Range Management, Denver, Colorado. (i)

Olson, D.M., E. Dinerstein, E.D. Wikramanayake, N.D. Burgess, G.V.N. Powell, E.C. Underwood, J.A. D'Amico, H.E. Strand, J.C. Morrison, C.J. Loucks, T.F. Allnutt, J.F. Lamoreux, T.H. Ricketts, I. Itoua, W.W. Wettengel, Y. Kura, P. Hedao, and K. Kassem. 2001. Terrestrial ecoregions of the world: A new map of life on Earth. BioScience 51:933-938. (i)

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77(1):118-125. (i)

Omernik, J.M. and A.L. Gallant. 1986. Ecoregions of the Pacific Northwest. EPA/600/3-86/033. U.S. Environmental Protection Agency, Corvallis, Oregon. (i)

Ortolano, L.K., K. Cushing, and contributing authors. 2000. Grand Coulee Dam and the Columbia Basin Project, USA. World Commission on Dams, Cape Town, South Africa. (viii)

Osterkamp, W.R., and C.R. Hupp. 2010. Fluvial processes and vegetation – glimpses of the past, the present, and perhaps the future. Geomorphology 116:274-285. (i)

Ott, J. 2003. "Ruining" the rivers in the Snake country. Oregon Historical Quarterly 104(2):166-195. (i)

Pabst, R.J., and T.A. Spies. 1999. Structure and composition of unmanaged riparian forests in the coastal mountains of Oregon, USA. Canadian Journal of Forest Research 29:1557-1573. (i)

Parker, M., F.J. Wood, B.H. Smith, and R.G. Elder. 1985. Erosional downcutting in lower order riparian ecosystems: have historical changes been caused by the removal of Beaver? Pages 35-38 in R.R. Johnson, C.D. Ziebell, D.R. Patton, P.F. Ffolliott, R.H. Hamre, editors. Riparian ecosystems and their management: reconciling conflicting uses. RMRS-GTR-RM-120. U.S. Forest Service, Rocky Mountain Forest and Range Experimental Station, Fort Collins, Colorado. (viii)

Patten, D.T. 1998. Riparian ecosystems of semi-arid North America: diversity and human impacts. Wetlands 18:498–512. (i)

Platts, W.S., and R.L. Nelson. 1989. Stream canopy and its relationship to salmonid biomass in the intermountain west. North American Journal of Fisheries Management 9:446-457. (i)

Pollen-Bankhead, N., and A. Simon. 2010. Hydrologic and hydraulic effects of riparian root networks on streambank stability: Is mechanical root-reinforcement the whole story? Geomorphology 116:353-362. (i)

Pollock, M.M., T.J. Beechie, and C.E. Jordan. 2007. Geomorphic changes upstream of Beaver dams in Bridge Creek, an incised stream channel in the interior Columbia River basin, eastern Oregon. Earth Surface Processes and Landforms 32:1174-1185. (i)

Pollock, M.M., T.J. Beechie, J.M. Wheaton, C.E. Jordan, N.Bouwes. N. Weber, and C. Volk. 2014. Using Beaver dams to restore incised stream ecosystems. Bioscience 64:279-290. (i)

Pollock, M.M., M. Heim, and D. Werner. 2003. Hydrological and geomorphic effects of Beaver dams and their influence on fishes. Pages 213-233 in S.V. Gregory, K.L. Boyer, and A.M. Gurnell, editors. The ecology and management of wood in world rivers. American Fisheries Society, Bethesda, Maryland. (i)

Polvi, L.E., E.E. Wohl, and D.M. Merritt. 2014. Modeling the functional influence of vegetation type on streambank cohesion. Earth Surface Processes and Landforms 39:1245-1258. (i)

Polyakov, V., A. Fares, and M.H. Ryder. 2005. Precision riparian buffers for the control of nonpoint source pollutant loading into surface water: a review. Environmental Reviews 13:129-144. (i)

Reidy Liermann, C.A., J.D. Olden, T.J. Beechie, M.J. Kennard, P.B. Skidmore, C.P. Konrad, and H. Imaki. 2012. Hydrogeomorphic classification of Washington state rivers to support emerging environmental flow management strategies. River Research and Applications 28:1340–1358. (i)

Richardson, J.S., R.J. Naiman, F.J. Swanson, and D.E. Hibbs. 2005. Riparian communities associated with Pacific Northwest headwater streams: assemblages, processes, and uniqueness. Journal of the American Water Resources Association 41:935-947.

Robison, G.E., J. Runyon, and C. Andrus. 1999. Cooperative stream temperature monitoring: project completion report for 1994–1995. Forest Practices Technical Report 2, Oregon Department of Forestry, Salem, Oregon. (viii)

Rockie, W.A. 1939. Man's effects on the Palouse. The Geographical Review 29(1):34-45. (i)

Roe, A.L. 1958. Silvics of Black Cottonwood. Miscellaneous Publication 17. U.S. Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. (viii)

Rood, S.B., S.G. Bigelow, M.L. Polzin, K.M. Gill, and C.A. Coburn. 2015. Biological bank protection: trees are more effective than grasses at resisting erosion from major river floods. Ecohydrology 8:772-779. (i)

Salemi, L.F., J.D. Groppo, R. Trevisan, J.M. de Moraes, W. de Paula Lima, and L.A. Martinelli. 2012. Riparian vegetation and water yield: a synthesis. Journal of Hydrology 454–455:195–202. (i)

Salo, E.O., and T.W. Cundy, editors. 1987. Streamside management: forestry and fishery interactions. Contribution No. 57. Institute of Forest Resources, University of Washington, Seattle. (viii)

Scheffer, P.M. 1938. The Beaver as an upstream engineer. Soil Conservation 3:178-181. (i)

Sedell, J.R., F.H. Everest, and D.R. Gibbons. 1989. Streamside vegetation management for aquatic habitat. Pages 115-125 in Proceedings of the National Silviculture Workshop: silviculture for all resources. U.S. Forest Service, Washington, D.C. (i)

Sedell, J.R., and F.J. Swanson. 1984. Ecological characteristics of streams in old-growth forest of the Pacific Northwest. Pages 9-16 in W.R. Meehan, T.R. Merrell, and T.A. Hanley, editors. Fish and wildlife relationships in old-growth forests. American Institute of Fishery Research Biologists. (i)

Simon, A., and A.J.C. Collison. 2002. Quantifying the mechanical and hydrologic effects of riparian vegetation on streambank stability. Earth Surface Processes and Landforms 27:527–546. (i)

Simon, A., N. Pollen, and E. Langendoen. 2006. Influence of two woody riparian species on critical conditions for streambank stability: upper Truckee River, California. Journal of the American Water Resources Association 42:99-113. (i)

Sleeter, B.M. 2012. Columbia Plateau Ecoregion. Pages 299- 236 in B.M. Sleeter, T.S. Wilson, and W. Acevedo, editors. Status and trends of land change in the Western United States – 1973 to 2000: U.S. Geological Survey Professional Paper 1794–A. U.S. Geological Survey, Reston, Virginia.

Stannard, M., and W. Crowder. 2001. Biology, history, and suppression of Reed Canarygrass (Phalaris arundinacea L.). Technical Note Plant Materials No. 40. Natural Resources Conservation Service, Boise, Idaho. (viii)

Stanford, J.A., E.B. Snyder, M.N. Lorang, D.C. Whited, P.L. Matson, and J.L. Chaffin. 2002. The reaches project: ecological and geomorphic studies supporting normative flows in the Yakima River basin, Washington. Flathead Lake Biological Station, Polson, Montana. (viii)

Stoddard, J.L., D.P. Larsen, C.P. Hawkins, R.K. Johnson, and R.H. Norris. 2006. Setting expectations for the ecological condition of streams: the concept of reference condition. Ecological Applications 16:1267–1276. (i)

Snyder, E.B., and J.A. Stanford. 2001. Review and synthesis of river ecological studies in the Yakima River, Washington, with emphasis on flow and salmon habitat interactions. Flathead Lake Biological Station, Polson, Montana. (viii)

Sweeney, B.W., and J.D. Newbold. 2014. Streamside buffer width needed to protect stream water quality, habitat, and organisms: a literature review. Journal of the American Water Resources Association 50:560-584. (i)

Talabere, A.G. 2002. Influence of water temperature and Beaver ponds on Lahontan Cutthroat Trout in a high-desert stream, southeastern Oregon. Master's thesis. Oregon State University, Corvallis. (i)

Tait, C.K., J.L. Li, G.A. Lamberti, T.N. Pearsons, and H.W. Li. 1994. Relationships between riparian cover and the community structure of high desert streams. Journal of the North American Benthological Society 13:45-56. (i)

Tate, K., G. Nader, and D. Lewis. 2000. Evaluation of buffers to improve the quality of runoff from irrigated pastures. Journal of Soil and Water Conservation 55:473–478. (i)

Thomas, F.M. 2014. Ecology of phreatophytes. Progress in Botany 75:335-375. (i)

Thomas, J.W., C. Maser, and J. E. Rodiek. 1979. Wildlife habitats in managed rangelands – the Great Basin of southeastern Oregon: riparian zones. GTR-PNW-80. U.S. Forest Service, Pacific Northwest Experimental Station, Portland, Oregon. (viii)

Thomas, H., and T.R. Nisbet. 2007. An assessment of the impact of floodplain woodland on flood flows. Water and Environment Journal 21:114-126. (i)

Thut, R.N., and E.P. Haydu. 1971. Effects of forest chemicals on aquatic life. Pages 159-171 in J.T. Krygier and J.D. Hall, editors. A symposium on forest land uses and the stream environment. Continuing Education Publications, Oregon State University, Corvallis. (i)

Toledo, Z.O., and J.B Kauffman. 2001. Root biomass in relation to channel morphology of headwater streams. Journal of the American Water Resources Association 37:1653-1663. (i)

Tribal Tribune. 2013. Horses on the landscape. Available: http://www.tribaltribune.com/news/article_3abf8d87-e606-54b1-9e42-5ef6c0fb1036.html. (February 2018). (viii)

Triska, F.J., J.R. Sedell, K. Cromack Jr, S.V. Gregory, and F.M. McCorison. 1984. Nitrogen budget for a small coniferous forest stream. Ecological Monographs 54:119-40. (i)

Tu, M. 2006. Reed Canarygrass, *Phalaris arundinacea*. Pages 12–13 *in* P.D. Boersma, S.H. Reichard, and A.V. van Buren, editors. Invasive species in the Pacific Northwest. University of Washington Press, Seattle. (i)

Tuttle, G.M., G.L. Katz, J.M. Friedman, and A.P. Norton. 2016. Local environmental context conditions the impact of Russian Olive in a heterogeneous riparian ecosystem. Invasive Plant Science and Management 9:272-289. (i)

USACE (U.S. Army Corps of Engineers). 2002. Final Lower Snake River juvenile salmon migration feasibility report/environmental impact statement, Appendix I: Economics. Walla Walla District, Washington. (i)

USBR (U.S. Bureau of Reclamation). 2017a. Yakima Project. Available: https://www.usbr.gov/projects/index.php?id=400. (September 2018). (viii)

USBR (U.S. Bureau of Reclamation). 2017b. Columbia Basin Project. Available: https://www.usbr.gov/projects/index.php?id=438. (September 2018). (viii)

USBR & WDOE (U.S. Bureau of Reclamation and Washington Department of Ecology). 2012. Final programmatic environmental impact statement Yakima River basin integrated water resource management plan. Yakima, Washington. (viii)

USFS (U.S. Forest Service). 2004. Riparian restoration. 0423 1201–SDTDC. Technology & Development Program, San Dimas, California. (viii)

USFWS (U.S. Fish and Wildlife Service). 1994. An ecosystem approach to fish and wildlife conservation. Washington, D.C. (viii)

Vaccaro, J.J. 2011. River-aquifer exchanges in the Yakima River basin, Washington. U.S. Geological Survey, Reston, Virginia. (viii)

Warren, S.D. 2014. Role of biological soil crusts in desert hydrology and geomorphology: implications for military training operations. Reviews in Engineering Geology 22:177-186. (i)

Webb, R.H., and S.A. Leake. 2006. Ground-water and surface-water interactions and long-term change in riverine riparian vegetation in the southwestern United States. Journal of Hydrology 320:302-323. (i)

Weddell, B.J. 2001. Changing perspectives in nineteenth century written descriptions of Palouse and canyon grasslands. Technical Bulletin No. 01-13. Bureau of Land Management, Cottonwood District, Cottonwood, Idaho. (viii)

West, E., and G. Ruark. 2004. A long, long time ago: historical evidence of riparian forests in the Great Plains and how that knowledge can aid with restoration and management. Journal of Soil and Water Conservation 59:105A-110A. (i)

Westbrook, C.J., D.J. Cooper, and B.W. Baker. 2006. Beaver dams and overbank floods influence groundwater-surface water interactions of a Rocky Mountain riparian area. Water Resources Journal 42:W06404. (i)

Westbrook, C.J., D.J. Cooper, and B.W. Baker. 2011. Beaver assisted river valley formation. River Research and Applications 27:247–256. (i)

White, P., and J.L. Walker. 1997. Approximating nature's variation: selecting and using reference information in restoration ecology. Restoration Ecology 5:338-349. (i)

Whiting, P.J., and M. Pomerants. 1997. A numerical study of bank storage and its contribution to streamflow. Journal of Hydrology 202:121-136. (i)

Winter, T.C., J.W. Harvey, O.L. Franke, and W.M. Alley. 1998. Ground water and surface water: a single resource. Circular 1139. U.S. Geological Survey, Denver, Colorado. (viii)

Wissmar, R.C. 2004. Riparian corridors of eastern Oregon and Washington: functions and sustainability along lowland-arid to mountain gradients. Aquatic Sciences 66:373-387. (i)

Wissmar, R.C., J.E. Smith, B.A. McIntosh, H.W. Li, and G.H. Reeves. 1994. A history of resource use and disturbance in riverine basins of eastern Oregon and Washington (early 1800s-1990s). Northwest Science 68 (special issue):1-35. (i)

Wohl, E. 2005. Compromised rivers: understanding historical human impacts on rivers in the context of restoration. Ecology and Society 10(2):2. (i)

Wohl, E., B.P. Bledsoe, R.B. Jacobson, N.L. Poff, S.L. Rathburn, D.M. Walters, and A.C. Wilcox. 2015. The natural sediment regime in rivers: broadening the foundation for ecosystem management. Bioscience 65:358-371. (i)

WSDA (Washington State Department of Agriculture). 2016. Washington State noxious weed general distribution maps. Olympia, Washington. Available: https://agr.wa.gov/washington-agriculture/maps/weed-distribution. (January 2020). (viii)

Wuehlisch, G.V. 2011. Evidence for nitrogen-fixation in the Salicaceae family. Tree Planter Notes 54(2):38-41. (i)

WWBWC (Walla Walla Basin Watershed Council). 2013. Walla Walla basin aquifer recharge strategic plan. Milton-Freewater, Oregon. (viii)

Xiong, S., and C. Nilsson. 1997. Dynamics of leaf litter accumulation and its effects on riparian vegetation: a review. Botanical review 63:240–264. (i)

YN (Yakama Nation). 2010. Wild Horse (K'u-See) Project. Wildlife, Range & Vegetation Resources Management Program, Confederated Tribes and Bands of the Yakama Nation, Toppenish, Washington. Available: https://www.ynwildlife.org/wildhorseprogram.php. (February 2018) (viii)

YSPB (Yakima Subbasin Planning Board). 2004. Yakima subbasin plan. Yakima Subbasin Fish and Wildlife Planning Board, Benton and Yakima counties, Washington. (viii)

Yuan, Y., R.L. Bingner, and M.A. Locke. 2009. A review of effectiveness of vegetative buffers on sediment trapping in agricultural areas. Ecohydrology 2:321-336. (i)

Zhang, X., X. Liu, M. Zhang, and R.A. Dahlgren. 2010. A review of vegetated buffers and a meta-analysis of their mitigation efficacy in reducing nonpoint source pollution. Journal of Environmental Quality 39:76-84. (i)

Zoellick, B.W. 2004. Density and biomass of redband trout relative to stream shading and temperature in southwestern Idaho. Western North American Naturalist 64:18-26. (i)

Chapter 8. Watersheds

By: Derek B. Booth

8.1. Introduction

This chapter on watershed-scale processes and management looks beyond the typical site-by-site perspective at which riparian management and stream protection is normally applied. This chapter also considers the interactions between site-specific treatments, whose collective effects may be greater (or less) than anticipated by the individual actions themselves, and it uses these insights to offer a broader approach to riparian management for the protection of aquatic systems. Given this expanded focus, the conditions and influences discussed here may lie outside the framework of normal guidance and regulatory mandates, but they nonetheless affect the health and productivity of riparian areas and their associated aquatic systems. Thus, the conceptual framework provided here should be useful when considering the likely effects of riparian management policies or practices.

The purpose of this chapter is to explore the relationship (and the importance) of watershed-scale management to achieving the goal of abundant, self-sustaining fish and wildlife populations. It assumes that a broader watershed-scale perspective on aquatic ecosystems will ultimately enhance the beneficial effects of management applied at all scales.

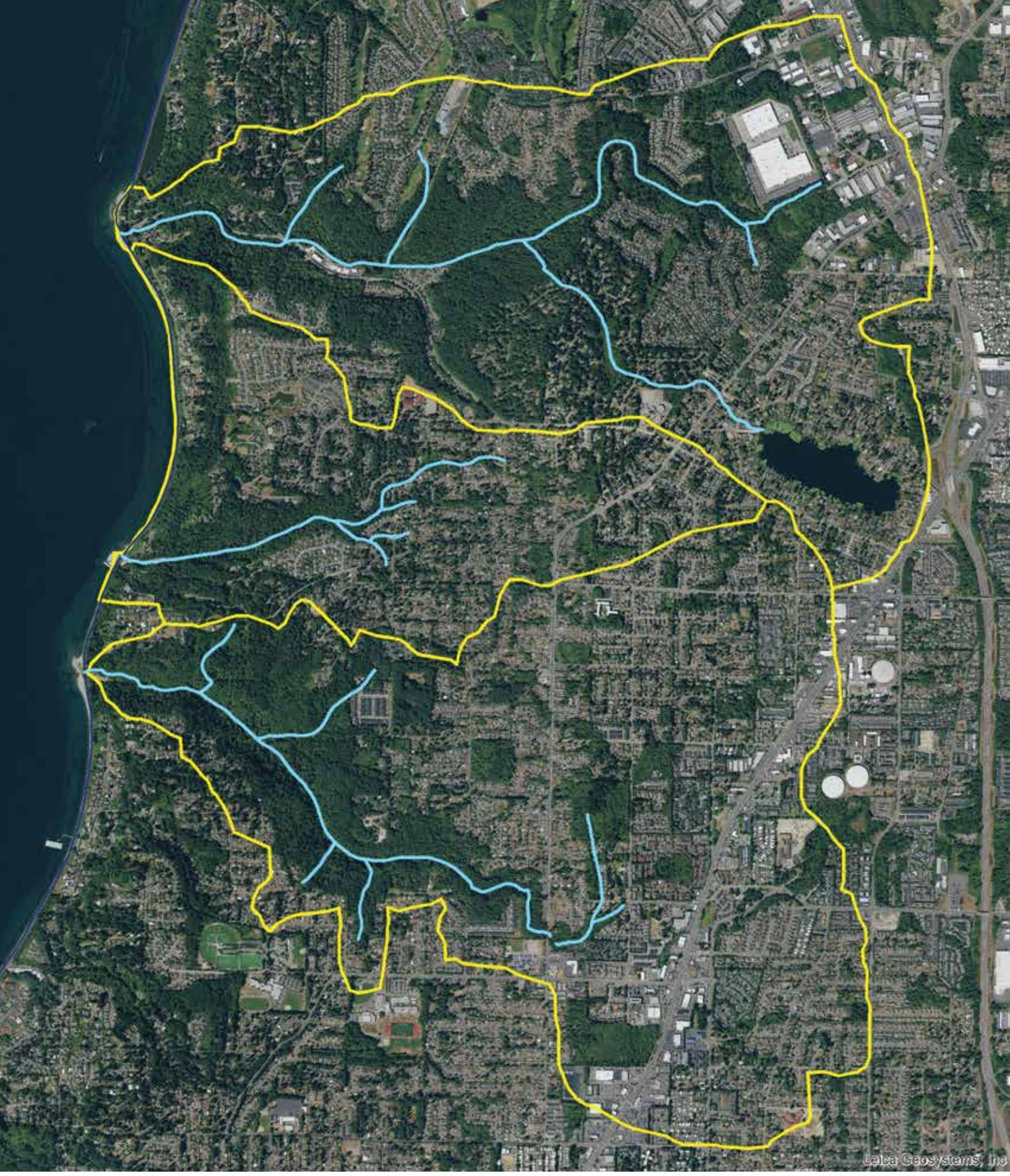
The chapter is divided into four primary sections:

1. A conceptual framework that identifies the key watershed processes and their primary influences on riparian ecosystems and their watercourses, a perspective with a long history in the scientific literature. However, advances in the discipline of landscape ecology over the past two decades—particularly the recognized importance of interrelationships between landscape elements in both spatial (e.g., connectivity and discontinuities) and temporal (e.g., disturbances and recovery) domains—have changed how biological and physical scientists view aquatic ecosystems and the riverine landscape that they occupy.

2. A discussion of how riparian management at the site scale, the emphasis of the other chapters in this document, can best support ecological functions and improve habitat conditions for fish and wildlife, even if a complementary set of watershed-scale management actions (e.g., land use at the watershed scale) cannot be implemented.

3. A description of how individual site-scale management actions, and their recognized site-scale benefits, relate to one another across a channel network and/or landscape. In other words, how do the consequences and overall value/benefit of isolated actions integrate along a channel network? Are the effects of individual actions simply additive, or are there synergistic effects that are revealed by a landscape ecology perspective?

4. Guidance, developed from an understanding of watershed processes and the perspective of landscape ecology, for improving the management of riparian ecosystems. This goal is complicated by the fact that most watersheds are managed under diverse and often uncoordinated responsibility: different landowners and managers have different goals and objectives. Furthermore, many of these managers have neither responsibility nor a process by which to coordinate their



Three watersheds (outlined in yellow) in urban areas of north Seattle/Terry Johnson, WDFW

actions, especially over the long durations necessary for riparian management actions to achieve their greatest effects. This chapter offers no prescription for resolving these challenges, but it proceeds under the belief that greater awareness of these interactions will ultimately lead to more successful protection of riparian systems, streams, and their biota.

8.2. Conceptual Framework

This chapter seeks to integrate the functions of riparian ecosystems into the overall landscape in which they interact–the riverine landscape or *riverscape*. This riverine landscape differs from the contributing watershed of the river or stream: although the flux of water and water-borne biota respect the drainage divides of a watershed almost exactly, other components do not. In particular, mobile organisms (e.g., birds, and large mammals such as American Beaver *Castor canadensis*, and bear (*Ursus* spp.), wind-borne seeds, and wildfire all have the potential to affect and be affected by landscape elements both within and beyond the boundaries of any given watershed, and so they must be included in any comprehensive conceptual framework (Figure 8.1). Despite these watershed-crossing elements, the lotic (flowing-water) environment itself is strongly organized by the unidirectional flow of water, a property that is distinct from terrestrial environments, and so rivers commonly display systematic patterns in the downstream direction (e.g., the "river continuum" of Vannote 1980.) They also display systematic cross-stream patterns, notably the spatial, physical, and ecological relationships between the channel and its adjacent floodplain; and to a less visible but still significant degree in the vertical dimension as well, particularly the interaction of shallow groundwater with stream water in the hyporheic zone (Boulton et al. 1998).

Landscape ecology is the scientific discipline best suited to this larger perspective of the riverine landscape: "...we perceive a need to conceptualize rivers not as sampling points, lines, or gradients, but as spatially continuous longitudinal and lateral mosaics. As such, heterogeneity in the river landscape, or riverscape, becomes the focus of study" (Fausch et al. 2002:485) (Figure 8.2). The foundational premise of landscape ecology is that both biotic and abiotic elements of the landscape interact with one another, and those interactions are spatially mediated (Malanson 1995).

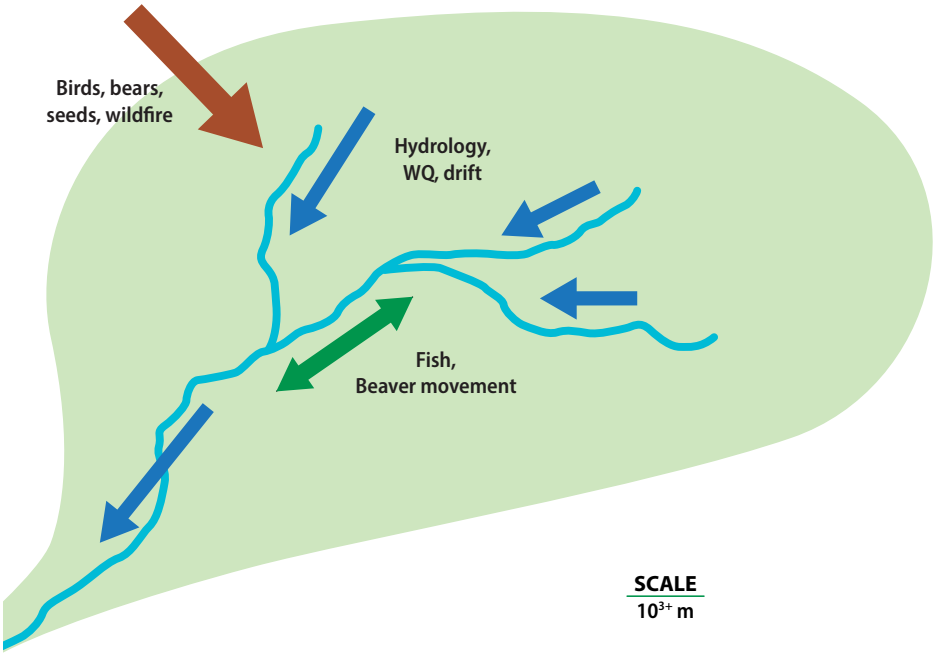


Figure 8.1. Movement of water and biota at the whole-watershed scale. WQ refers to water quality, and drift refers to the downstream transport of bottom-dwelling invertebrates by flowing water.

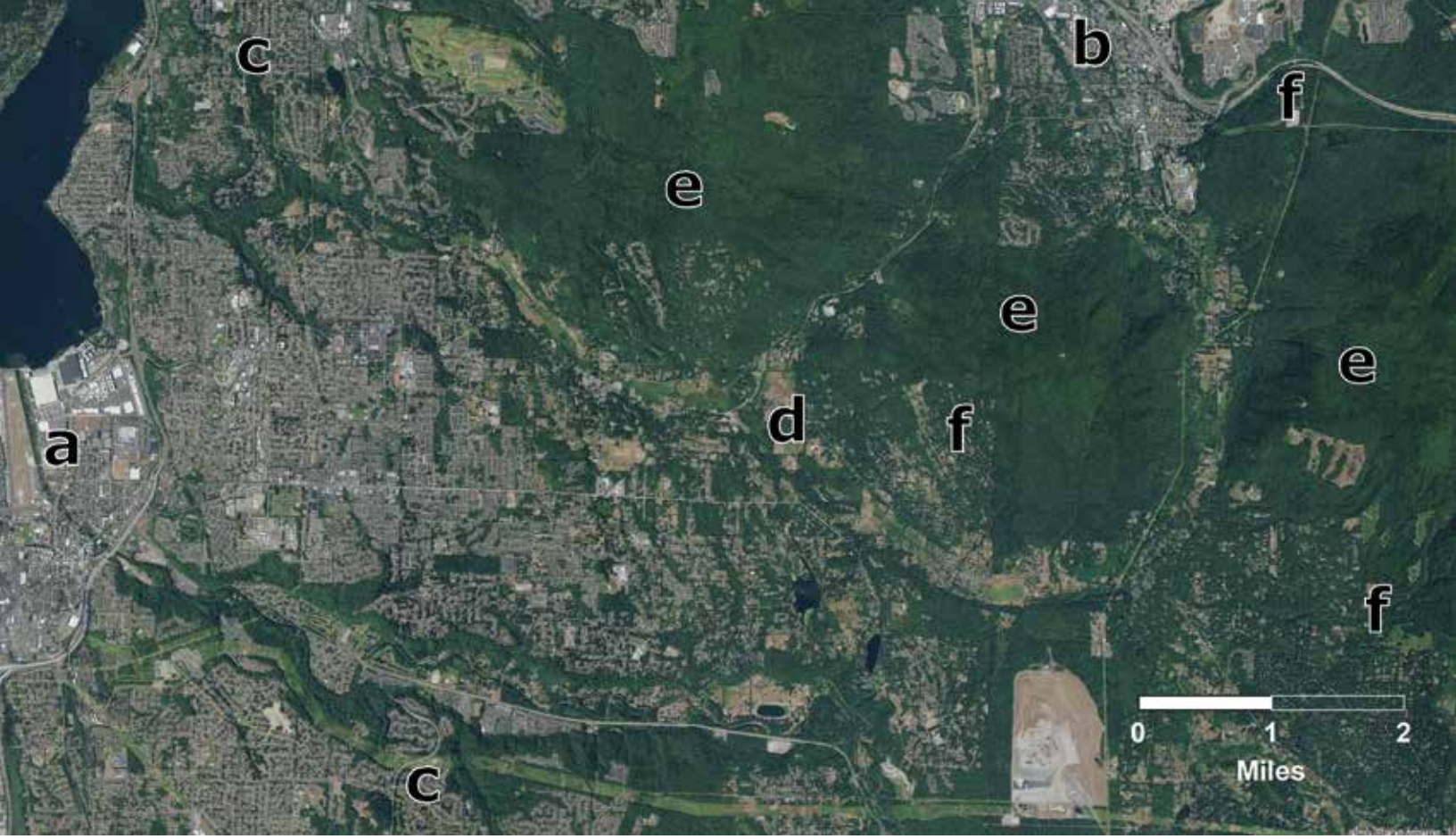


Figure 8.2. An example of landscape heterogeneity at multiple scales in an aerial view that includes the urban centers of Renton (west edge, labeled a) and Issaquah (northeast corner, b); suburban development throughout the south-central and northwest parts of the image (c); agriculture and rural-residential development, particularly in the valleys of May Creek and McDonald Creek trending NW across the center of the image (d); and extensive forest lands of Cougar, Squak, and Tiger Mountains (e) in the north-central and east parts. At finer spatial scales within the largely undeveloped areas in the eastern part of the image, fragmentation is nonetheless widespread from roads, utility lines, and clearing for residential lots and subdivisions (f).

This perspective emphasizes the importance of spatial heterogeneity; it also acknowledges the key role of episodic disturbances in determining the flux of energy and materials, the movement of organisms, and the creation of unique dynamics within the watershed (Wiens 2002).

At a finer spatial scale, water and biota interact across the permeable and dynamic boundary between riparian areas and a watershed's uplands (Figure 8.3, left panel). These areas comprise multiple components. Within riparian areas, these components include surface waters, in-channel bars and islands, floodplains, marshes, wet meadows, alluvial forests, and woody debris. For the uplands, these components might include unstable slopes, aquifer recharge areas, wetlands, seeps, forests, and areas of intensive human modification. Both areas also include the vast variety of organisms that occupy one or more of these habitats.



River running through rural residential area/Jane Atha, WDFW

Riparian areas occupy a particularly dynamic and disturbance-prone region (Figure 8.3, right panel) that can experience decadal, annual, or even more frequent flood events that locally alter, rearrange, or obliterate its components altogether.

> *In the natural state, riverine landscapes exemplify the* new paradigm in ecology *(sensu Talbot 1996), in which ecological systems are widely recognized as non-deterministic, open systems in continual states of flux, rather than internally regulated, homeostatic systems exhibiting equilibrium conditions. Yet, despite their highly dynamic nature, riverine landscapes provide predictable ecological conditions. Although individual landscape components exhibit high turnover, largely as a function of interactions between fluvial dynamics and successional phenomena, their relative abundances in the river corridor as a whole tend to remain constant over ecological time. [From Ward et al. 2002:518.]*

So, for example, a flood may scour a gravel bar at one location in a river and deposit sediment in another; but along any given channel reach the relative frequency of pools and bars may not vary substantially over time. The resulting transience and diversity of habitats provide a variety of habitats that, although ideally always present in aggregate, are not necessarily static in place or time (Robinson et al. 2002). Thus, managers should recognize this dynamic equilibrium as the key attribute of a truly functional riparian–aquatic ecosystem and make the protection of its dynamic *behavior* (rather than any specific *feature*) the overarching goal of riparian management.

Existing policies, however, generally do not facilitate management for dynamic conditions:

> *Policies setting underlying riparian goals that are essentially static and homogenous have become an integral part of many of the management guidelines that drive the goals for riparian management on federal, state and private lands in western Washington. Discussions [at a statewide forest management symposium] did not indicate that current management and policy guidelines necessarily preclude practices that might produce dynamic and heterogeneous riparian conditions. Because they promote uniform conditions over large areas, however, current policy and management guides do little to encourage treatments that would lead to ecologically diverse landscapes that could maintain critical functions that were formerly produced by natural disturbance regimes... [From Ryan and Calhoun 2010:viii-ix].*

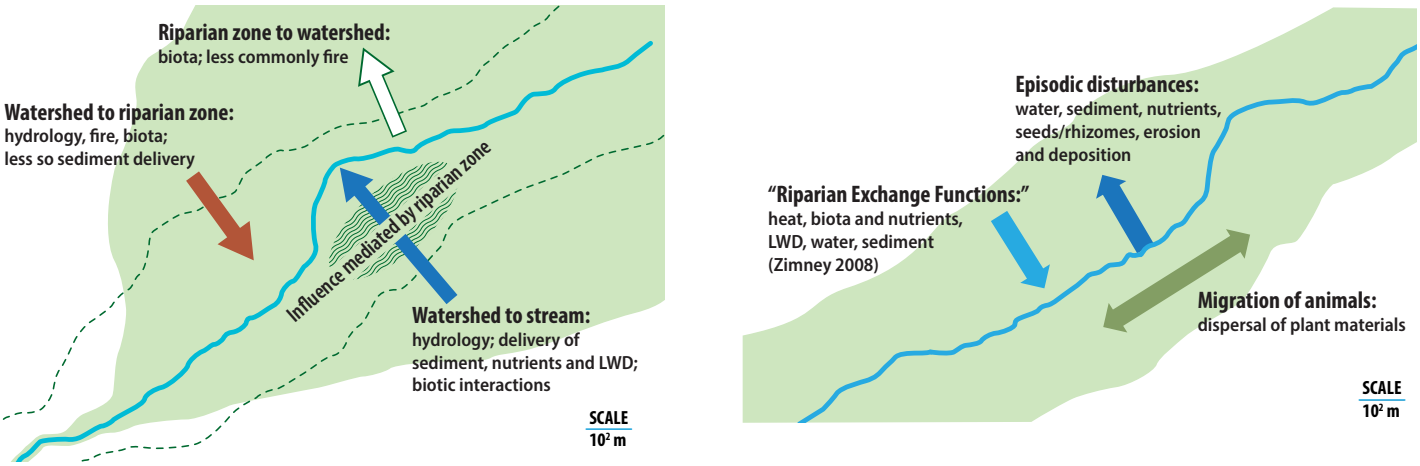


Figure 8.3. Movement of water, biota, and other elements of the aquatic system from the watershed into and through riparian areas (left) and between riparian areas and the stream (right).

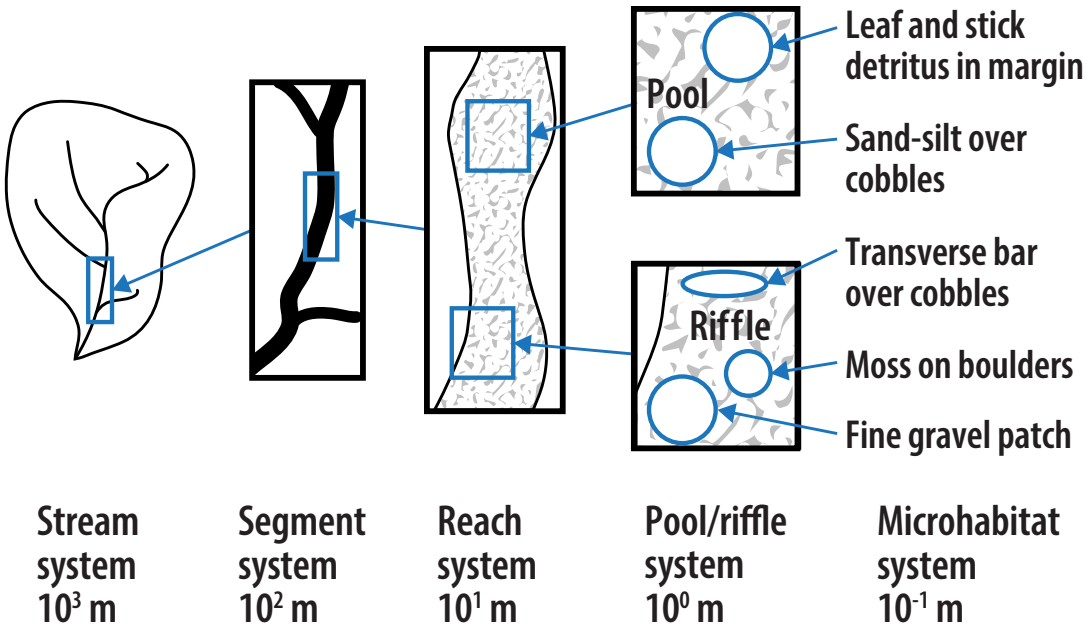


Figure 8.4. Hierarchical spatial organization of a watershed and its aquatic habitats. Approximate spatial scale, appropriate to second or third-order mountain stream (modified from Frissell et al. 1986).

On the other hand, riparian areas have experienced high levels of anthropogenic disturbance, both directly (e.g., harvest, road building) and indirectly (e.g., windthrow, landslides, and forest fire) due to forest management, which also compromises the dynamic equilibrium in riparian-aquatic ecosystems. In response, policy makers have reduced forest management-related disturbances in riparian areas, with the intent of passively reestablishing underrepresented late-seral classes (such as mature forest) which should improve riparian ecological functions, and conserve fish and wildlife species dependent on older forest. Such policies are all likely necessary parts of a successful riparian management strategy. However, because they do not address watershed-scale processes, these policies by themselves are almost surely insufficient to achieve desired riparian and aquatic ecosystem outcomes.

8.2.1. What are Watershed Processes?

Although the immediate goal of riparian management is the protection of species and their habitats, Frissell et al. (1986:199) suggested that "[w]e begin with the assumption that structure, operation, and other aspects of the organization and development of stream communities are largely determined by the organization, structure, and dynamics of the physical stream habitat." (Using the terminology elsewhere in this document, these terms correspond to the structure, composition, and functions of physical habitat). If so, "the problem becomes one of understanding these physical patterns across time and space. This requires a broad, integrative framework that places streams, their habitats, and their

communities in wider geographic context" (Frissell et al. 1986:200). Frissell et al. (1986) developed this wider context by describing a spatial hierarchy that recognizes the influence of larger scale conditions and processes acting primarily (but not exclusively) unidirectionally on smaller scales (Figure 8.4). Factors that are best characterized over the largest extents, and that exert their influence over longest time frames, can be thought of as the ultimate "drivers" of the conditions and processes at lower levels in the hierarchy.

Three overarching process drivers—climate, geology, and topography—structure the suite of landscape-forming processes that are distributed over a landscape and that, in turn, govern watershed characteristics and processes (paraphrasing the framework of Montgomery 1999). At management time scales (i.e., years to decades), these process drivers are invariant and immutable—they are the "givens" under which a watershed evolves. The physical habitat features of any watershed do not simply arise from these process drivers directly, however; instead, they are created and continuously modified by the fluxes of materials (particularly water and sediment) and energy that arise from these process drivers and are widely termed watershed processes. Watershed processes are defined as "[t]he dynamic physical and chemical interactions that form and maintain the landscape and ecosystems on a geographic scale of watershed to basins (i.e., hundreds to thousands of square miles)" (Stanley et al. 2011:8).

To this simple, unidirectional, physical model of watershed influences must be added a few complications of lesser but still critical importance. First, the flow of influence is not always one-way: although topography exerts the dominant influence on the flow of water, over time the erosion by that flowing water will alter the topography to some degree (which, over geologic time scales, may be sufficient to change the very boundaries of the watershed). Second, biota are not always passive respondents to the presence and changes of physical habitat, but instead can also influence that physical habitat in ways that are only slowly being recognized (see Moore 2006 for an overview of such effects). Robinson et al. (2002) emphasizes the role of fauna as ecosystem engineers of riverine landscapes, for which the modification of stream substrates by spawning salmon (Montgomery et al. 1996) or the rearrangement of floodplain dynamics by Beaver (Pollock et al. 2003) are two widely recognized examples. Biological conditions and processes are also of fundamental importance to the expression of some watershed processes: the flux of nutrients may not alter the physical habitat but is key to the health of the ecosystem; the character and extent of vegetative cover will greatly mediate the effects of topography, climate, and geology on the movement of runoff, the downslope transport of sediment, and the potential for dramatic, process-altering wildfire. Finally, the effects of people and human activities cannot be ignored in any useful conceptual framework applied to the modern landscape. Although direct modification of habitat and streams is an obvious impact with a long historical legacy in the Pacific Northwest (and beyond), the aggregate effects of human activities across whole watersheds can be even more consequential to instream resources, to the extent that land use, in many settings, becomes no less of a process driver (i.e., a determinant in a watershed) than is topography or climate.

These concepts are integrated into Figure 8.5, which emphasizes the unidirectional, hierarchical flow of influence from the large-scale process drivers onto the watershed processes that, in turn, give rise to the instream physical and ecological conditions and responses. This representation is not intended to deny the *upstream* influences that also occur (see Beechie et al. 2010, Figure 1 as an alternative representation), but it sacrifices completeness for clarity in acknowledging the overriding importance of this unidirectional perspective. This conceptual model also articulates the variety of processes that are embraced within each of the major watershed processes we

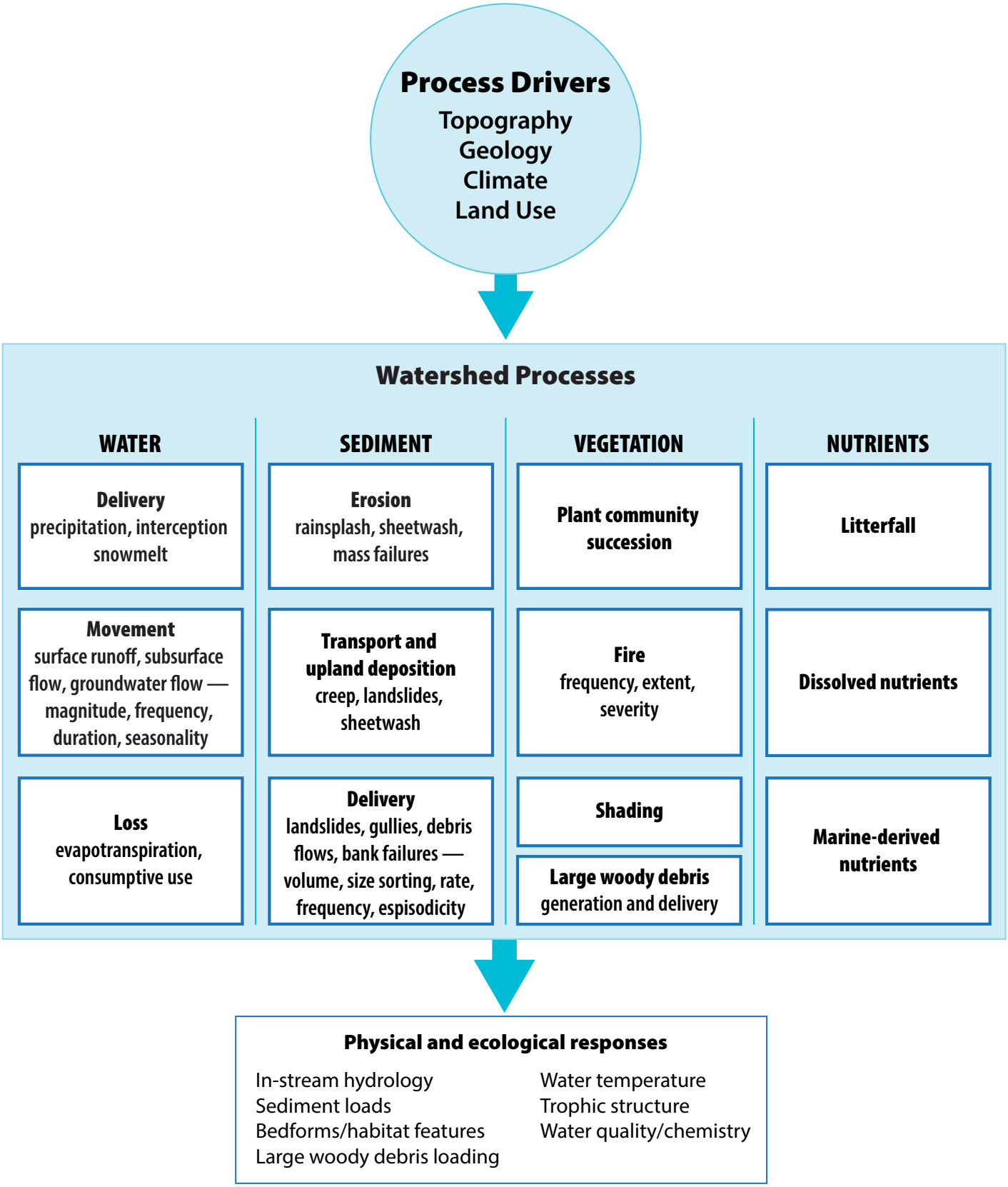


Figure 8.5. Conceptual framework for the hierarchical relationship of invariant, large-scale process drivers, the suite of watershed processes that are determined by these drivers, and the instream physical and biological responses to those processes. Multiple additional interactions between elements and levels are not shown on this diagram to emphasize the primary influences; but in any given setting, one or more of these secondary interactions may temporarily achieve equivalent importance. This framework embraces the definition of watershed processes from Stanley et al. (2011:8): "[t]he dynamic physical and chemical interactions that form and maintain the landscape and ecosystems."

recognize (water, sediment, vegetation, and nutrients), and it reminds us of the major instream responses to these dynamic watershed processes.

8.2.2. How Does the Watershed Affect Instream Conditions?

The direct effects (both physical and biological) of watershed processes on the stream channel are most commonly understood as the delivery of material from the watershed, with or without some attenuation or other modifications as they pass through the riparian ecosystem: water, sediment, nutrients, pollutants, and large wood. These materials are delivered primarily by surface water flow, subsurface flow, landslides and debris flows (Figure 8.6). These fluxes of material and energy from the broader riverine landscape interact with those arising from the riparian corridor itself, to different degrees and over different time scales, with a resulting complexity that defies our current efforts to quantitatively predict their expression in the physical form or biological condition of a stream.

The complexity of these interactions is highlighted by relatively weak correlations reported between various instream features and landscape predictors, regardless of the spatial scale being evaluated (e.g., whole-watershed vs. riparian areas). For example, Anlauf et al. (2011) evaluated the correlation between eleven instream habitat features with landscape variables characterizing both process drivers (e.g., watershed gradient, rainfall) and management-influenced factors (e.g., forest cover, disturbance history, road density) across 121 coastal Oregon streams. The strongest relationships showed unexceptional correlations between particular habitat features and the suite of landscape variables (active channel width, R^2 = 0.72; percentage of fine sediments, R^2 = 0.48). Other habitat features expressed essentially no relationship (percentage gravel, R^2 = 0.05; pools per 328 ft (100 m), R^2 = 0.11; percentage secondary channel area, R^2 = 0.12). Including management-influenced predictors increased adjusted R^2 values only modestly (by up to 16%). Many of the strongest relationships followed intuitive expectations, such as: "Wood volume was associated with several landscape predictors reflecting wood availability (% non-forest, % small trees, and % remnant forests), whereas pools per 328 ft (100 m) were associated with disturbances affecting pool retention (cow density, road density) and pool formation (% small trees)" (Anlauf et al. 2011:708). However, no relationship was sufficiently strong to suggest that either deterministic understanding or statistical correlations are sufficient to precisely characterize the influence of watershed-scale processes on a stream.

Our inability to predict instream conditions from watershed processes and riparian conditions with any useful degree of accuracy is widely recognized. In part, this inability is because the riparian corridor itself has significant, complex effects on the stream (see other chapters in this document). In addition, all of these influences—at every spatial scale—occur within a time-dependent framework mediated by rates of vegetation growth and decay, seasonal variations in flow, and episodic disturbances from floods, and even less frequent but potentially long-lasting channel impacts from fire or landslides (Lake 2000; Roper et al. 2007; Luce et al. 2012; Jellyman et al. 2013).

> ***[E]mpirical associations between land use and stream response only varyingly succeed in implicating pathways of influence. This is the case for a number of reasons, including (a) covariation of anthropogenic and natural gradients in the landscape; (b) the existence of multiple, scale-dependent mechanisms; (c) nonlinear responses; and (d) the difficulties of separating present-day from historical influences. [From Allan 2004:257.]***

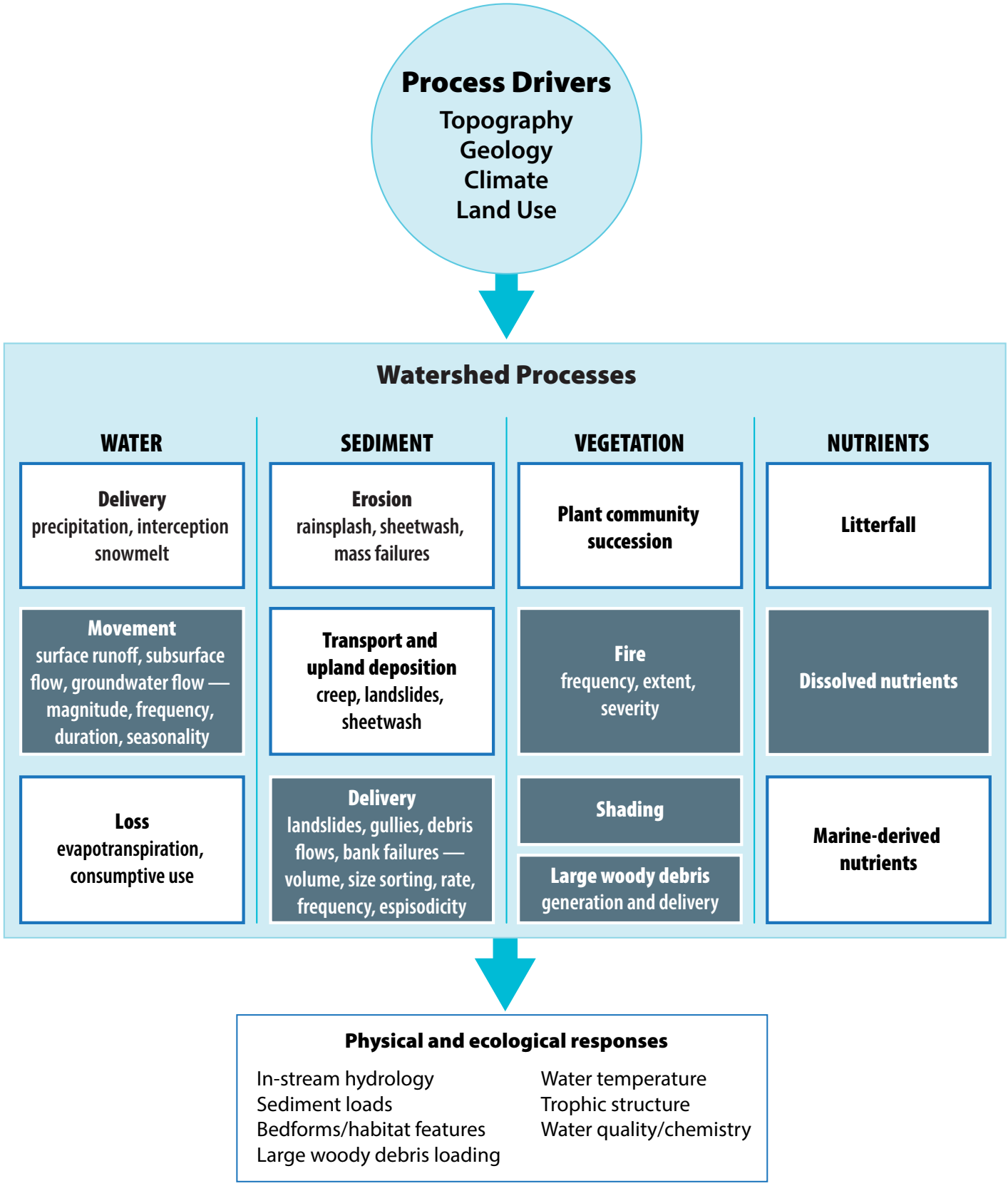


Figure 8.6. The conceptual framework of Figure 8.4, highlighting the subset of watershed processes (dark shaded boxes) that most directly affect instream conditions.



Clearcut harvest in a managed forest landscape/Jane Atha, WDFW

Regardless of our present inability to make reliable predictions of instream conditions from watershed processes, watershed processes do create and maintain instream habitat, and so the determinants of those processes are of indirect, but ultimately critical importance, to the understanding and the management of aquatic resources. Because the nature and intensity of these processes are strongly influenced by prevailing (and past) watershed land use(s), the effects of the dominant land use activities of the Pacific Northwest are discussed individually.

Forestry

The effects of watershed-scale forestry on instream conditions have been a primary focus of scientific research and forest practice regulations for many decades. Most of the attention has been paid to several discrete problems: increased stream temperature from loss of riparian vegetation, the degree to which large-scale loss of forest canopy alters the hydrologic regime, whether the creation of new roads has a discernible impact on both hydrology and sediment delivery to the channel network, and whether forest practices increase the frequency and intensity of debris flows and other forms of mass failure that reach the stream.

The potential for hydrologic alteration in logged watersheds focuses on two major mechanisms: 1) the loss of forest canopy, which should increase total water yield by reducing interception and evapotranspiration, and increase accumulation of snow on canopy-less ground, which increases the total volume of water available during subsequent rain-on-snow events, and 2) more rapid drainage of surface runoff to stream channels from a newly created road network. The review article of Andréassian (2004:12) provides a convenient summary of much of the voluminous literature on this topic, concluding that "deforestation could definitely increase both flood volumes and flood peaks. However, this effect is much more variable than the effect on total flow and may even be inverted in some years or in some

seasons." The underlying causes for such increases are associated not only with the loss of forest canopy but also (and, perhaps, primarily) the consequences of soil compaction and development of the road network.

Increased sediment delivery to streams from watersheds is an anticipated outcome of both the direct and indirect effects of logging. Direct consequences result from the loss of canopy cover, increasing the potential for rainsplash and sheetwash erosion in areas of intrinsically low infiltration capacity, and the eventual loss of soil cohesion in areas of steep slopes. Indirect effects result from the construction of roads, for which inappropriate siting can result in sheetwash erosion and a greater incidence of landslides and debris flows from either concentrated road runoff or failure of the road prism itself. A variety of case studies making use of detailed field mapping, radionuclide tracers, and suspended sediment measurements have implicated various landscape features and erosive processes in post-logging watersheds, such as skid trails and landings, promoting surface runoff and erosion (Wallbrink et al. 2002), enhanced gully erosion (Reid et al. 2010), and road-initiated debris flows (May 2002).

Nutrient dynamics across the watershed are also affected by forest practices, with potential effects throughout the ecosystem (including the channel network and its riparian corridor). Richardson et al. (2005) offered a well-focused and detailed evaluation of the consequences of watershed disturbance, including logging, on the delivery and retention of organic matter in small streams of the Pacific Northwest. He noted that the replacement of coniferous with deciduous trees in recently logged areas can increase the delivery of nutrients, but that more rapid breakdown of delivered material and the accompanying reduction in both large wood and channel complexity, commonly expressed throughout the channel network of logged watersheds, "could produce a substantial reduction in stored organic matter." (Richardson et al. 2005:930).

Agriculture

Cultivated agriculture normally occupies a comparatively narrow range of low-gradient settings in a watershed. Thus, processes associated with steep slopes—particularly landslides and debris flows—found in logged watersheds are nearly absent here. However, the working of the agricultural land surface is far more intensive where it does occur, and a wider range of water-borne contaminants are potentially introduced. As with forestry, hydrology, sediment delivery, and nutrient dynamics are all affected by agricultural land use, but the nature and severity of its impacts on instream resources can be quite different. Runoff from agricultural watersheds, notably its load of nutrients and pesticides, were the historical impetus for the use of riparian buffers under an assumption of surface-runoff filtration (Osborne and Kovacic 1993). Brown et al. (2009) found that the legacy of prior agricultural land use, even in areas presently undergoing urbanization, is one of the strongest determinants of instream conditions in their nine study areas nationwide.

Grazing is a second, broad category of agricultural activities with significant impacts to streams, primarily as a result of direct encroachment into riparian areas and the channel itself. Belsky et al. (1999:2) reviewed dozens of mid- to late-20th century evaluations of grazing throughout arid lands of the American West that evaluated impacts to water quality and temperature, hydrology, channel geomorphology,

Watershed processes help create and maintain instream habitat. Thus the determinants of those processes are indirect but critically important to the understanding and the management of aquatic systems.

wildlife, and instream and riparian-zone vegetation. Their conclusion was that "[n]o positive environmental impacts were found" as a result of grazing, and they advocate complete cessation of grazing as the only sure course for recovery of riparian areas. More recent work (e.g., Agouridis et al. 2005; Raymond and Vondracek 2011) suggest that various strategies of rangeland management may have local success at reducing the magnitude of such impacts; but the large spatial extent over which grazing occurs in certain areas of the Pacific Northwest continues to make this a regionally significant impact to streams and riparian areas.

Urbanization

Urbanization is widely recognized to be the most intensive land use affecting watershed processes. It is also typically the most permanent, insofar as urban developments are rarely returned to anything approaching a natural state, a transition that is not precluded by agriculture and is quite practical in commercially managed forests. As a pervasive, near-total conversion of the land surface, urbanization has the ability to alter each of the dominant watershed processes wherever it occurs: hydrology (both surface and groundwater); the delivery of sediment, nutrients, pollutants, and sunlight; and the interaction of upland/terrestrial biota with the stream channel (Booth et al. 2004; Walsh et al. 2005). Nearly all of these alterations stem from the same fundamental change: the conversation of the land surface, with its vegetative cover and natural soils, to a variety of impervious and near-impervious surfaces. Undisturbed riparian corridors are widely recognized as useful protective measures for streams in urban areas, but all multi-scale evaluations of urban land cover and instream quality affirm the shared importance of not only riparian areas but also upland urbanization in ultimately determining instream conditions (e.g., Wang et al. 2001; Morley and Karr 2002). These watershed-level effects are significant at even low levels of urbanization (e.g., Vietz et al. 2014), and to date they have proven virtually impossible to control under typical riparian-management policies, highlighting the continuing challenge of achieving meaningful aquatic-system protection in an urbanizing watershed.

8.2.3. How Does the Watershed Affect Riparian Areas?

Changes to an upland watershed and watershed processes can also affect the conditions and functions of riparian areas directly (Figure 8.7). Although a riparian area is commonly defined in terms of its relationship to the stream, it also has a relationship to the uplands that surround it. Water from the stream channel will commonly be the riparian area's dominant source of both overland flow (during floods) and groundwater, but adjacent upland water sources can support riparian hydrology during periods of low flow. Much of the sediment that originates from the uplands is transported directly to the streams via channeled flow, but some fraction of that load will deposit before ever reaching the main channel, particularly if the riparian area includes a broad, low-gradient floodplain or if delivery occurs via episodic and channel-overtopping debris flows. Upland vegetation "buffers" riparian areas, providing

More important than simply protecting the habitat itself is protecting the processes that create and sustain that habitat. For this strategy to be successful, however, space in which that habitat can be expressed must also be protected.

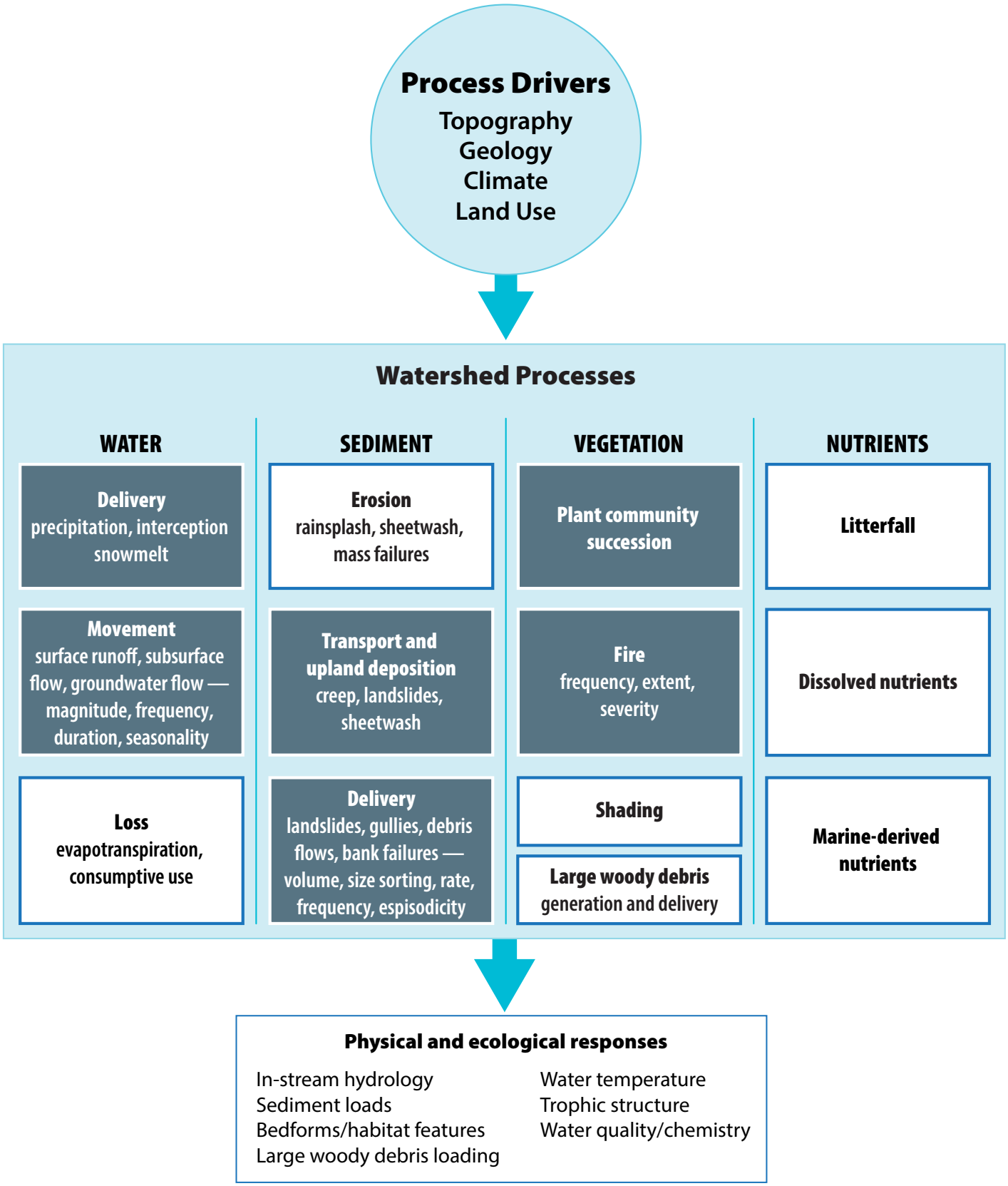


Figure 8.7. The conceptual framework of Figure 8.4, highlighting the subset of watershed processes (dark shaded boxes) that most directly affect conditions in riparian areas.

ecological connectivity between upland plant and animal communities with their riparian counterparts, and providing protection from mechanical disturbances, such as windthrow. Uplands also constitute a broader environment that either supports or suppresses wildfires that may freely cross the upland/riparian boundary.

Various land uses are relatively consistent with respect to their particular impacts to riparian ecosystems. That is, all three of the primary types (forestry, agriculture, urban) physically remove native vegetation, with differences only in the degree of impact. The loss of upland vegetation will consistently affect ecological connectivity and the risks of windthrow and fire regardless of the specific upland land use.

The interactions between uplands, riparian areas, and instream conditions are particularly complex with respect to wildfire. Arkle et al. (2010:299) found that "increasing riparian burn severity and extent were associated with greater year-to-year variation, rather than a perennial increase, in sediment loads, organic debris, large woody debris (LWD) and undercut bank structure." They emphasized a decrease in the stability of physical habitat and high variability in macroinvertebrate communities, which they attributed to annually fluctuating loadings of sediment, large wood and other organic material. They did not recognize any tendency for the macroinvertebrate community to become more like those of relatively undisturbed, reference streams over time, suggesting that changes to wildfire regime can result in permanent changes to stream ecosystems, and that these changes are a result not only of direct influence of burned areas on the stream but also of a permanently altered structure of the riparian corridor. With greater human disturbance, invasive species with high flammability (including those that have begun transforming riparian areas from fire breaks to fire-prone areas of a landscape; Coffman et al. 2010) become more common, as does the greater overall frequency of wildfire in modern human-dominated landscapes (Keeley et al. 2009). Thus this process driver, operating largely independent of typical considerations of riparian area management, can have a profound influence on instream resources (Pausas and Keeley 2014).



Wildfire in Methow River valley, 2018/ Scott Fitkin, WDFW

8.3. The Role and Limitations of Site-Scale Riparian Area Management

Whereas large-scale watershed processes govern the interactions and delivery of water, sediment, organic material, and nutrients to the stream over long distances, the effects of riparian vegetation on physical and ecological processes occur over much shorter distances with complex, direct, time-dependent interactions. These effects are expressed along river corridors "by influencing temperature and light regimes; producing organic detritus (leaf litter, woody debris); by routing water and sediment; by structuring the physical habitat at several scales; by providing a substrate for biological activity and habitat/cover for aquatic, amphibious and terrestrial animals" (Ward et al. 2002:524). For this reason, particular management attention to riparian areas is warranted, insofar as this part of a watershed has a unique, intimate interaction with the stream channel and its biota. Previous chapters explore these specific interactions in detail.

In addition to spatial relationships, temporal interactions are fundamental attributes of aquatic and riparian habitats. These habitats can be created by disturbances and also are episodically affected by them—streams are not static. Just as the influence of process drivers is not uniform across a watershed, so also is the influence of disturbances. In the case of floods, the most common and obvious of disturbances in rivers, this variability is primarily temporal and can be expressed through flood frequency, duration, seasonality (i.e., when in the year they occur), magnitude, and the predictability of occurrence (Lytle and Poff 2004).

The expression of these drivers, their interactions within a watershed and in individual streams, and their variability over time creates and maintains a dynamic mosaic of habitats. These interactions among drivers are complex and intertwined even in the absence of anthropogenic disturbances. Therefore, scientists have had difficulty separating the effects of the different drivers independently and in assessing how any species (even well studied salmon species) respond to this mosaic (Fausch et al. 2002). Adding to this complexity is the fact that habitats are species-specific; what constitutes habitat for one species may be mostly unrelated to what constitutes habitat for another aquatic species in the same river.

Thus, if riparian areas are managed with the objective of maintaining high-quality habitats for aquatic species, managers must ensure that riparian areas contribute what they can (i.e., separate from, but in combination with, watershed processes or drivers) to the long-term maintenance of the temporally variable spatial mosaic of habitat conditions. The mere presence of these habitats, however, is not sufficient: they must exist in configurations that are advantageous to aquatic species, with sufficient variety to support multiple life stages, adequate size and number to support a population, sufficiently proximate to be accessible from one to another, and yet sufficiently distal to not be subject to the same deleterious disturbances.

This, then, defines the fundamental challenge of watershed and riparian ecosystem management: given a system of great diversity and complexity, with attributes that can vary greatly and unpredictably in their influence over time, and biological communities that depend on both the diversity and interconnections between habitats, what fundamental principles should guide management to perpetuate fish and wildlife? We return to this question in the last section of this chapter.

8.4. Integrated Effects of Site-Scale Riparian Areas Management

"Connectivity" is the term most often used to describe whether organisms can move from one habitat to another (Taylor et al. 1993). It comprises two parts: structural connectivity, the physical relationships among habitat patches without regard for the behavior or organisms; and functional connectivity, the degree of movement of organisms through the landscape (Taylor et al. 2006; Kadoya 2009). The two are obviously related in all landscapes, but lotic systems impose some characteristic influences. First, there is a strong (though not universal) downstream bias on functional connectivity, insofar as most organisms and all inert constituents move in the direction of water flow. Second, impediments to flow can impose partial barriers to both structural and functional connectivity, but to very different degrees. For example, a culvert may allow most or all discharges to pass unimpeded but nevertheless present a barrier to migrating salmon (e.g., Davis and Davis 2011).

Concern over longitudinal barriers along a channel network typically focuses on the effects of instream physical barriers, particularly dams, culverts, and road crossings, rather than the consequences of longitudinal disturbances to riparian areas more broadly. Instream connectivity and riparian connectivity are related, however, even if they are not direct surrogates. Some types of discontinuity (e.g., a road running perpendicular to the stream) will affect the longitudinal connectivity (both structural and functional) of both; but others (e.g., an impassible migration barrier in the stream) will affect the movement of aquatic and terrestrial organisms quite differently. Most importantly from the perspective of riparian management, alterations that are limited to riparian areas can nonetheless affect instream (functional) connectivity. For example, loss of shading from riparian area disturbance (Chapter 4) can create unfavorable instream temperatures that impact the movement or outright survival of migrating salmonids (e.g., Thorstad et al. 2008; Martins et al. 2012). Other direct and indirect actions, such as channelization, removal of large wood, or bank failures from vegetation loss can affect connectivity for migratory fish and among other aquatic species, and alter the flow of material and nutrients through the stream network.

These impacts have been explored in a variety of studies at multiple scales. Flitcroft et al. (2012:288) reported that "…[spatial] network variables perform better at explaining juvenile Coho Salmon *Oncorhynchus kisutch* density than instream habitat variables. Moreover, analysis of network distances among seasonal habitats indicates that juvenile Coho Salmon density may be higher where the distance between critical seasonal habitats is short." Perkin and Gido (2012:2183) found lower species richness in fish communities in stream networks fragmented by road crossings across multiple spatial scales. "Our findings support network connectivity as a mediator of ecological processes occurring within complex dendritic ecosystems and promote the need for improved connectivity to enhance conservation of metacommunity dynamics and biodiversity in dendritic ecological networks." Similarly, Favaro et al. (2014:1815) interpreted their findings on the influence of culverts in a channel network to demonstrate that "…fragmentation of habitats and populations acted on a whole stream scale rather than being restricted to within-stream differences that related to position."

These findings speak to the importance of recognizing the channel as part of the riparian ecosystem, that is, they form an interconnected system, both laterally and longitudinally. The degree to which seemingly isolated discontinuities affect either of these elements directly can ultimately impact the entire ecological network. Prescriptive management is challenging, however,



Chum Salmon Oncorhynchus keta *need connected habitat to reach spawning grounds/Alex Biswas, WDFW*

because the ecological functions of any given site or habitat patch along a channel network depend on its context and interconnection with other such sites. Furthermore, not all habitats have the same value for all species:

> ***The relationship between species richness and connectivity is therefore determined by complex relationships among several interacting variables. In addition, species richness maxima for different faunal and floral elements occur at different positions along the connectivity gradient (Tockner et al. 1998). Fish diversity, for example, may peak in highly connected habitats, whereas amphibian diversity tends to be highest in habitats with low connectivity. Other groups attain maximum species richness between these two extremes. The resulting pattern is a series of overlapping species diversity peaks along the connectivity gradient, suggesting that habitats collectively traversing a broad range of connectivity will optimise community diversity in riverine landscapes. [From Ward et al. 2002:535.]***

Although such studies emphasize the importance of connectivity along the channel corridor, they offer little guidance for managing these barriers and discontinuities beyond *less is better.* The impacts of road crossings, in particular, have been evaluated in several studies in Pacific Northwest lowland streams, comparing measures of biological conditions with the frequency of crossings that describe a negative, monotonic relationship (May et al. 1997; McBride and Booth 2005). Unfortunately, these studies do not suggest a consistent, discrete threshold of impacts that might serve as a management objective. For example, the study of McBride and Booth (2005) showed correlations between biological health (as characterized by a multi-metric index of benthic macroinvertebrates) and road crossings with more than three crossings per km, whereas the biological differences reported by Perkin and Gido (2012) occurred on fragmented streams with as few as one road crossing over a stream segment length of one to many kilometers.

The overarching message from these studies is that any given implementation of site-scale riparian area management does not occur in a vacuum: "protecting a site" has ecological meaning only within the context of the entire channel network. Although existing computational tools can characterize the degree of fragmentation from discontinuities or the spatial coherence of a riparian corridor of varying width, the existing literature suggests that we lack clear deterministic linkages between alternative riparian management strategies and the resulting response of instream organisms, particularly the identification of thresholds of disturbance that impact fish mobility. However, any management action that results in frequent interruptions to riparian areas, or riparian corridors where blockage of terrestrial and aquatic organisms is not fully mitigated, is sure to have deleterious impacts to aquatic and terrestrial system health.

8.5. Managing Riparian Areas From a Watershed Perspective

The perspective of riparian area management developed in this chapter has been intentionally expanded, in both space and time, beyond that normally applied (and most feasibly implemented) in the Pacific Northwest. It relies heavily on the active research in the field of landscape ecology, which is organized around a few themes of particular relevance to riparian area management: 1) patches differ in quality, 2) patch boundaries affect flows, 3) patch context matters, 4) connectivity is critical, 5) organisms are important, and 6) scale is important (Wiens 2002:501). We will explore each of these in turn with an eye towards how management of riparian areas might be improved with respect to perpetuating fish and wildlife.

8.5.1. Patches Differ in Quality

Not every location along a stream is equally influential on the physical processes or ecological functions of the riparian-aquatic ecosystem. This generalization is complicated, however, by the fact that different perspectives may not assign the same level of "influence" to every location. For example, bedrock-bound channels have very limited capacity for response (Montgomery and Buffington 1997), despite the potential for highly variable, episodic inputs of water and sediment. Thus, from a geomorphological perspective they might be considered less sensitive and so "less critical" for riparian area protection. However, such channels commonly occupy headwater, high-elevation positions in their watersheds that host potentially critical habitat(s) for a variety of non-fish species. A general treatment of the topic such as this cannot resolve the multiplicity of such complex phenomena across the diversity of landscapes in the Pacific Northwest, but this brief discussion suggests the importance of recognizing the range of riparian functions that must be served, and the improbability that they are all of equivalent importance throughout a channel network.

8.5.2. Patch Boundaries Affect Flows

In general, riparian regulations rarely consider the nature of the transition from riparian to upland (i.e., from regulated to unregulated) areas. This theme provides a reminder that the character of those transitions can affect each of the patches through the flux of material, energy, and organisms across their shared boundary. So, for example, when what was once a part of a forest interior becomes the exposed edge of a buffer strip, adjacent to recently cleared uplands, windthrow can greatly increase (and so compromise the riparian management area itself). Direct adjacency of a riparian area to urban development can invite substantial human intrusion (e.g., invasive species, excess nutrients, pesticides) into the riparian area, reaching all the way to the nominally protected stream because attention is not given to the relationship of upland development to the riparian area, nor to the "porosity" of the boundary between them.

8.5.3. Patch Context Matters

Riparian areas within separate watersheds containing different land uses (e.g., forestry, agricultural, urban) provide very different ecological functions depending on the adjacent land uses. The impacts to a stream from watershed urbanization, for example, span the range

from pervasive hydrologic changes (for which buffers are typically irrelevant) to pesticide-laden run-off (for which the pollutant removal that a buffer provides may be somewhat to highly effective). In a forestry dominated watershed, primary concerns may be the potential for unnaturally high delivery of sediment from increased rates of mass wasting; or potential losses of streambank integrity, habitat complexity, shading, large wood, and allochthonous inputs of organic matter.

According to Hansen et al. (2015:54):

> ***Our review demonstrated that greater widths were required to achieve objectives when adjacent land use intensity was high, or when the objective of management was improving terrestrial biodiversity (particularly fauna). This becomes problematic when intense land use practices occur on small properties, reducing the amount of riparian land that can economically be protected or targeted for management…For example, if we apply the evidence summarized here to a streamside property used for dairying in the lower Hunter River, New South Wales, a riparian zone width of 40 m may achieve ≥75% reduction of nitrogen inputs to the river and reduce streambank erosion, contributing to improved downstream water quality. However, the same investment in riparian set-aside in the upper reaches of the Hunter catchment may provide additional improvements to stream nutrient processing (Lowe and Likens 2005), aquatic biodiversity (Chessman et al. 1997) and bird diversity (Bennett et al. 2014).***

8.5.4. Connectivity is Critical

Connectivity in riparian areas occurs not only parallel to the stream (previous section), but also orthogonally to the channel in a lateral dimension – from the stream through the riparian area into uplands–and the vertical dimension in the hyporheic zone. Typical riparian area regulations are generally successful at maintaining connectivity in the longitudinal dimension at some minimum width, although the consequences of limited interruptions to longitudinal connectivity (e.g., bridges, utility crossings) are commonly dismissed, a consequence of viewing riparian areas only from the perspective of lateral width rather than a recognition of the importance of stream network connectivity.

Longitudinal connectivity is especially important for the movement of sediment, large wood, and other organic matter. Fox (2003), for instance, found that the condition of riparian areas was a reasonable predictor for the quantity of large wood key pieces in adjacent stream channels; however, upstream basin characteristics and processes were likely responsible for most of the large wood in larger channels. Therefore, land managers should not base site-level objectives for in-stream large wood on the condition of adjacent riparian areas alone, but should also manage riparian areas at the watershed scale to provide adequate in-stream large wood throughout a watershed's stream network.



Issaquah Creek is a tributary to Lake Sammamish in King County/ Derek Booth

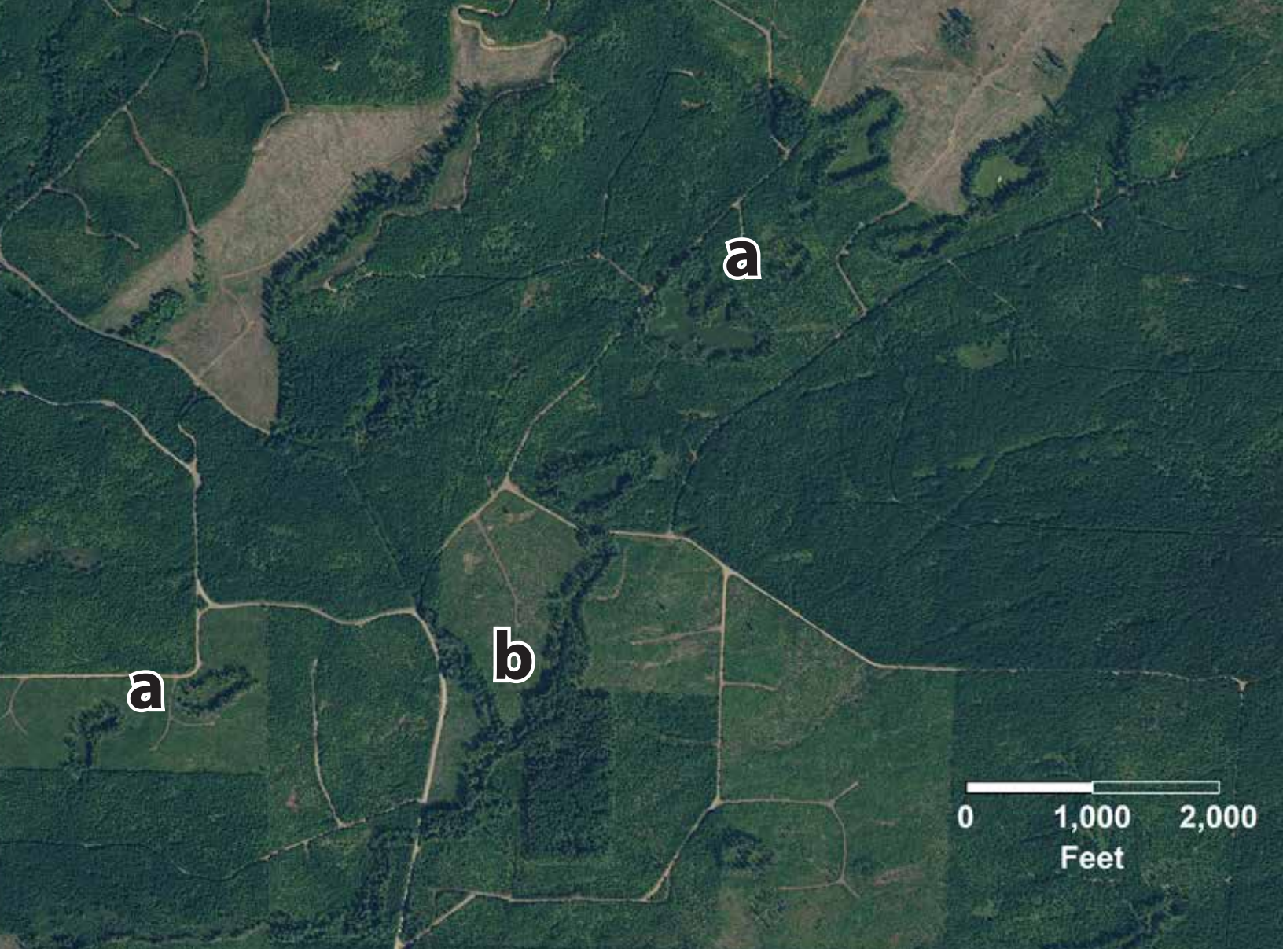


Figure 8.8. View of isolated wetlands (a) and riparian management zones (b) in a commercially logged portion of southwest Washington, providing some degree of local, structural connectivity within each buffer but no functional connectivity between them. Forested buffers in this image are approximately 50 feet (15 meters) wide.

Lateral connectivity, particularly between the riparian area and the adjacent uplands, is a more complex relationship, because improving this connectivity simultaneously enhances ecosystem protection but can also compromise the protection of a stream from upland activities. Continuity of a protected riparian area with uplands that are protected as well provides a range of key habitats for mobile species that depend on both upland and riparian environments for different needs or at different life stages. Separated patches with relatively porous boundaries may achieve only a modest fraction of these benefits, however, and truly isolated riparian–upland patches may be no better than an absence of such habitats altogether (at least for many terrestrial species of concern) (Figure 8.8). Porous boundaries also run the risk of compromising some of the primary goals of a riparian management area, and so the nature of connectivity does not universally result in beneficial outcomes (see 8.5.2 above).

Vertical connectivity occurs at the ecotone between stream water and deeper groundwater. This ecotone, known as the hyporheic zone, is comprised of coarse sediments, and the vertical connectivity occurring there is more commonly referred to as hyporheic exchange (Boultan et al. 1998). Hyporheic exchange includes

water, dissolved solutes, fine sediments, fine organic matter, and small organisms. The size of the hyporheic zone is enlarged by structures such as large wood and boulders that store sediment. Hyporheic exchange is enhanced by structures such as large wood or boulders that redirect flow into the streambed and by undulations in channel morphology (e.g., meanders, pool-riffle beds) that intercept the flow of water.

In summary, the importance of connectivity is broadly recognized:

> ***Restoration of important ecological processes often implies improving connectivity of the stream. For example, longitudinal and lateral connectivity can be enhanced by restoring fluvial dynamics on flood-suppressed rivers and by increasing water availability in rivers subject to water diversion or withdrawal, thereby increasing habitat and species diversity. Restoring links between surface and ground water flow enhances vertical connectivity and communities associated with the hyporheic zone. [From Jansson et al. 2007:589.]***

However, tangible recommendations for how best to manage for this outcome in typical regulatory settings are more elusive.

8.5.5. Organisms are Important

Although not strictly an issue of spatial or temporal relationships between landscape elements, the recognition of organisms as key elements of riverine composition, structure, and functions is a valuable contribution of landscape ecology to watershed management. Some of these influences have been long-appreciated: the importance of large wood to stream structure and salmonid habitat, the role of root strength in mediating bank erosion, and indeed the entire construct of conserving riparian areas of native



Black Bear Ursus Americanus *feeding on grass/Scott Fitkin, WDFW*

vegetation to maintain ecosystem health. However, this perspective has broadened our appreciation of the multiple ways in which biota interact with the physical environment and each other to support the full range of watershed processes and thus the systems that depend on them (Beavers, bears, and marine nutrients, etc.). Management of riparian areas thus must include not only some awareness of the watershed in which that riparian area exists but also the biota that inhabit this environment (and, in some cases, move beyond its boundaries), and the ways in which those biota support the integrity of the aquatic ecosystem (Robinson et al. 2002).

8.5.6. Scale is Important

The goals and application of riparian management actions are generally limited in both space (i.e., the site) and time (i.e., the present). In a system as interconnected and disturbance-prone as a stream channel network, however, the site-scale management of a riparian area is *necessary*, but not *sufficient*, to ensure the desired composition, structure, and functions

of riparian and aquatic habitats. Of all locations on a natural or human-dominated landscape, river channels are probably the least stable in time, experiencing (and depending on) both gradual changes and episodic disturbance that structure their habitats and the organisms that utilize them. They also are subject to a spatial hierarchy of influences, not only those of the immediately adjacent riparian area itself (such as shade) but also those of the upstream watershed (delivering water and sediment to the channel) and the landscape even beyond its drainage boundaries. "Conditions far from stream banks affect the distribution of key instream habitat characteristics. Amount of instream wood, percentage of gravel, and pool frequency, which are essential to healthy salmon habitat, are particularly sensitive to land use" (O'Callaghan 2012:2). At even larger scales, the mobility of large terrestrial animals, the ability of salmon to return to headwater streams from the ocean, and the episodic disturbance from wildfire can exert equivalent (or greater) influences.

8.6. Conclusions

The perspective provided by landscape ecology emphasizes the temporally and spatially varying nature of habitats, and it suggests that achieving genuine habitat protection (and thus species conservation) is crippled by management that is limited to only narrow riparian corridors. To perpetuate fish and wildlife in the long term, three principles need to become integrated into the current paradigm for protecting aquatic ecosystems:

1. More important than simply protecting habitats is protecting the processes that create and sustain habitats. For this strategy to be successful, however, space in which that habitat can be expressed must also be protected. So, for example, instream and riparian area protection is indeed necessary, but it is not sufficient—the watershed and local-scale processes that create habitats within these areas must also be maintained. Current paradigms that focus on site-level management of riparian areas will not successfully support the dynamic processes that maintain diverse, productive fluvial ecosystems.

2. Habitats have not only spatial but also temporal dimensions to their creation and maintenance, and they cannot retain their functions if they remain static. The historical frequencies, durations, and magnitudes of natural disturbances (flood and fire being the most common) need to be better understood and then emulated to the greatest extent that surrounding land uses can tolerate.

3. Spatial connectivity between habitats is critical, particularly for species (such as salmon) with a variety of habitat requirements at different life stages. Isolated key habitats for mobile species are scant improvement over no habitat at all.

Integration of these principles into the management of aquatic systems will be challenging under existing regulatory frameworks. However, even an awareness of their relevance to sustaining healthy ecosystems may reveal opportunities for their application in regulatory and non-regulatory settings alike. The following key points are offered in support of such opportunities:



Decaying salmon carcass/Ned Pitmann, WDFW

8.6.1. Manage the Riverine Landscape

The riverine landscape is the proper construct for understanding and managing aquatic systems. Although riparian areas are disproportionately important for fish and wildlife relative to their area on a landscape, they are not exclusively important. Although riparian areas affect many critical instream conditions, including temperature, nutrient input, bank stability, and large wood, while also filtering sediment and other pollutants from adjacent upland areas, the watershed outside of the riparian area is no less influential on the ultimate state of instream conditions, particularly with respect to its control of hydrology and sediment delivery. From even beyond a watershed's boundaries, influences on the stream can be carried by wind, mobile biota, and wildfire.

8.6.2. Manage at Multiple Scales

Effective and efficient conservation of fish and wildlife habitats requires management at multiple spatial and temporal scales. Just as the influences on streams arise from within and beyond the riparian area, management must find vehicles to embrace these multiple spatial scales as well. Treatments must also embrace the ever-changing temporal patterns of stability and disturbance, which not only result in constantly shifting physical habitats but also create the ecological template necessary for healthy, resilient biological communities (Ryan and Calhoun 2010). This will require approaches that allow sufficient space and for the expression of key habitat-forming processes (Beechie et al. 2010) rather than simply the creation or protection of static habitat features.

8.6.3. Connect Individual Actions

Particularly in rivers, longitudinal connectivity of individual locations is a defining feature of these systems and their biota, and so maintaining this connectivity is an essential consideration of aquatic ecosystem protection. We increase our chances of maintaining connectivity with coordinated actions across all riparian sites, and even more so by considering the entire riverine landscape as the focus of conservation efforts. However, connectivity is only as strong as its weakest link, and so even a single ill-executed action can preclude achieving this goal altogether.

8.6.4. Engage the Challenge of Implementing Effective Management

Adhering to these key points for achieving genuine riparian ecosystem protection, particularly in the face of continued human impacts, may not be presently attainable. Even if specific beneficial actions are neither everywhere known nor universally feasible to implement, our current understanding can support a positive trajectory. "Landscape conditions far from the river's edge may have strong impacts on instream conditions. Understanding the effects of natural processes and human activities across entire drainage basins is key to researching, monitoring, and restoring aquatic resources." (O'Callaghan 2012:5). Progress will require not only an appreciation of the most effective riparian management strategies but also a broadened perspective on the scope of necessary actions, actions that must extend far beyond the river itself and its adjacent riparian ecosystem.

8.7. Literature Cited[1]

Agouridis, C.T., S.R. Workman, R.C. Warner, and G.D. Jennings. 2005. Livestock grazing management impacts on stream water quality: a review. Journal of the American Water Resources Association 41:591-606. (i)

Allan, J.D. 2004. Landscapes and riverscapes: the influence of land use on stream ecosystems. Annual Review of Ecology, Evolution, and Systematics 35:257-284. (i)

Andréassian, V. 2004. Waters and forests: from historical controversy to scientific debate. Journal of Hydrology 291:1-27. (i)

Anlauf, K.J., D.W. Jensen, K.M. Burnett, E.A. Steel, K. Christiansen, J.C. Firman, B.E. Feist, and D.P. Larsen. 2011. Explaining spatial variability in stream habitats using both natural and management-influenced landscape predictors. Aquatic Conservation: Marine and Freshwater Ecosystems 21:704-714. (i)

Arkle, R.S., D.S. Pilliod, and K. Strickler. 2010. Fire, flow and dynamic equilibrium in stream macroinvertebrate communities. Freshwater Biology 55:299-314. (i)

Beechie, T.J., D.A. Sear, J.D. Olden, G.R. Pess, J.M. Buffington, H. Moir, P. Roni, and M.M. Pollock. 2010. Process-based principles for restoring river ecosystems. BioScience 60:209-222. (i)

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54:419-431. (i)

Bennett A.F., D.G. Nimmo, and J.Q. Radford. 2014. Riparian vegetation has disproportionate benefits for landscape-scale conservation of woodland birds in highly modified environments. Journal of Applied Ecology 51:514-523. (i)

Booth, D.B., J.R. Karr, S. Schauman, C.P. Konrad, S.A. Morley, M.G. Larson, and S.J. Burges. 2004. Reviving urban streams: land use, hydrology, biology, and human behavior. Journal of the American Water Resources Association 40:1351-1364. (i)

Boulton, A.J., S. Findlay, P. Marmonier, E.H. Stanley, and H.M. Valett. 1998. The functional significance of the hyporheic zone in streams and rivers. Annual Review of Ecology and Systematics 29:59-81. (i)

Brown, L.R., T.F. Cuffney, J.F. Coles, F. Fitzpatrick, G. McMahon, J. Steuer, A.H. Bell, and J.T. May. 2009. Urban streams across the USA: lessons learned from studies in 9 metropolitan areas. Journal of the North American Benthological Society 28:1051-1069. (i)

Chessman B.C., J.E. Growns, and A.R. Kotlash. 1997. Objective derivation of macroinvertebrate family sensitivity grade numbers for the SIGNAL biotic index: application to the Hunter River system, New South Wales. Marine and Freshwater Research 48:159-172. (i)

Coffman, G.C., R.F. Ambrose, and P.W. Rundel. 2010. Wildfire promotes dominance of invasive Giant Reed (*Arundo donax*) in riparian ecosystems. Biological Invasions 12:2723-2734. (i)

Davis, J.C., and G.A. Davis. 2011. The influence of stream-crossing structures on the distribution of rearing juvenile Pacific salmon. Journal of the North American Benthological Society 30:1117-1128. (i)

Fausch, K.D., C.E. Torgersen, C.V. Baxter, and L.W. Li. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. BioScience 52:483-498. (i)

Favaro, C., J.W. Moore, J.D. Reynolds, and M.P. Beakes. 2014. Potential loss and rehabilitation of stream longitudinal connectivity: fish populations in urban streams with culverts. Canadian Journal of Fisheries and Aquatic Sciences 71:1805-1816. (i)

[1] References are classified according to RCW 34.05.271 (see Appendix 1) denoted by a lower case roman numeral (i – viii) in parentheses at the end of the citation.

Flitcroft, R.L., K.M. Burnett, G.H. Reeves, and L.M. Ganio. 2012. Do network relationships matter? Comparing network and instream habitat variables to explain densities of juvenile Coho Salmon (*Oncorhynchus kisutch*) in mid-coastal Oregon, USA. Aquatic Conservation: Marine and Freshwater Ecosystems 22:288-302. (i)

Fox, M.J. 2003. Spatial organization, position, and source characteristics of large woody debris in natural systems. Doctoral dissertation. University of Washington, Seattle. (i)

Frissell, C.A., W.J. Liss, C.E. Warren, and H.D. Hurley. 1986. A hierarchical framework for stream habitat classification: viewing streams in a watershed context. Environmental Management 10:199-214. (i)

Hansen, B.D., P. Reich, T.R. Cavagnaro, and P.S. Lake. 2015. Challenges in applying scientific evidence to width recommendations for riparian management in agricultural Australia. Ecological Management and Restoration 16:50-57. (i)

Jansson, R., C. Nilsson, and B. Malmqvist. 2007. Restoring freshwater ecosystems in riverine landscapes: the roles of connectivity and recovery processes. Freshwater Biology 52:589-596. (i)

Jellyman, P.G., D.J. Booker, and A.R. Mcintosh. 2013. Quantifying the direct and indirect effects of flow-related disturbance on stream fish assemblages. Freshwater Biology 58:2614-2631. (i)

Kadoya, T. 2009. Assessing functional connectivity using empirical data. Population Ecology 51:5-15. (i)

Keeley J.E., G.H. Aplet, N.L. Christensen, S.G. Conard, E.A. Johnson, P.N. Omi, D.L. Peterson, and T.W. Swetnam. 2009. Ecological foundations for fire management in North American forest and shrubland ecosystems. PNW-GTR-779. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

Lake, P.S. 2000. Disturbance, patchiness, and diversity in streams. Journal of the North American Benthological Society 19:573-592. (i)

Lowe, W.H., and G.E. Likens. 2005. Moving headwater streams to the head of the class. BioScience 55:196–197. (i)

Luce, C., P. Morgan, K. Dwire, D. Isaak, Z. Holden, and B. Rieman. 2012. Climate change, forests, fire, water, and fish: building resilient landscapes, streams, and managers. RMRS-GTR-290. U.S. Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado. (viii)

Lytle, D.A., and N.L. Poff. 2004. Adaptation to natural flow regimes. Trends in Ecology and Evolution 19:94-100. (i)

Malanson, G.P. 1995. Riparian landscapes. Cambridge University Press, Cambridge, United Kingdom. (i)

Martins, E.G., S.G. Hinch, D.A. Patterson, M.J. Hague, S.J. Cooke, K.M. Miller, D. Robichaud, K.K. English, and A.P. Farrell. 2012. High river temperature reduces survival of Sockeye Salmon (*Oncorhynchus nerka*) approaching spawning grounds and exacerbates female mortality. Canadian Journal of Fisheries and Aquatic Sciences 69:330-342. (i)

May, C.L. 2002. Debris flows through different forest age classes in the central Oregon Coast Range. Journal of the American Water Resources Association 38:1097-1113. (i)

May, C.W., R.R. Horner, J.R. Karr, B.W. Mar, and E.B. Welch. 1997. Effects of urbanization on small streams in the Puget Sound Lowland Ecoregion. Watershed Protection Techniques 2:483-494. (i)

McBride, M., and D.B. Booth. 2005. Urban impacts on physical stream conditions: effects of spatial scale, connectivity, and longitudinal trends. Journal of the American Water Resources Association 41:565–580. (i)

Montgomery, D.R. 1999. Process domains and the river continuum. Journal of the American Water Resources Association 35:397-410. (i)

Montgomery, D.R., and J.M. Buffington. 1997. Channel-reach morphology in mountain drainage basins Bulletin of the Geological Society of America 109:596-611. (i)

Montgomery, D.R., J.M. Buffington, N.P. Peterson, D. Schuett-Hames, and T.P. Quinn. 1996. Stream-bed scour, egg burial depths, and the influence of salmonid spawning on bed surface mobility and embryo survival. Canadian Journal of Fisheries and Aquatic Sciences 53:1061-1070. (i)

Moore, J.W. 2006. Animal ecosystem engineers in streams. BioScience 56:237-246. (i)

Morley, S.A., and J.R. Karr. 2002. Assessing and restoring the health of urban streams in the Puget Sound Basin. Conservation Biology 16:1498-1509. (i)

O'Callaghan, J. 2012. Thinking big: linking rivers to landscapes. Science Findings, Issue 139. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

Osborne, L.L., and D.A. Kovacic. 1993. Riparian vegetated buffer strips in water-quality restoration and stream management. Freshwater Biology 29:243-258. (i)

Pausas, J.G., and J.E. Keeley. 2014. Abrupt climate-independent fire regime changes. Ecosystems 17:1109-1120. (i)

Perkin, J.S., and K.B. Gido. 2012. Fragmentation alters stream fish community structure in dendritic ecological networks. Ecological Applications 22:2176-2187. (i)

Pollock, M.M., M. Heim, and D. Werner. 2003. Hydrologic and geomorphic effects of Beaver dams and their influence on fishes. American Fisheries Society Symposium 37:213-233. (i)

Raymond, K.L., and B. Vondracek. 2011. Relationships among rotational and conventional grazing systems, stream channels, and macroinvertebrates. Hydrobiologia 669:105-117. (i)

Reid, L.M., N.J. Dewey, T.E. Lisle, and S. Hilton. 2010. The incidence and role of gullies after logging in a coastal redwood forest. Geomorphology 117:155-169. (i)

Richardson, J.S., R.E. Bilby, and C.A. Bondar. 2005. Organic matter dynamics in small streams of the Pacific Northwest. Journal of the American Water Resources Association. 41:921-934. (i)

Robinson, C.T., K. Tockner, and J.V. Ward. 2002. The fauna of dynamic riverine landscapes. Freshwater Biology 47:661-677. (i)

Roper, B.B., B. Jarvis, and J.L. Kershner. 2007. The role of natural vegetative disturbance in determining stream reach characteristics in central Idaho and western Montana. Northwest Science 81:224-238. (i)

Ryan, D.F., and J.M. Calhoun. 2010. Riparian adaptive management symposium: a conversation between scientists and management. PNW-GTR-830. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

Stanley, S., S. Grigsby, D.B. Booth, D. Hartley, R. Horner, T. Hruby, J. Thomas, P. Bissonnette, R. Fuerstenberg, J. Lee, P. Olson, and G. Wilhere. 2011. Puget Sound characterization. volume 1: the water resources assessments (water flow and water quality). Publication #11-06-016. Washington State Department of Ecology, Olympia. Available: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf. (January 2019). (viii)

Talbot L.M. 1996. The linkage between ecology and conservation policy. Pages 368-378 *in* S.T.A. Pickett, R.S. Ostfeld, M. Shachak, and G.E. Likens, editors. The ecological basis of conservation. Chapman & Hall, New York. (i)

Taylor, P.D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity is a vital element of landscape structure. Oikos 68:571-573. (i)

Taylor P.D., L. Fahrig, and K.A. With. 2006. Landscape connectivity: a return to the basics. Pages 29–43 *in* K. Crooks and M.A. Sanjayan, editors. Connectivity conservation. Cambridge University Press, Cambridge, United Kingdom. (i)

Thorstad, E.B., F. Økland, K. Aarestrup, and T.G. Heggberget. 2008. Factors affecting the within-river spawning migration of Atlantic Salmon, with emphasis on human impacts. Reviews in Fish Biology and Fisheries 18:345-371. (i)

Tockner, K., F. Schiemer, and J.V. Ward. 1998. Conservation by restoration: the management concept for a river-floodplain system on the Danube River in Austria. Aquatic Conservation: Marine and Freshwater Ecosystems 8:71-86. (i)

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137. (i)

Vietz, G.J., M.J. Sammonds, C.J. Walsh, T.D. Fletcher, I.D. Rutherfurd, and M.J. Stewardson. 2014. Ecologically relevant geomorphic attributes of streams are impaired by even low levels of watershed effective imperviousness. Geomorphology 206:67-78. (i)

Wallbrink, P.J., B.P. Roddy, and J.M. Olley. 2002. A tracer budget quantifying soil redistribution on hillslopes after forest harvesting. Catena 47:179-201. (i)

Walsh, C.J., A.H. Roy, J.W. Feminella, P.D. Cottingham, P.M. Groffman, and R.P. Morgan II. 2005. The urban stream syndrome: current knowledge and the search for a cure. Journal of the North American Benthological Society 24:706-723. (i)

Wang, L., J. Lyons, P. Kanehl, and R. Bannerman. 2001. Impacts of urbanization on stream habitat and fish across multiple spatial scales. Environmental Management 28:255-266. (i)

Ward, J.V., K. Tockner, D.B. Arscott, and C. Claret. 2002. Riverine landscape diversity. Freshwater Biology 47:517-539. (i)

Wiens, J.A. 2002. Riverine landscapes: taking landscape ecology into the water. Freshwater Biology 47:501-515. (i)

Chapter 9. Science Synthesis to Management Implications

By: Timothy Quinn, Kirk L. Krueger, and George F. Wilhere

9.1. Introduction

This chapter summarizes important scientific findings from chapters 1 through 8 and provides a brief discussion of scientific themes that can inform thoughtful approaches to protecting or restoring riparian ecosystems and associated aquatic habitats. The current state of the science, as reviewed in chapters 1 through 8, clearly demonstrates the importance of an intact riparian ecosystem to the proper functioning of aquatic habitats. It also introduces new studies on conservation of watershed-scale processes that directly affect aquatic habitats and that help maximize the ecological benefits of riparian ecosystems.

Riparian ecosystems are a priority habitat because their composition, structure, and functions dramatically affect a multitude of fish, amphibian, reptile, bird, mammal, and invertebrate species (Cummins 1974; Richardson et al. 2005). Although riparian ecosystems are a small portion of the landscape, approximately 85% of Washington's wildlife species use them (Thomas et al. 1979). Protecting or restoring high function to this relatively small portion of the landscape can disproportionally benefit many species and other important ecosystem goods and services (e.g., clean water, fisheries, and flood control) (NRC 2002).

Our definition of riparian ecosystem is integral to the development of management recommendations. Riparian ecosystems are transitional areas (ecotones) between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota (NRC 2002). Riparian ecosystems include areas through which surface and subsurface hydrology connect waterbodies with uplands. They include those portions of terrestrial area that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., a zone of influence). Following Naiman and Bilby (1998), we include active floodplains and the terraces and adjacent uplands that contribute organic matter to active channels or active floodplains as part of the riparian ecosystem.

9.2. Summary of Chapters 2 Through 8

Chapters 2 through 8 discussed five key riparian ecosystem functions including bank stability, stream shading, wood recruitment, litter fall, and pollutant removal, as well as other topics related to the riparian ecosystems including stream channel morphology, nutrient dynamics, dryland riparian areas, and watershed-scale processes. Here we summarize the main points of each chapter.

9.2.1. Stream Channel Morphology (Chapter 2)

The stream morphology chapter explained how the composition, structure, and functions of riparian ecosystems and their associated aquatic habitats

depend on dynamic interactions of water, sediment, wood, and riparian vegetation. Important points from this chapter are:

- Erosion, transport, and deposition of sediment are part of a hierarchy of disturbance processes that continually create, maintain, destroy, and recreate the variety of aquatic habitats.

- Geomorphic processes related to the input of sediments to streams (from local stream bank erosion to mass wasting events) are integral to a watershed's natural disturbance regime and necessary for long-term ecological sustainability. For example, sediments delivered to streams from hillslope mass wasting events are often the predominant source of gravel, which is essential for salmon spawning habitat.

- Bank stability is one of five key ecological functions of riparian areas. Vegetation has mechanical and hydrologic effects on bank stability, and these effects can be stabilizing or destabilizing. However, in general, the net effect of vegetation is stabilizing.

- Simple models suggest that in an old-growth riparian forest, the full contribution of root strength to streambank stability is provided by trees within approximately 33 ft (10 m) of the streambank.

- Over a period of decades to centuries, a river or stream will travel across the entirety of its channel migration zone. Because the riparian ecosystem is defined by proximity to water, as the active channel moves back and forth across the channel migration zone, the riparian ecosystem moves with it.

9.2.2. Wood (Chapter 3)

Chapter 3 focused on the role of wood in aquatic ecosystems, and the recruitment of large wood to aquatic ecosystems. Wood plays a critical role in the composition, structure, and functions of riparian and aquatic ecosystems. In-stream large wood increases hydraulic complexity, i.e., creates a wider range of flow velocities, which causes pool formation, streambed scour, sediment deposition, and channel migration. The net result is a diversity of aquatic habitat types. Main points from the wood chapter include:

- The effects of wood on aquatic ecosystems in the Pacific Northwest are well-understood and ecologists are very confident about the critical role of wood in fish habitats.

- Ecologists are also confident about the role of riparian forests in supplying large wood to aquatic systems.

- Source distances for in-stream wood are a function of tree height in riparian ecosystems. Source distances are longer for riparian forests with taller trees.

- The main uncertainties for management are: the shape of the wood recruitment function, and in particular, the shape under different site-level and watershed conditions; and the potential contributions from recruitment mechanisms outside the riparian forest, such as landslides, debris flows, and extreme channel migration.

- In an unmanaged natural riparian area, 100% of a site's large wood recruitment potential comes from a distance of about 85 to 230 ft (26 to 70 m), depending on site productivity class. This does not account for additional wood recruitment through landslides, debris flows, or extreme channel migration.

9.2.3. Stream Temperature (Chapter 4)

The chapter on stream temperature presented a conceptual model for stream thermal regimes, discussed the effects of water temperature on fish, herpetofauna, and invertebrates; and reviewed the impacts of various land uses on stream thermal regimes. The chapter's key points include:

- Riparian vegetation can strongly affect stream thermal regimes (i.e., the spatial and temporal distribution of temperatures) which affects the survival and productivity of aquatic species. The importance of the thermal regime, not just summer peak temperatures, to aquatic species is increasingly acknowledged, but our ability to manage for suitable thermal regimes is limited.

- Fish and other aquatic organisms use different stream habitats, defined in part by specific water temperature ranges. However, the scientific literature is conclusive about the importance of cool stream temperatures (≤60°F [15.6°C]) for salmonid survival and productivity.

- Shade can substantially reduce the amount of direct solar radiation to the stream, which is one of the main sources of heating, especially in narrow low-order streams.

- Shade from riparian vegetation is affected by vegetation height, canopy density, and stem density. The width of a riparian area affects the amount of shading to the stream.

- A stream's thermal regime is also affected by latitude, elevation, aspect, topographic shading, channel bed shape, and water volume in addition to tributary, groundwater, and hyporheic flows.

- Structures such as large wood can reduce stream temperature by increasing pool depths, causing the development of undercut banks that provide shade, and by enhancing hyporheic exchange through redirecting surface flow to subsurface flow.

9.2.4. Pollution Removal (Chapter 5)

The pollutant removal function is unique in that it only exists in the presence of human activities that generate polluted water, and it is only necessary when nonpoint source runoff from upland activities threaten to degrade water quality. The pollution removal chapter covered the common sources, biological impacts, in situ chemistry, transport pathways, and results of removal efficacy studies for five types of pollutants—sediments, excess nutrients, metals, pesticides and other organic compounds, and pathogens. Key points from the pollution removal chapter include:

- There is overwhelming evidence in the scientific literature that riparian buffers[1] reduce nonpoint source water pollution for a variety of pollutants, and that riparian buffer width is the most important variable explaining removal efficacy.

- Research also indicates that the second most important variable in pollution removal is the vegetative composition and structure in riparian buffers.

[1] Riparian buffer refers to a strip of land adjacent to a stream that helps protect the stream from nonpoint source pollutants originating from upslope areas.

- Riparian buffer width recommendations depend on the particular pollutant to be removed and the desired removal efficacy. Policy makers must choose the desired removal efficacy.

- Models from four separate peer-reviewed meta-analyses show that riparian buffer widths for 95% removal efficacy of sediment range from 56 to 251 ft (17 to 76 m). Meta-analyses for other pollutants exhibit a similar degree of uncertainty with regard to riparian buffer width.

- Due to uncertainty regarding riparian buffer widths needed for a desired removal efficacy, management of riparian areas for the removal of pollutants should be monitored within an adaptive management program.

9.2.5. Nutrient Dynamics (Chapter 6)

The nutrient dynamics chapter explained the many effects of riparian areas on the three primary macro-nutrients: nitrogen, phosphorus, and carbon. Riparian areas can be nutrient sources or sinks, and riparian areas mediate the movements of nutrients between uplands and surface waters. Key points from the nutrient dynamics chapter include:

- Organic matter from riparian areas is an essential source of nutrients and chemical energy for aquatic ecosystems. Nutrients enter streams via plant litter fall or via surface and subsurface water flow.

- Streams in the Pacific Coastal Ecoregion of Washington (Naiman et al. 2000) are generally nutrient-poor and well shaded. Hence, additional nutrients (e.g., salmon carcasses) may enhance aquatic ecosystem productivity. However, aquatic communities may be adversely impacted by excessive anthropogenic nutrients such as nitrogen and phosphorus.

- One study suggests that riparian area widths needed to deliver 95% of annual litter input from mature conifer forests to streams ranges from 39–54% of mean tree height depending on a site's slope and wind exposure.

- Empirical evidence suggests increasing salmon carcasses, and their marine-derived nutrients and energy, to riparian ecosystems could contribute significantly to the recovery of imperiled salmon populations.

- More research is needed on the effects of riparian litter fall on stream productivity and on the relationship between salmon harvest escapement and salmon population productivity.

9.2.6. Riparian Areas of the Columbia Plateau (Chapter 7)

The chapter on riparian areas of the Columbia Plateau covered aspects of riparian ecology that are unique to this semi-arid to arid (i.e., dryland) ecoregion. The chapter clarified the definition of riparian ecosystem in dryland ecoregions, and reviewed the history of human impacts to riparian areas in the Columbia Plateau. It also reviewed the scientific literature on the five key riparian ecosystem functions – bank stability, stream shading, wood recruitment, litter fall, and pollutant removal – and it added a function of particular importance in the Columbia Plateau – alluvial water storage. Other important points include:

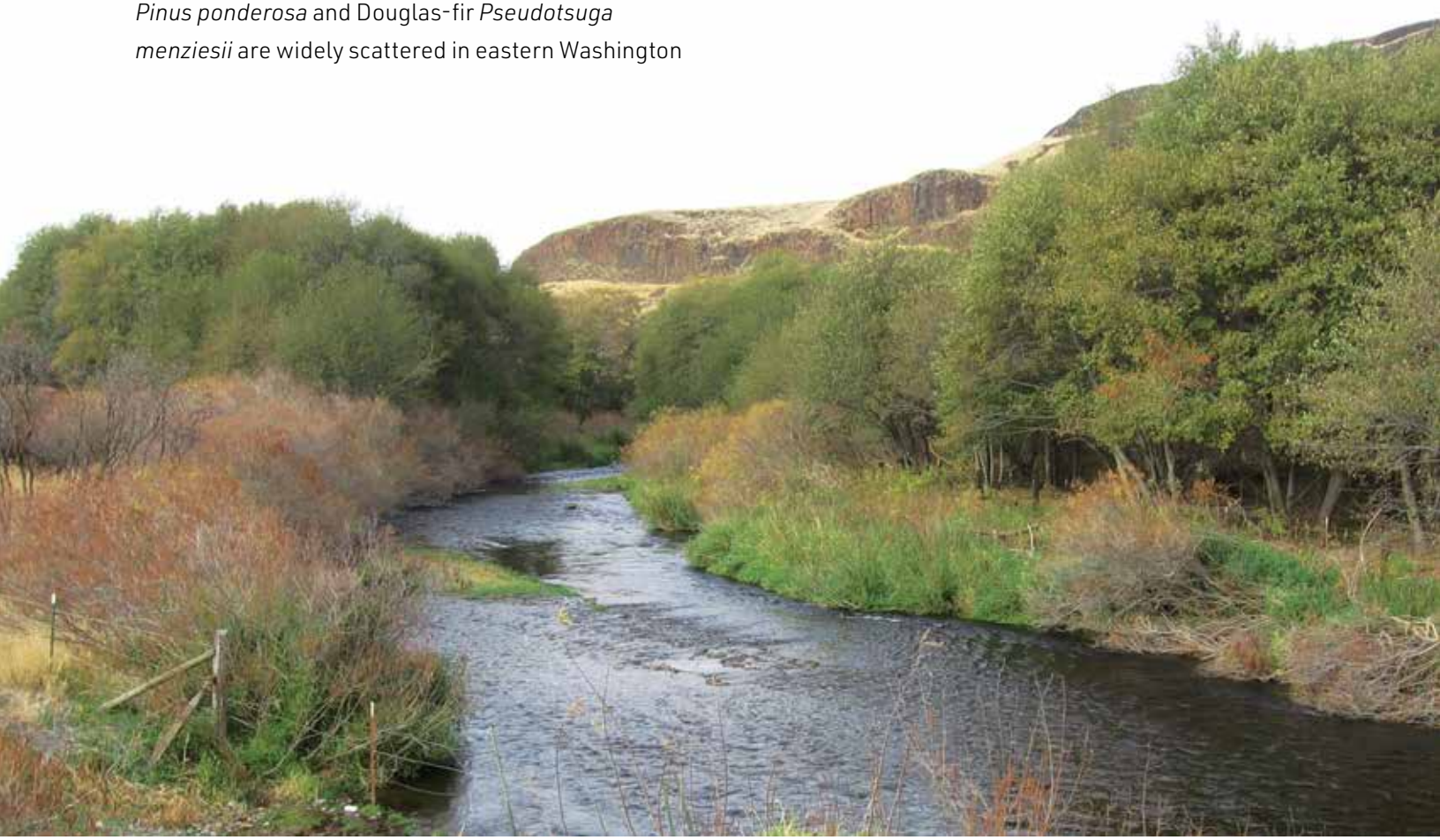
- Vegetation within riparian ecosystems of the Columbia Plateau often exhibits an abrupt demarcation between the riparian zone and the zone of influence. Phreatophytic trees and shrubs and hydrophytic herbaceous plants are confined to moist streamside areas, but the upland zone of influence may consist of sagebrush or bunchgrass communities.

- Nearly all riparian areas in the Columbia Plateau have been significantly impacted by human land use (grazing, intensive agriculture), resource exploitation (Beaver *Castor canadensis* trapping, timber harvest), water management (dams, diversions, reservoirs), or invasive plant species.

- Riparian areas in the Columbia Plateau are inhabited by a variety of deciduous woody plants, with the largest being Black Cottonwood *Populus trichocarpa* and White Alder *Alnus rhombifolia*. Pondersoa Pine *Pinus ponderosa* and Douglas-fir *Pseudotsuga menziesii* are widely scattered in eastern Washington riparian areas and were likely more common historically than at present. Compared to forested ecoregions, large woody debris play a much smaller role in fluvial processes.

- A rudimentary classification system based on overstory conveys obvious differences in stream shading provided by riparian areas: tall tree, short tree, tall shrub, shrub, grass-like, grass, and forb. The obvious implication of these vegetation types is that some stream channels in the Columbia Plateau receive little or no shade from vegetation, even historically. However, the actual historical condition of many riparian areas is unknown.

- Where the riparian zone is narrow (<100 ft [<30 m]) or the zone of influence lacks tall trees (<100 ft), the width of the riparian ecosystem is based on the pollutant removal function.



The Tucannon River flows generally northwest from headwaters in the Blue Mountains of southeastern Washington to the Snake River/Terra Hegy, WDFW

9.2.7. Watersheds (Chapter 8)

The chapter on watershed-scale processes looked beyond the site-level perspective at which riparian ecosystems are normally studied and managed. The chapter presented a conceptual framework that identified the key watershed processes and their primary influences on riparian ecosystems. The key points from the watersheds chapter are:

- Riparian ecosystems occupy perhaps the most dynamic and disturbance-prone area in a watershed. Nevertheless, the relative abundances of various aquatic habitat types in unmanaged, natural watersheds tends to remain constant over long periods (decades to centuries). In other words, at the watershed scale, habitat types appear to be in dynamic equilibrium.

- Riparian areas and surrounding watersheds are complex and dynamic systems comprised of many interacting components. These interactions across the watershed and through time create a mosaic of stream conditions necessary for self-sustaining populations of fish and other aquatic organisms.

- Some animal species have major impacts on the composition and structure of stream networks. Salmon, for example, restructure channel bed substrates during spawning and Beaver restructure the morphology and hydrology of floodplains. These "ecosystem engineers" are vital components of riparian ecosystems.

- Longitudinal, lateral, and vertical connectivity are critical for maintaining or restoring riparian ecological composition, structure, and functions. Studies have shown the importance of connectivity along the riparian corridor, but are often lacking specific guidance for management beyond "more is better."

- The composition, structure, and functions of riparian areas are affected by surrounding land uses (e.g., forestry, agriculture, residential).

- The effectiveness of riparian ecosystems to protect aquatic habitats can be circumvented by anthropogenic changes at the watershed scale. The routing of water from human development to streams via channelized flow, for example, can result in changes to the stream hydrograph, changes in channel morphology, reduced efficacy of the riparian pollutant removal function, and increases in fine sediment inputs to streams.

- More research is needed on practical ways to maintain or emulate natural disturbances in watersheds dominated by human land uses (e.g., agriculture, residential). This includes disturbances such as flooding and landslides that are essential for maintaining aquatic habitats.

9.3. Key Management Implications from Chapters 1 through 8

- Protection and restoration of riparian ecosystems continues to be critically important because: a) they are disproportionately important, relative to area, for aquatic species, e.g., salmon, and terrestrial wildlife, b) they provide ecosystem services such as water purification and fisheries (Naiman and Bilby 2001; NRC 2002; Richardson et al. 2012), and c) by interacting with watershed-scale processes, they contribute to the creation and maintenance of aquatic habitats.

- Stream riparian ecosystems encompass the riparian zone, the active floodplain including riverine wetlands, and the terraces and adjacent uplands that contribute matter and energy to the active channel or active floodplain (Gregory et al. 1991; Naiman and Bilby 1998).



Engineered large wood structure in the north fork of the Lewis River/ Chuck Stambaugh, WDFW

Such terraces and adjacent uplands are called the zone of influence.

- The width of the riparian ecosystem is estimated by one 200-year site-potential tree height (SPTH) measured from the edge of the active channel or active floodplain. Protecting functions within at least one 200-year SPTH is a scientifically supported approach if the goal is to protect and maintain full function of the riparian ecosystem.

- Where the riparian zone is narrow (<100 ft [30 m]) and the zone of influence lacks tall trees (<100 ft), (e.g., in parts of the Columbia Plateau Ecoregion) the pollution removal function may determine the width of the zone of influence.

- The riparian ecosystem begins at the edge of the active channel or active floodplain, whichever is wider. As the active channel moves back and forth across the channel migration zone (CMZ), the riparian ecosystem moves with it. Consequently, there are times when the riparian ecosystem lies adjacent to and immediately outside the CMZ. Hence, to maintain riparian ecosystem functions, management must anticipate and protect future locations of the riparian ecosystems.

- A near consensus of scientific opinion holds that the most effective and reliable means of maintaining viable self-sustaining fish, especially salmon, is to maintain/restore ecosystems to conditions that resemble or emulate their historical range of natural variability (Swanson et al. 1994; Reeves et al. 1995; Bisson et al. 2009). This opinion is based in part on the complexity of processes that affect the expression of habitats over time and space.

- The protection and restoration of watershed-scale processes, especially related to hydrology, water quality, connectivity, and inputs of wood, shade, and sediment are important for aquatic system function, and help maximize the ecological benefits of riparian ecosystem protections.

- Riparian areas and surrounding watersheds are complex and dynamic systems comprised of many interacting components. Natural disturbances (floods, fire, and landslides) across the watershed and through time create the mosaic of conditions necessary for self-sustaining populations of fish, especially salmon, and other aquatic organisms.

- Impending changes to aquatic systems as a result of climate change increase risk to species already threatened by human activities. The effects of climate change on rivers and streams threaten to reduce fish distribution and viability throughout the Pacific Northwest (Beechie et al. 2013).

- The use of the precautionary principle and adaptive management are particularly appropriate when dealing with complex and dynamic systems, and when we have uncertainty related to exactly how management activities affect functioning of watersheds and riparian ecosystems.

9.4. Width of Riparian Ecosystems

The width of the riparian ecosystem is based on the zone of influence, and the zone of influence is based on riparian ecosystem functions (or processes) that affect aquatic habitats. FEMAT's (1993) curves are conceptual models describing how four key riparian ecosystem functions change with distance from the stream channel (Figure 9.1). The four functions are root strength (i.e., streambank stability), stream shading, litter fall (i.e., input of detrital nutrients), and coarse wood debris to

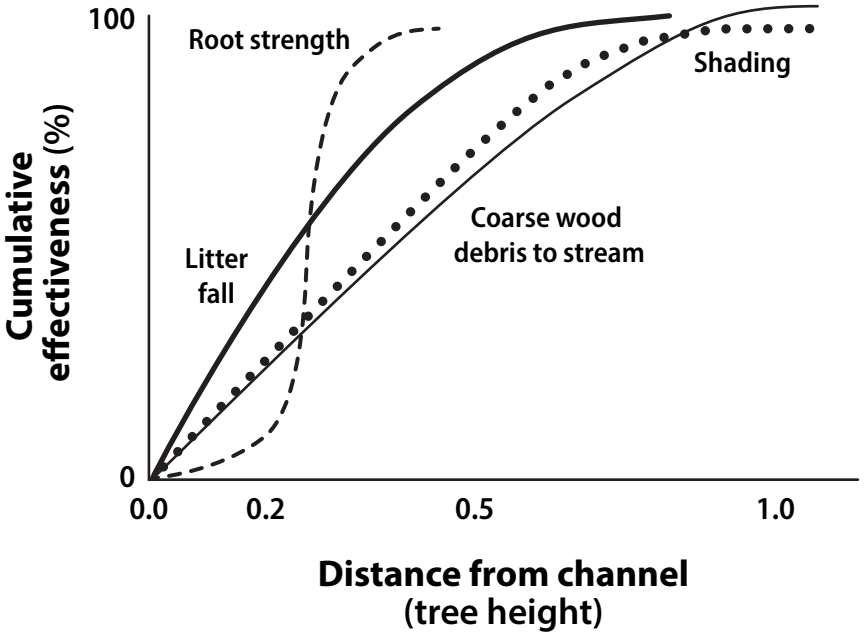


Figure 9.1. The "FEMAT Curves" (FEMAT 1993) are generalized conceptual models describing some riparian ecosystem functions and processes as the distance from a stream channel increases. "Tree height" in this figure is based on the average maximum height of the tallest dominant trees (200 years old or greater) and is referred to as site-potential tree height (SPTH).

stream (i.e., recruitment of large wood). FEMAT (1993) also included the pollution removal function (i.e., water quality) but did not create a curve for it. Originally, the curves were meant to convey two important points: 1) these four riparian ecosystem functions occur within one SPTH, and 2) the marginal return for each function decreases as distance from the stream channel increases. In other words, the FEMAT curves show that areas closer to the stream provide more of each function per unit width than areas farther from the stream.

The FEMAT curves are generalizations that ignore site-specific variability in riparian function among stream reaches. Nevertheless, FEMAT's conceptual models have influenced the width of riparian management zones (RMZs) in a number of important conservation plans such as the Forests and Fish Habitat Conservation Plan (DNR 2005).[2] Protecting natural vegetation within at least one SPTH is a scientifically supported approach if the goal is to protect and maintain ecological functions of riparian areas for the benefit of aquatic species. All else being equal, protecting areas narrower than one SPTH will result in lower levels of ecological function, and generally increase risk to fish and aquatic wildlife.

Although not all riparian functions are strongly associated with tree height (e.g., pollution removal), several key functions are, e.g., large wood recruitment, stream shading, and litter fall. Hence, the FEMAT curves use tree height of the dominant tree species to help estimate the amount of function provided by riparian areas of different widths. Consequently, the area within a site-potential tree height has often been used to define the extent of the "riparian ecosystem." However, FEMAT curves dealt strictly with functions strongly associated with vegetation and thus did not attempt to represent all aspects of the riparian ecosystem, such as other riparian functions or habitats for terrestrial species. For example, FEMAT curves did not explicitly address floodplains and riverine wetlands, sub-surface water movements, nutrient dynamics, pollutant removal, or groundwater recharge.

Given its utility, the height of site-potential trees has been described for a wide variety of tree species and can be readily found in the silvicultural literature. Fox (2003) found that mean heights of dominant trees in riparian old-growth forest of Washington range from 100 to 240 ft (30 to 70 m). The wide range of heights reflects differences in site productivity, i.e., local differences in soil nutrients and moisture, light and temperature regimes, and topography (Avery and Burkhart 1994: 278). Site productivity is described quantitatively through a site index, which is the average height that dominant trees of a particular species are expected to attain at a specified tree age. Tables (e.g., King 1966) have been developed to predict the future average height of dominant trees on a site.

FEMAT (1993:V-34) defined site-potential tree height as "the average maximum height of the tallest dominant trees (200 years or more) for a given site class." The key phrase in this definition is "200 years or more" which refers to the approximate minimum age of old-growth forests (Franklin and Spies 1991). This reflects FEMAT's underlying assumption that old-growth forest conditions are needed for full riparian ecosystem functions. Because Douglas-fir can continue height growth for more than 200 years (Herman and Lavender 1990), site-potential height based on age 200 years is the minimum width for full riparian ecosystem functions according to FEMAT. Moreover, in addition to changes in SPTH with increasing forest age, other riparian forest components (e.g., basal area of live trees, species composition, volume of dead woody material) continue to change after 200 years of age (Fox 2003) resulting in what may be important but relatively unstudied implications for riparian ecosystem functions and values.

[2] However, we note that the Forests and Fish Habitat Conservation Plan (FFHCP) did not adopt the FEMAT (1993) definition of site-potential tree height. The FFHCP defined SPTH as the height of dominant trees at age 100 years.



Quinault River/Wendy Cole, WDFW

9.5. The Condition of Riparian Ecosystems

Many scientific experts (Swanson et al. 1994; Reeves et al. 1995; Bisson et al. 2009) believe that the most likely way to realize viable self-sustaining fish, especially salmon, populations is to maintain/restore ecosystems to conditions that resemble their historical range of natural variability[3] (hereafter historical conditions). The scientific rationale for this opinion is that fish species have over many millennia adapted to particular disturbance regimes and consequent habitat conditions. Therefore, many scientists believe that dramatic deviation from historical conditions reduces the average survival and fecundity of animal populations, and thus puts species at risk of extinction (Swanson et al. 1994).

We define the historical conditions as the dynamic range of ecosystem composition, structure, and functions prior to significant impacts by Euro-American settlement (Swanson et al. 1994). Landres et al. (1999) suggest that the historical conditions provides guidance, context, and benchmarks for management. Understanding changes to historical conditions imposed by past management action (e.g., clearcutting riparian areas) can inform decisions on future management and realistic future objectives, such as desired future condition (DFC). Articulating riparian DFC with awareness of historical conditions provides a meaningful benchmark for assessing potential loss of riparian function and potential risks to fish and wildlife populations (Landres et al. 1999; Morgan et al. 1994). Because historical composition and structure were driven by disturbances, Landres et al. (1999) also suggest that managers should maintain, or at least emulate, the disturbance processes that created historical conditions. In other words, historical conditions describe relationships between species and habitats and thus provide context and guidance for managing ecological systems in the future. Emulating historical conditions could include the appropriate use of engineered solutions (e.g., stormwater basins to reduce peak flows, placing large wood in streams) to protect or restore habitats. Bisson et al. (2009) promote this same concept for conserving freshwater habitats of anadromous salmonids.

Managing a site, reach, or watershed to more closely resemble historical conditions may also effectively serve as a coarse-filter conservation strategy. Coarse filter strategies are based on the idea that managing for a habitat type, perhaps by emulating historical

[3] Also referred to as "historical natural variability," "natural variability," "range of natural variability," "natural range of variability," "historical range of variability," or "reference variability" (Landres et al. 1999).



Riparian ecosystem near Naches/Mary Huff, WDFW

conditions, will more efficiently conserve many species rather than managing for each species separately (Hunter et al. 1988; Swanson et al. 1994). Consistent with Landres et al. (1999), managing riparian areas with a goal of emulating historical conditions may be more cost effective in the long run than other approaches as it should require fewer investments in mitigation for degraded riparian ecosystem functions. In other words, managing for historical conditions is consistent with the idea that avoiding impacts to habitat is less expensive and more scientifically defensible than restoring habitat for each species after impacts.

Emulating an ecosystem's historical conditions poses both empirical and conceptual challenges. Empirical data needed to estimate the historical conditions are seldom available, and when available, the data are usually inadequate for the task of reliably estimating historical variation over time and space (Keane et al. 2009). The biggest conceptual challenge is posed by the ever-changing environment, much of it wrought by humans. While the historical conditions provides the best description of habitats that supported fish and wildlife species in the past, we recognize the challenge of applying that knowledge to watersheds that have been drastically altered by exotic species, fire suppression, intensive land uses, and climate change. Despite these challenges, Keane et al. (2009) still believe that the historical conditions provides an essential perspective for managers.

Historical conditions are the result of natural processes such as frequent floods, landslides, and wildfire – some of catastrophic magnitude – occurring throughout a watershed. Hence, for obvious reasons, managing riparian areas so that they roughly match their historical conditions may be unrealistic, especially in residential or agricultural settings. Furthermore, WDFW acknowledges that other uses of riparian areas as legitimate and worthwhile. Such uses and a wide variety of societal values must also be considered when developing strategies, plans, or rules for riparian areas. Therefore, rather than a goal, the historical conditions may better serve as a guide.

Dynamic mosaics of riparian and aquatic habitats are created, maintained, and altered in predictable (e.g., seasonally) and unpredictable ways (e.g., due to random events like storms, fires, and landslides).

9.6. Other Important Issues

We highlight three important issues that deserve more in-depth discussion: complexity, connectivity, and climate change. We also consider management implications of each issue for riparian areas and watersheds.

9.6.1 Complexity

The ecologist Frank Egler stated, "Ecosystems are not only more complex than we think, but more complex than we can think" (Egler 1977). Riparian ecosystems fit that description – they are dynamic, nonstationary, nonlinear systems comprised of many interacting components. In dynamic systems, conditions continually change over time. Dynamic equilibrium, for instance, means that conditions continually fluctuate about an average state, and the long-term statistics describing that process – mean, variance, fluctuation frequency – remain virtually constant. Nonstationary means that a system's functional relationships are changing over time, and consequently, the long-term statistics describing the process are changing. Some scientists believe that future climate change will lead to more pronounced nonstationarity in aquatic ecosystems (Milly et al. 2008). Nonlinear implies that functional relationships between ecosystem components are complicated. Under certain conditions, some types of nonlinear relationships may exhibit chaotic behavior. Not surprisingly, predicting the effects of management actions on dynamic, nonstationary, nonlinear systems is challenging.

Frissell et al. (1986) helped conceptualize watersheds as hierarchical systems where larger scale components, structures, and processes act primarily in the downstream direction on smaller scale components, structures, and processes. Factors that affect processes



The Nooksack River is located in the northwest part of Washington. It drains an area of the Cascade Range around Mount Baker, and flows through a fertile agricultural area before emptying into Bellingham Bay./Department of Natural Resources

over the longest duration can be considered "drivers" of the conditions and processes at lower levels in the hierarchy. Climate, geology, topography (and land cover) largely determine watershed characteristics and processes (paraphrasing the framework of Montgomery 1999). However, the composition, structure, and functions of streams and riparian ecosystems do not simply arise from these drivers. They are created and modified by continuous and episodic fluxes of materials (particularly water, sediment, and wood) and energy, which are broadly termed watershed processes. Dynamic mosaics of riparian and aquatic habitats are created, maintained, and altered in predictable (e.g., seasonally) and unpredictable ways (e.g., due to random events like storms, fires, and landslides).

These types of nonlinear dynamics are intrinsic properties of all ecosystems and important for the creation and maintenance of habitats that fish and wildlife populations depend on (Fausch et al. 2002; Ward et al. 2002; Wiens 2002), including salmon (Merz et al. 2015). The availability of multiple types of habitat (i.e., habitat heterogeneity) within and among streams may be essential for the persistence of multiple life history strategies in salmon species (Hilborn et al. 2003; Bisson et al. 2009; Waples et al. 2009; Merz et al. 2015) and the coexistence of other aquatic and riparian-dependent species (Bellmore et al. 2015).

The availability of multiple types of habitat within and among streams may be essential for the persistence of multiple life history strategies in salmon species and the coexistence of other aquatic and riparian-dependent species.

How should we approach the management of ecosystem complexity? Because ecosystems are wickedly complex (Ludwig 2001) and exhibit irreducible natural variability at multiple spatial and temporal scales, managers should adopt an attitude of humility. Over-confident managers who approach decisions with resolute certainty may fail to anticipate problems or recognize potential risks. Humility should instill in managers a desire to understand more before acting and a further desire to continually improve one's understanding of the system. The former is a quality of the precautionary principle, and the latter is a philosophical underpinning of adaptive management. Adaptive management is discussed later in this chapter.

9.6.2. Connectivity

Several chapters in this volume introduce the idea of watershed connectivity, in particular, longitudinal, lateral, and vertical connectivity. Connectivity is vital to aquatic ecosystem function and especially important at conferring resiliency to the negative effects of climate change (see section 9.6.3). Streams and their associated riparian ecosystems transport water, wood, sediment, nutrients, and organisms predominantly, but not exclusively in the downstream direction. Longitudinal (upstream to downstream) fragmentation of streams, for example by road crossings that block passage of fish, can reduce habitat capacity for individual species and change aquatic community composition by impeding movements of fish and other animals. Dams and undersized culverts also reduce the transport of large wood and sediment from upstream areas, which can adversely impact habitat composition and structure. Loss of lateral connectivity between streams and their floodplains due to levees, dams, or channel incision can reduce development of off-channel aquatic habitats, alter riparian plant communities, and impact processes such as water storage and nutrient cycling. Reduction of vertical connectivity, i.e., exchanges between stream water and deeper groundwater in the

hyporheic zone, can increase stream water temperatures, alter stream chemistry, and impact macroinvertebrate populations.

The importance of connectivity is also supported by our understanding of the extents at which aquatic species, especially fish, use stream habitat (Fausch et al. 2002). Movement of individuals among reaches and watersheds to locate specific habitat conditions (e.g., suitable water temperatures) is increasingly acknowledged as important to fish population persistence, particularly in light of climate change.



Bull trout in Deep Creek, Yakima County/Eric Anderson, WDFW

Maintaining connectivity in aquatic ecosystems likely requires management at site and watershed-scales. Management to protect or restore salmon and other aquatic species should ensure that all parts of a stream network that could be accessible to fish are in fact accessible to fish. That is, artificial structures should not impede fish movement. This requires watershed-scale stream network inventories and site-scale correction of artificial barriers. Additionally, barriers to the longitudinal or lateral transport of sediment and wood should be corrected, and hyporheic exchange should be enhanced by restoring the processes that supply in-stream large wood and coarse sediments. Where practical, management should ensure that the flows of water, sediment, and wood continue to flow as they did historically.

9.6.3. Climate Change

Climate change is expected to directly affect aquatic ecosystems by increasing air and water temperatures, altering stream hydrology, and impacting sediment yields throughout Washington. Indirect effects are too numerous to mention here but are likely to include changes to riparian plant communities, changes in fire regime, introduction of new diseases, exotic pests, and competitors with salmon. Because water temperature is widely recognized as one of the most important environmental factors influencing the geographic distribution, growth, and survival of fish (Regier et al. 1990; Armour 1991; McCullough 1999), the warming effects of climate change on rivers and streams threaten to reduce fish distribution and population viability (Beechie et al. 2013). The Pacific Northwest experienced a significant warming trend in summer stream temperatures of approximately 0.40°F/decade (0.22°C/decade) between 1980 and 2009 (Isaak et al. 2012). In the future, August stream temperatures are expected to increase an average of 5.1°F (2.8°C) by the 2080s (Isaak et al. 2015), and stream temperatures are expected to increase in all seasons of the year. The effects of climate change on surface water temperatures are compounded by other anthropogenic increases of water temperature caused by removal of riparian vegetation, water withdrawals, and channelization of streams (Poole and Berman 2001; Moore et al. 2005).

Climate change is projected to cause major changes in hydrology across Washington. Scientists have already detected negative trends in glacier volume and snowpack (Granshaw and Fountain 2006, Sitts et al. 2010, Stoelinga et al. 2010) and earlier peak streamflow in many rivers (Stewart et al. 2005). These trends are expected to continue in the future, along with increasing flood magnitudes, declining summer minimum flows, and rising stream temperatures (Elsner et al. 2010, Mantua et al. 2010). In Washington State, projected changes in future annual total precipitation are generally small compared to year-to-year fluctuations in seasonal and annual rainfall. Nonetheless, hydrological projections for the mid to late 21st century show a shift in flood frequencies that results in larger peak flows at all recurrence intervals , e.g., 2-year, 5-year, 10 year, etc. in some watersheds (Salathè et al. 2014). Changes are projected to be most pronounced in middle elevation basins, where a substantial proportion of the basin is located near the snowline (i.e., the "mixed rain and snow" zone). In these watersheds, warming will cause more precipitation to fall as rain instead of snow, which will decrease snow accumulation, hasten melt, and increase runoff (Hamlet et al. 2007).

Changes in stream flow are expected to alter sediment transport and channel morphology, however, published research analyzing the potential impact of future climate change on fluvial processes is limited. Praskievicz (2015) modeled the effects of future climate on geomorphic responses in three snow-dominated river basins of Idaho and eastern Washington. The results from the first site on the Tucannon River indicate that net sediment deposition is likely to occur, with increasing mid-channel bars. The second study site on the Coeur d'Alene River projects net erosion, and results for the third site forecast minimal changes on the Red River. These varying results indicate that the impacts of climate on sediment movement also depend on local context, i.e., how reach traits, such as substrate size or riparian vegetation, affect a stream channel's morphological stability or lateral mobility.

Management to minimize direct detrimental effects of climate change on aquatic habitat includes: 1) increasing shade to streams by protecting or restoring riparian forests, 2) decreasing thermal sensitivity of surface waters by increasing summer low flows, 3) maintaining longitudinal, lateral, and vertical connectivity within watersheds, 4) monitoring and mitigating stream temperatures, especially when management actions are known to cause stream temperature increases, and 5) developing contingency plans for responding to climate related changes to water temperature, hydrology, or channel morphology. Because riparian areas can provide longitudinal habitat connectivity, link aquatic and terrestrial ecosystems, and create thermal refugia for wildlife, climate change makes the restoration of riparian areas especially important (Seavy et al. 2009).

9.7. Uncertainty and Management

Chapters 2 through 8 demonstrate that management of riparian ecosystems often involves substantial and unavoidable uncertainty, despite the fact that many riparian ecosystem functions are well understood. We include a discussion on uncertainty in management because effective use of scientific knowledge requires an understanding of its uncertainty (Fischhoff and Davis 2014) and because addressing uncertainty can lead to better long-term outcomes (Steel et al. 2009) for all stakeholders.

Some uncertainty is due to limited knowledge. For instance, the historical composition and structure of native riparian vegetation in the Columbia Plateau remains relatively unknown (see Chapter 7). Research can improve knowledge and reduce this type of uncertainty. A less well-appreciated type of uncertainty is associated with stochastic environmental variability, which introduces irreducible uncertainty or "unavoidable unpredictability" (sensu Spielgelhalter and

Riesch 2011) into the expected effects of management decisions. In other words, the longer one's time horizon for management decisions, the more likely that less expected, or even unexpected effects are going to occur. This type of uncertainty can be quantified through research, but never reduced. For example, large floods may unexpectedly alter channel form (e.g., widen a channel) and as a result change a stream's thermal regime. This in turn can decrease the effectiveness of management aimed at maintaining stream temperature based on pre-flood riparian conditions (see Chapter 4). This concept is important because conditions created by some land management actions are ubiquitous and long-lived (e.g., young forests after timber harvest), thus creating a situation where less expected effects due to environmental variability are virtually guaranteed.

Using stream temperatures to discuss uncertainty is instructive because our understanding of riparian effects on stream temperatures is arguably the best developed of any riparian function (see Chapter 4). We know for instance how certain ecosystem composition, structures, and functions (predictor variables) affect stream temperatures, so we could accurately predict the effects of common management actions with high certainty. Unfortunately, logistical or economic constraints of collecting predictor variable data usually preclude the development and use of such models. Instead, we often employ simpler, statistical models or correlations to inform management. For instance, we can generally predict changes to water temperatures based on changes to shade from riparian vegetation because changes in shade are often strongly correlated with changes in water temperatures (Cristea and Janisch 2007).

Figure 9.2 shows the results of several studies relating changes in summer stream temperatures to changes in riparian buffer width. Stream temperatures were measured before and after reducing the widths of forested riparian buffers, which decreased shading of streams. The results of such studies are often assumed to predict the effects of shade reduction on stream temperatures in other locations. However, because each stream is unique (e.g., differences in stream widths, topographic shade, groundwater flows, etc.), changes in water temperature based solely on shade are relatively uncertain. For example, Jackson et al. (2001) found that 30-ft wide forested buffers caused summer stream temperatures to increase by an average of 4.2°F (2.4°C), but the 95% confidence interval for the average was -0.1° to 8.6°F (0.0 to 4.8°C). At one site, temperatures decreased, likely due to unmeasured effects on groundwater flow (Janisch et al. 2012). Such uncertainty is common. Additional studies of this type might narrow confidence intervals and more accurately estimate the average response, but predictions of stream temperature based on buffer width alone will remain highly uncertain despite our knowledge that shade can strongly affect water temperature.

Similarly, empirical data describe wood recruitment from riparian areas as increasing with distance from the channel (i.e., riparian area width), but this relation varies widely among streams (Figure 9.3). Other potential predictor variables might include the wood recruitment mechanism, topography, fire regime, and forest age. However, we are unaware of other recruitment models that include variables that would allow us to predict the effects of management actions on wood recruitment with high certainty.

Currently, most riparian ecosystem functions described in this volume are best described with statistical models or correlations that often reliably predict the direction or sign (+ or -) of the correlation and some of the variability around the central tendency. Many such models rely on data from few sites that poorly describe the average or range of relations. For example, sample sizes for studies in Figure 9.2 are small, i.e., $N = 6, 3, 5,$ and 5. Additional studies with larger sample sizes could better describe responses to shade reduction but are unlikely to substantially reduce uncertainty if they do not consider other important predictors in addition to buffer width.

Even as we conduct studies that reduce uncertainty associated with a lack of knowledge, we are continually challenged to make sound decisions into the future by irreducible uncertainty due to stochastic events, such as natural disturbances, and non-stationary processes like climate change. As riparian ecosystems change through time, whether due to future wildfire, floods, or climate change, we must ensure that our management strategies meet their intended goals. Uncertainty about the future effects of current management actions is perhaps the biggest challenge faced by managers because those effects of management often persist over long periods or may be practically irreversible (e.g., loss of riparian areas due to residential development). With this uncertainty comes the risk that the unpredictable may convert current and successful regulatory policies or management practices into future failures.

We can never eliminate uncertainty, but we can make management decisions that are appropriate given our current level of uncertainty. We recommend reducing risk to riparian ecosystems by: 1) reducing uncertainty through new research, 2) explicitly acknowledging and directly addressing uncertainty in policy and management decisions that affect fish and wildlife habitats, 3) considering the application of the precautionary principle to reduce unacceptable risk (O'Riordan and Jordan 1995; Gullet 1997). That is, erring on the side of caution, particularly when dealing with environmental impacts that are difficult to undo (irreversible damage or long recovery times), and 4) practicing adaptive management.

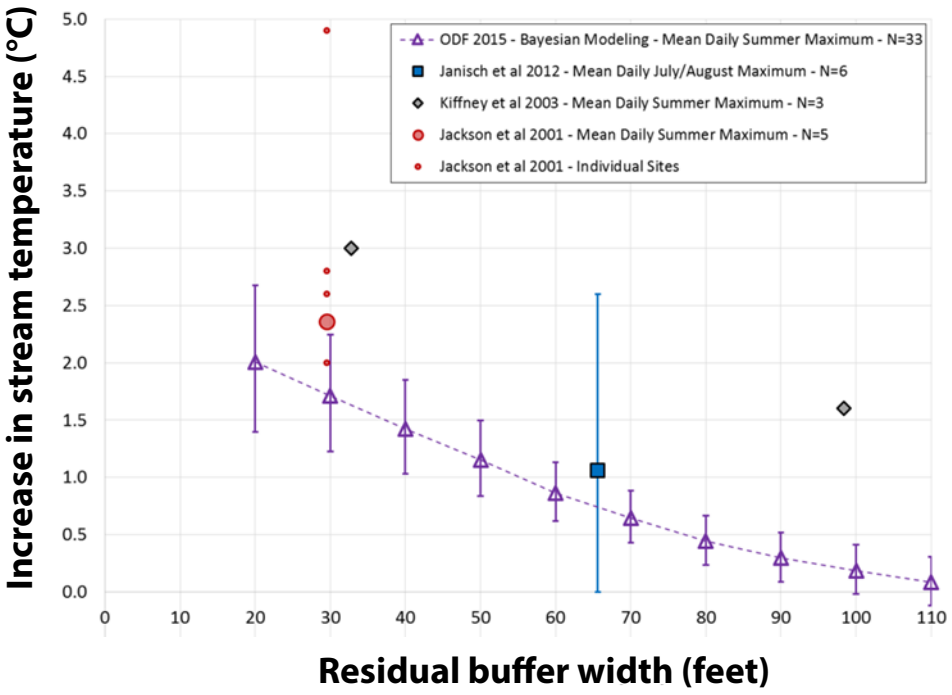


Figure 9.2. Observed temperature response associated with "no-cut" riparian buffers with adjacent clearcut harvest. Only studies that employed a Before-After-Control-Impact design and conducted in Pacific Northwest forests are included. Bayesian modeling results (and 90% credible intervals) were derived from data collected as part of Groom et al. (2011). A change of 1°C is equivalent to a 1.8°F change. Analyses provided by P. Leinenbach, USEPA Region 10 (See Chapter 4 for a more complete description of this figure).

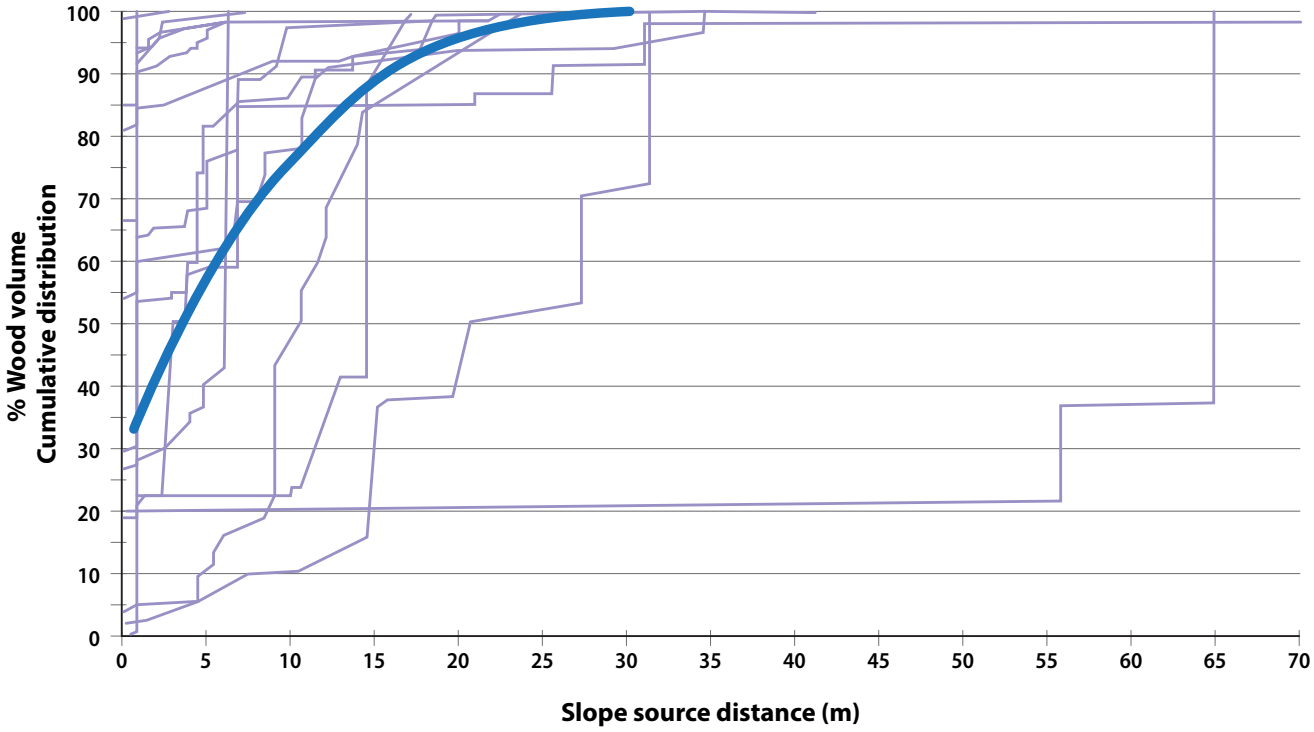


Figure 9.3. Sixteen large wood recruitment curves for second-growth redwood forest on 16 sites in northern California (from Benda et al. 2002). The theoretical prediction curve (thick line) is based on mortality recruitment only using random 360° fall trajectories. Curves to the left of the theoretical curve are sites where bank erosion is a major recruitment mechanism. Curves to the right of the theoretical curve are sites where landsliding is a major recruitment mechanism. (See Chapter 3 for a more complete description of this figure).

9.8. Adaptive Management

Despite new insights into ecosystems dynamics and better understanding of the effects of management actions on species and their habitats, natural resource management decisions will always struggle with some level of uncertainty. Adaptive management is widely recognized as a sensible, if not essential, approach to the management of natural resources under uncertainty. As originally conceived, adaptive management can be defined as the systematic acquisition and application of reliable information to improve management over time (Wilhere 2002). Reliable information is acquired through statistically-valid research and monitoring. Furthermore, adaptive management can facilitate a way forward when levels of uncertainty become high enough to threaten stakeholder agreement about environmental policies (Wilhere and Quinn 2018).

The adaptive management process is a continual cycle consisting of planning, action, monitoring, evaluation, and adjustment (Bormann et al. 1994, Wilhere 2002) (Figure 9.4). Monitoring and evaluation form a feedback loop that provides information for management decisions. However, feedback alone cannot fulfill the goal of adaptive management, that is, the continual improvement of management. Ideally, an "adaptive management plan" integrates every phase of management with monitoring, and considers how information collected through monitoring will lead to future changes in management. Developing an adaptive management plan should be a collective endeavor of policy makers, managers, field staff, and scientists.

Successful adaptive management requires an understanding of all stakeholder perspectives. Hence, developing an adaptive management plan should begin with discussions amongst stakeholders about their concerns regarding uncertainty and risk. The plan should be developed through a negotiated process, and it should explain how specific risks will be addressed through a program of systematic learning (e.g., management experiments, focused monitoring, targeted literature reviews, etc.). Importantly, the best adaptive management plans have agreements about the specific information necessary to change policy or management and what those changes might be.

Adaptive management programs can fall victim to the widespread confusion between the roles of values and science in management decisions (Wilhere and Quinn 2018). Maintaining a clear distinction between values (cultural, social, and economic) and science, and between the roles of policy makers and scientists, is critical to success. That said, WDFW recognizes that natural resource management or land use policies must often balance competing ecological, economic, and social values. In fact, one of WDFW's conservation principles is that management decisions should integrate ecological, economic, and social perspectives. This volume addresses only the ecology of riparian area management; it does not cover economic and social aspects. Determining an acceptable balance requires a political process involving stakeholders, local governments, tribes, and state agencies. We hope this volume can help to inform that process.

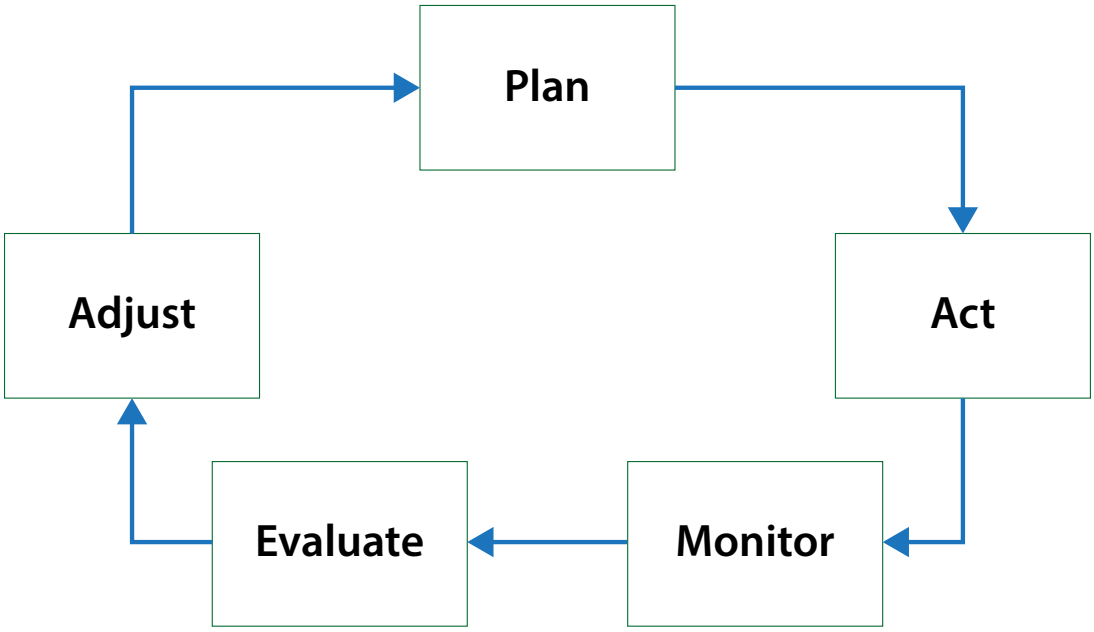


Figure 9.4. The adaptive management cycle (modified from Bormann et al. 1994).

9.9. Literature Cited[4]

Armour, C. 1991. Guidance for evaluating and recommending temperature regimes to protect fish. Biological Report 90(22). Fish and Wildlife Service, Washington, D.C. (viii)

Avery, T.E., and H.E. Burkhart. 1994. Forest measurements. McGraw-Hill, New York. (i)

Beechie, T.J., H. Imaki, J. Greene, A. Wade, H. Wu, G. Pess, P. Roni, J. Kimball, J. Stanford, P. Kiffney, and N. Mantua. 2013. Restoring salmon habitat for a changing climate. River Research and Applications 29:939–960. (i)

Bellmore, J.R., C.V. Baxter, and P.J. Connolly. 2015. Spatial complexity reduces interaction strengths in the meta-food web of a river floodplain. Ecology 96:274-283. (i)

Benda, L.E., P. Bigelow, and T.M. Worsley. 2002. Recruitment of wood to streams in old-growth and second-growth redwood forests, northern California, U.S.A. Canadian Journal of Forest Research 32:1460-1477. (i)

Bisson, P.A., J.B. Dunham, and G.H. Reeves. 2009. Freshwater ecosystems and resilience of Pacific salmon: habitat management based on natural variability. Ecology and Society 14(1):45. (i)

Bormann, B.T., P.G. Cunningham, M.H. Brookes, V.W. Manning, and M.W. Collopy. 1994. Adaptive ecosystem management in the Pacific Northwest. PNW-GTR-341. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

Cristea, N., and J. Janisch. 2007. Modeling the effects of riparian buffer width on effective shade and stream temperature. Washington Department of Ecology, Olympia. (viii)

Cummins, K.W. 1974. Structure and function of streams ecosystems. BioScience 24:631-641. (i)

DNR (Washington Department of Natural Resources). 1999. Forests and fish report. Forest Practices Division, Olympia, Washington. (viii)

DNR (Washington Department of Natural Resources). 2005. Final forest practices habitat conservation plan. Forest Practices Division, Olympia, Washington. (viii)

Egler, F.E. 1977. The nature of vegetation: its management and mismanagement. Aton Forest, Norfolk, Connecticut. (viii)

Elsner, M.M., L. Cuo, N. Voisin, J.S. Deems , A.F. Hamlet, J.A. Vano , K.E.B. Mickelson, S.Y. Lee, and D.P. Lettenmaier. 2010. Implications of 21st century climate change for the hydrology of Washington State. Climatic Change 102:225–260. (i)

Fausch, K.D., C.E. Torgersen, C.V. Baxter, and H.W. Li. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. BioScience 52:483-498. (i)

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic and social assessment. U.S. Department of Agriculture and U.S. Department of the Interior, Portland, Oregon. (viii)

Fischhoff, B., and A.L. Davis. 2014. Communicating scientific uncertainty. Proceedings of the National Academy of Science 111(Supplement 4): 13664-13671. (i)

Fox, M.J. 2003. Spatial organization, position, and source characteristics of large woody debris in natural systems. Doctoral dissertation. University of Washington, Seattle. (i)

Franklin, J.F., and T.A. Spies. 1991. Composition, function, and structure of old-growth Douglas-fir forests. Pages 71-82 *in* L.F. Ruggerio, K.B. Aubry, A.B. Carey, and M.H. Huff, technical coordinators. Wildlife and vegetation of unmanaged Douglas-fir forests. PNW-GTR-285. U.S. Forest Service, Pacific, Northwest Research Station, Portland, Oregon. (viii)

Frissell, C.A., W.J. Liss, C.E. Warren, and M.D. Hurley. 1986. A hierarchical framework for stream classification: viewing streams in a watershed context. Environmental Management 10:199-214. (i)

4 References are classified according to RCW 34.05.271 (see Appendix 1) denoted by a lower case roman numeral (i – viii) in parentheses at the end of the citation.

Granshaw, F.D., and A.G. Fountain. 2006. Glacier change (1958–1998) in the North Cascades National Park Complex, Washington, USA. Journal of Glaciology 52:251-256. (i)

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones: focus on links between land and water. Bioscience 41:540-551. (i)

Groom, J.D., L. Dent, and J. Madsen. 2011. Stream temperature change detection for state and private forests in the Oregon Coast Range. Water Resources Research 47:1-12. (i)

Gullet, W. 1997. Environmental protection and the "precautionary principle": a response to scientific uncertainty in environmental management. Environmental Planning and Law Journal 14:52-69. (i)

Hamlet, A. F., P.W. Mote, M.P. Clark, and D.P. Lettenmaier. 2007. Twentieth-century trends in runoff, evapotranspiration, and soil moisture in the western United States. Journal of Climate 20:1468-1486. (i)

Herman, R.K., and D.P. Lavender. 1990. *Pseudotsuga menziesii*. Pages 527-540 *in* R.M. Burns and B.H. Honkala, technical coordinators. Silvics of North America volume 1: conifers. Agriculture Handbook 654. U.S. Forest Service, Washington, D.C. (viii)

Hilborn, R. 1987. Living with uncertainty in resource management. North American Journal of Fisheries Management 7:1-5. (i)

Hilborn, R., T.P. Quinn, D.E. Schindler, and D.E. Rogers. 2003. Biocomplexity and fisheries sustainability. Proceedings of the National Academy of Sciences 100:6564-6568. (i)

Hunter, M.L. Jr., G.L Jacobson Jr., and T. Web III. 1988. Paleoecology and the coarse filter approach to maintaining biological diversity. Conservation Biology 2:375-385. (i)

Independent Scientific Group. 1999. Scientific issues in the restoration of salmonid fishes in the Columbia River. Fisheries 24:210-219. (i)

Isaak, D., S. Wenger, E. Peterson, J. Ver Hoef, C. Luce, S. Hostetler, J. Dunham, J. Kershner, B. Roper, D. Nagel, D. Horan, G. Chandler, S. Parkes, and S. Wollrab. 2015. Development and application of NorWeST stream temperature climate scenarios for the Pacific Northwest. Webinar, January 27. North Pacific Landscape Conservation. Cooperative, Lacey, Washington. (viii)

Isaak, D.J., S. Wollrab, D. Horan, and G. Chandler. 2012. Climate change effects on stream and river temperatures across the northwest U.S. from 1980 - 2009 and implications for salmonid fishes. Climate Change 113:499-524. (i)

Jackson, C.R., C.A. Sturm, and J.M. Ward. 2001. Timber harvest impacts on small headwater stream channels in the coast ranges of Washington. Journal of the American Water Resources Association 37:1533–1549. (i)

Janisch, J.E., S.M. Wondzell, and W.J. Ehinger. 2012. Headwater stream temperature: interpreting response after logging, with and without riparian buffers, Washington, USA. Forest Ecology and Management 270:302-313. (i)

Keane, R.E., P.F. Hessburg, P.B. Landres, and F.J. Swanson. 2009. The use of historical range and variability (HRV) in landscape management. Forest Ecology and Management 258:1025-1037. (i)

Kiffney, P.M., J.S. Richardson, and J.P. Bull. 2003. Responses of periphyton and insect consumers to experimental manipulation of riparian buffer width along headwater streams. Journal of the American Water Resources Association 40:1060-1076. (i)

King, J.E. 1966. Site index curves for Douglas-fir in the Pacific Northwest. Weyerhaeuser Forestry Paper No. 8. Forestry Research Center, Weyerhaeuser Company, Centralia, Washington. (viii)

Landres, P.B., P. Morgan, and F.J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications 9:1179-1188. (i)

Ludwig, D. 2001. The era of management is over. Ecosystems 4:758–764. (i)

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climatic Change 102:187-223. (i)

McCullough, D.A. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. EPA 910-R-99e010. U.S. Environmental Protection Agency, Region 10, Seattle, Washington. (viii)

Merz, J.E., D.G. Delaney, J.D. Setka, and M.L. Workman. 2015. Seasonal rearing habitat in a large Mediterranean-climate river: management implications at the southern extent of Pacific salmon (*Oncorhynchus* spp.). River Research and Applications 32:1220-1231. (i)

Milly, P.C.D., J. Betancourt, M. Falkenmark, R.M. Hirsch, Z.W. Kundzewicz, D.P. Lettenmaier, and R.J. Stouffer. 2008. Stationarity is dead: whither water management? Science 319: 573-574. (i)

Montgomery, D.R. 1999. Process domains and the river continuum. Journal of the American Water Resources Association 35:397-410. (i)

Moore, R.D., D.L. Spittlehouse, and A. Story. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. Journal of the American Water Resource Association 41:813-834. (i)

Morgan, P., G.H. Aplet, J.B. Haufler, H.C. Humphries, M.M. Moore, and W.D. Wilson. 1994. Historical range of variability: a useful tool for evaluating ecosystem change. Journal of Sustainable Forestry 2:87-111. (i)

Naiman, R.J., and R.E. Bilby, editors. 1998. River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer-Verlag, New York. (i)

Naiman, R.J., R.E. Bilby, and P.A. Bisson. 2000. Riparian ecology and management in the Pacific Coastal Rain Forest. BioScience 50:996-1011.

NRC (National Research Council). 2002. Riparian areas: functions and strategies for management. National Academy Press. Washington, D.C. (i)

O'Riordan, T., and A. Jordan. 1995. The precautionary principle in contemporary environmental politics. Environmental Values 4:191-212. (i)

Poole, G.C., and C.H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27:787-802. (i)

Praskievicz, S. 2015. A coupled hierarchical modeling approach to simulating the geomorphic response of river systems to anthropogenic climate change. Earth Surface Processes and Landforms 40:1616-1630. (i)

Reeves, G.H., L.E. Benda, K.M. Burnett, P.A. Bisson, and J.R. Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionary significant units of anadromous salmonids in the Pacific Northwest. American Fisheries Society Symposium 17:334-349. (i)

Regier, H.A., J.A. Holmes, and D. Pauly. 1990. Influence of temperature changes on aquatic ecosystems: an interpretation of empirical data. Transactions of the American Fisheries Society 119:374-389. (i)

Richardson, J.S., R.J. Naiman, F.J. Swanson, and D.E. Hibbs. 2005. Riparian communities associated with Pacific Northwest headwater streams: assemblages, processes, and uniqueness. Journal of the American Water Resources Association 41:935-947. (i)

Salathé Jr., E.P., A.F. Hamlet, C.F. Mass, S.-Y. Lee, M. Stumbaugh, and R. Steed. 2014. Estimates of twenty-first-century flood risk in the Pacific Northwest based on regional climate model simulations. Journal of Hydrometeorology 15:1881-1899. (i)

Seavy, N.E., T. Gardali, G.H. Golet, F.T. Griggs, C.A. Howell, R. Kelsey, S.L. Small, J.H. Viers, and J.F. Weigand. 2009. Why climate change makes riparian restoration more important than ever: recommendations for practice and research. Ecological Restoration 27:330-338. (i)

Sitts D., A.G. Fountain, and M. Hoffman. 2010. Twentieth century glacier change on Mount Adams, Washington, USA. Northwest Science 84:378-385. (i)

Spiegelhalter, D.J., and H. Reisch. 2011. Don't know, can't know: embracing deeper uncertainties when analysing risks. Philosophical Transactions of the Royal Society A 369:4730–4750. (i)

Stanford, J.A., J.V. Ward, W.J. Lis, C.A. Frissell, R.N. Williams, J.A. Lichatowich, and C.C. Coutant. 1996. A general protocol for restoration of regulated rivers. Regulated Rivers: Research & Management 12:391-414. (i)

Steel, E.A., T.J. Beechie, M.H. Ruckelshaus, A.H. Fullerton, P. McElhany, and P. Roni. 2009. Mind the gap: uncertainty and model communication between mangers and scientists. American Fisheries Society Symposium 71:357–372. (i)

Stewart, I.T., D.R. Cayan, and M.D. Dettinger. 2005. Changes toward earlier streamflow timing across western North America. Journal of Climate 18:1136-1155. (i)

Stirling, A., and D. Gee. 2003. Science, precaution, and practice. Public Health Reports 117:521-533. (i)

Stoelinga, M.T., M.D. Albright, and C.F. Mass. 2010. A new look at snowpack trends in the Cascade Mountains. Journal of Climate 23:2473-2491. (i)

Suter, G.W., L.W. Barnthouse, and R.V. O'Neill. 1987. Treatment of risk in environmental impact assessment. Environmental Management 11:295-303. (i)

Swanson, F.J., J.A. Jones, D.O. Wallin, and J.H. Cissel. 1994. Natural variability-implications for ecosystem management. Pages 80-94 *in* M.E. Jensen and P.S. Bourgeron, technical coordinators. Volume II: ecosystem management: principles and applications. PNW-GTR-318. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon. (viii)

Thomas, J.W., technical editor. 1979. Wildlife habitats in managed forests the Blue Mountains of Oregon and Washington. Agriculture Handbook No. 553. U.S. Forest Service, Washington, D.C. (viii)

Walker, B., C.S. Holling, S.R. Carpenter, and A. Kinzig. 2004. Resilience, adaptability and transformability in social–ecological systems. Ecology and Society 9(2):5. Available: http://www.ecologyandsociety.org/vol9/iss2/art5. (January 2019) (i)

Waples, R.S., T. Beechie, and G.R. Pess. 2009. Evolutionary history, habitat disturbance regimes, and anthropogenic changes: what do these mean for resilience of Pacific salmon populations? Ecology and Society 14(1):3. Available: http://www.ecologyandsociety.org/vol14/iss1/art3/. (January 2019) (i)

Ward, J.V., K. Tockner, D.B. Barscott, and C. Claret. 2002. Riverine landscape diversity. Freshwater Biology 47:517–539. (i)

Wiens, J.A. 2002. Riverine landscapes: taking landscape ecology into the water. Freshwater Biology 47:501-515. (i)

Wilhere, G.F. 2002. Adaptive management in habitat conservation plans. Conservation Biology 16:20-29. (i)

Wilhere, G.F., and T. Quinn. 2018. How wide is wide enough?: values, science, and law in riparian habitat conservation. Natural Resources Journal 58:279-318. (i)

Wohl, E. 2005. Compromised rivers: understanding historical human impacts on rivers in the context of restoration. Ecology and Society 10(2):2. Available: http://www.ecologyandsociety.org/vol10/iss2/art2. (January 2019) (i)

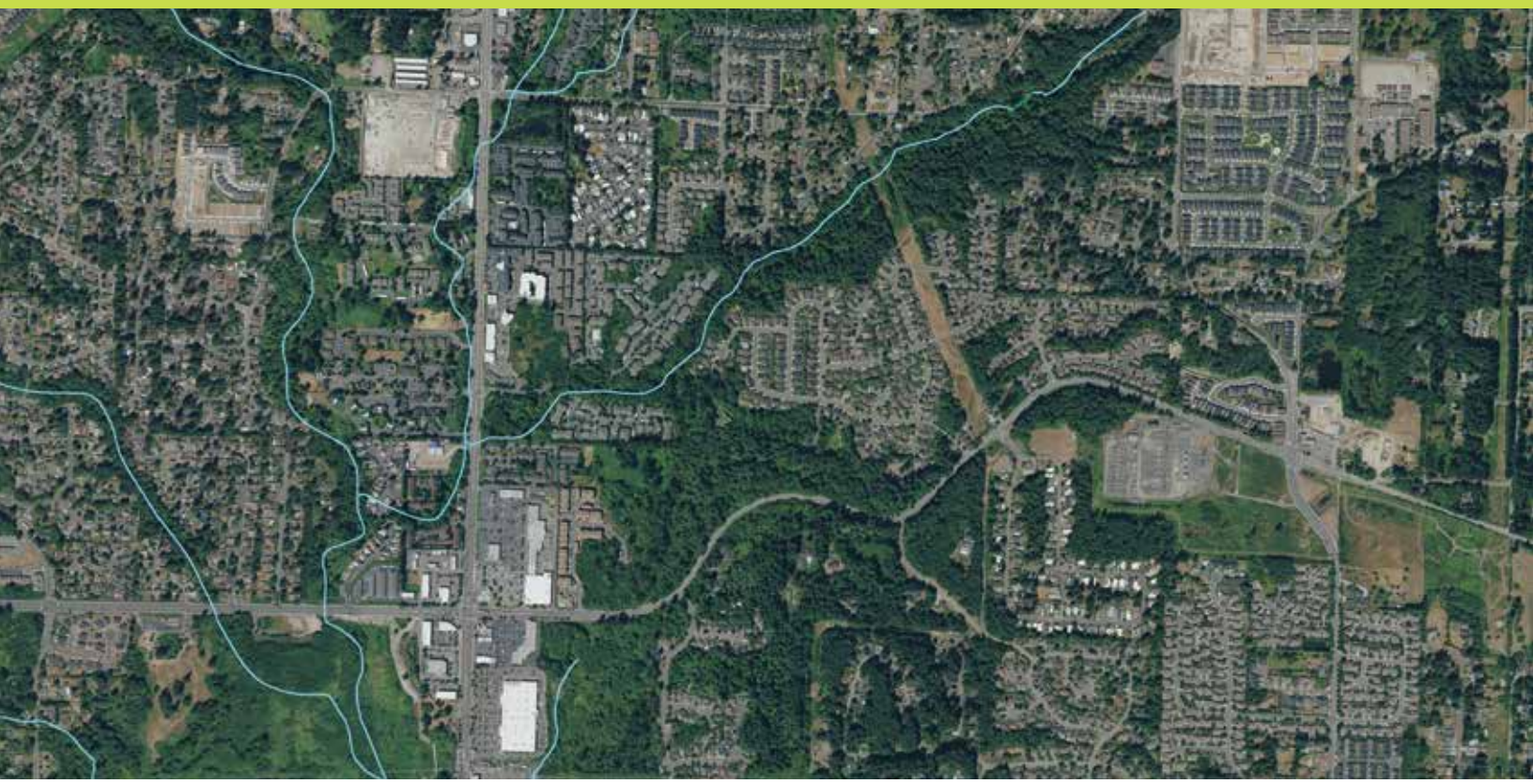
Wynne, B. 1992. Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. Global environmental change 2:111-127. (i)

Zar, J.H. 1996. Biostatistical analysis. Prentice-Hall, Upper Saddle, New Jersey. (viii)



Grande Ronde River/Alan Bauer

Appendix 1: Glossary



Riparian areas along streams (blue lines) in north King County/Terry Johnson, WDFW

Active channel

The portion of a stream channel defined by the lower limit of continuous riparian vegetation, and it may be delineated by absence of both moss on rocks and rooted vegetation. The upper most elevation of the active channel is sometimes equated with the ordinary high water mark.

Active floodplain

A portion of floodplain that is located between the active channel and adjacent terrace or hillslopes. Depending on the watershed, the flood return interval of the active floodplain varies between 1 and 10 years.

Adaptive management

The systematic acquisition and application of reliable information to improve management over time. Ideally, adaptive management treats management decisions as experiments in order to address critical uncertainties and learn more quickly from experience. It involves setting targets, monitoring outcomes, and adjusting management decisions based on results. Hallmarks of a well conceived adaptive management program include: 1) adequate funding for research, 2) a willingness to change course when pre-established triggers are reached, and 3) a commitment to monitor and evaluate conditions at appropriate spatial and temporal scales. See Ecosystem-based management.

Anthropogenic

Caused by human activity.

Channel confinement

A description of how much a channel can laterally move within its valley determined by the ratio of valley width (distance between toe of hillslopes on both sides of a

valley) to active channel width. Typically, a segment is considered confined when the ratio is less than two and unconfined when greater than four.

Channel migration zone
The area within which a river channel is likely to move laterally over a specified period (e.g., 100 years).

Channel morphology
A stream channel's shape, which changes over time due to the interplay of water, sediments, vegetation, and certain animals, e.g., Beaver *Castor canadensis* and salmon.

Channel reach (stream)
A continuous segment of a channel that has similar physical features, such as gradient and confinement.

Channel slope or gradient
The average steepness of a stream segment measured as its change in elevation divided by its length. Typically, a segment's gradient is considered low if less than 2%, moderate between 2% and 4%, and high if greater than 4%.

Composition: See *Ecological composition*.

Disturbance regime
The frequency, magnitude, and duration of disturbance events.

Disturbance
A disturbance is any relatively discrete event in time that disrupts the composition, structure, or functions of ecosystems, communities, or populations.

Dynamic equilibrium
An ecological system's long-term state of relative stability that is maintained through opposing processes. Understanding an ecosystem's equilibrium, is a goal of ecosystem-based management.

Ecological (biological) integrity
Capacity of an ecological system to maintain a community of organisms that has species composition, diversity, and functional organization comparable to those of natural habitats within a region. An ecological system has integrity when its dominant ecological characteristics (e.g., composition, structure, function) occur within their historical ranges of natural variation.

Ecological composition
A term encompassing all parts of an ecosystem that include both living (biotic) and nonliving (abiotic) parts. Ecosystem composition is an important consideration in conservation.

Ecological function(ing)
1) The process or cause-effect relationships between two or more interacting ecosystem components; 2) the sum of processes that sustain the system; or 3) the capacity of natural processes to provide goods and services that satisfy human needs, either directly or indirectly.

Ecological process
Interactions among components of an ecosystem, both biotic (living organisms) and abiotic (chemical and physical) components. Many processes involve the transfer, conversion, or storage of matter and energy. This term is synonymous with the first definition of *ecological function.*

Ecological structure
The arrangement of and relations among the parts or components of an ecosystem.

Ecosystem
A spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment. Ecosystems have *composition, structure,* and *functions.*

Ecosystem-based management (EBM)
An integrated management approach that recognizes the full array of interactions within an ecosystem, including humans, rather than considering single issues, species, or ecosystem services in isolation. EBM often involves balancing ecological, economic, and social trade-offs within the context of existing laws and policies.

Erosion
The loosening and transport of soil particles and other sediment by water. Terrestrial erosion includes raindrop splash erosion, overland flow sheet erosion, surface flow rill (shallow) and gully (deeper) erosion. Channel erosion includes streambank erosion and channel incision. Rill and gully erosion diminishes the capacity of riparian areas to trap sediment and pollutants and often can be avoided with intact riparian vegetation.

FEMAT curve
A conceptual model that describes the relationship between various riparian *ecosystem functions* and distance from channel. The model consists of generalized curves that show the cumulative effectiveness of litter fall, root strength, shading, and coarse wood debris recruitment to stream as a function of distance from channel.

Flow regime
The distribution of stream discharges through space and time. Flow regimes can be described by their magnitude (e.g., mean annual, hourly maximum), timing, frequency or return periodicity, duration, spatial distribution, and rate of change. The pathways that water takes to reach a stream (e.g., surface runoff) exert a strong influence on the flow regime.

Function
Physical, chemical, or biological processes that occur within an ecosystem. See *ecological function(ing)* and *ecological process.*

Historical conditions: See *Range of natural variability.*

Hot moments
Periods of elevated denitrification rates. Hot moments can occur during a rainfall event. Also see *hot spots.*

Hot spots
Areas that exhibit high denitrification rates. Hot spots often occur in floodplains and other riparian areas with oscillating groundwater levels and/or higher hyporheic flows. Locations of hot spots can vary through time.

Hydrology
Study of the occurrence, distribution, movement, and properties of the water and their relationship with land.

Hyporheic zone
The area beneath the bed of a river or stream that is saturated with water.

Impervious surface
Ground surfaces that resist or prevent water infiltration, e.g., roofs of houses and roadways.

Incision
The process of downcutting into a stream channel leading to a decrease in the channel bed elevation. Incision is often caused by a decrease in sediment supply or an increase in stream flows capable of transporting (scouring) sediment.

Infiltration
The rate or process by which water on the ground surface enters the soil.

Macroinvertebrates
Animals, including insects, mollusks, crustaceans, and worms, that do not have a backbone, and are large enough to be seen without a microscope. Aquatic macroinvertebrates are commonly used as an indicator of habitat and water quality.

Mass wasting
The down slope movement of soil, sediments, and rock due to gravity (rather than water, wind, or ice, for example).

Nutrient cycling
The movement, uptake, transformation, storage, and release of nutrients, especially carbon, nitrogen, and phosphorus. Riparian characteristics that affect nutrient cycling include flow path, vegetation composition and structure, topography, groundwater level, and soil type.

Nutrient spiraling length
The distance nutrients move downstream during a complete cycle; a measure of nutrient utilization to nutrient supply. Long spiraling lengths indicate that the system is saturated with nutrients and organisms can no longer use the incoming nutrient loads. Streams in Washington forests typically have relatively short nutrient spiraling lengths.

Ordinary high water mark
This mark occurs along stream channels where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland.

Precautionary principle
Erring on the side of causing no negative impact to natural resources when faced with uncertainty, especially for harm that is essentially irreversible. The precautionary approach involves: 1) taking preventive action (avoiding impacts), 2) shifting the burden of proof to the project proponents, 3) exploring a wide range of potential alternatives, and/or, 4) including multiple stakeholders and disciplines in decision making.

Process: See *Ecological process.*

Range of natural variability (or historical range of natural variability)
Refers to the range of ecological conditions (composition, structure, and functions) in a time period before widespread anthropogenic changes.

Riparian
An adjective meaning adjacent to a water body: stream, river, lake, pond, bay, sea, ocean. Riparian areas are sometimes referred to by different names: riparian ecosystems, riparian habitats, riparian corridors, or riparian zones. Depending on the context, these different terms may have somewhat different meanings.

Riparian buffer
Buffer refers to its purpose, which is to reduce or prevent adverse impacts to water quality, fisheries, and aquatic biodiversity from human activities occurring upslope of the buffer. Riparian buffers may also be called a riparian management zone. Riparian buffers managed specifically for pollutant removal may also be called a vegetated filter strip.

Riparian ecosystem
Riparian ecosystems are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., a zone of influence). Our definition of riparian ecosystem does not include adjacent waters (i.e., river or streams, but does include riverine wetlands) and recognizes the riparian zone as a distinctive area within riparian ecosystems.

Riparian management zone
Riparian management zone is often synonymous with riparian buffer. See *Riparian buffer.*

Riparian zone
A distinctive area within riparian ecosystems. The riparian zone contains wet or moist soils and plants adapted to growing conditions associated with periodically saturated soils.

Riverscape
A landscape organized around a river system that includes the river network and contributing watershed along with other components that are not organized by watershed boundaries such as wildfire, mobile organisms, and wind-borne seeds. Distinct from uplands, it is primarily organized in a downstream direction (e.g., movement of water, sediment, and wood) but also contains lateral elements (e.g., floodplain interaction), vertical elements (e.g., interaction of surface and hyporheic flow), and upstream elements (e.g., migrating salmon).

Salmonid
A family of fish comprised of salmon, trout, and whitefish. Native salmonid species in Washington State include: Chinook Salmon *Oncorhynchus tshawytscha,* Chum Salmon *O. keta,* Coho Salmon *O. kisutch,* Pink Salmon *O. gorbuscha,* Sockeye Salmon/Kokanee *O. nerka*, Steelhead/Rainbow Trout *O. mykiss,* Cutthroat Trout *O. clarki,* Bull Trout *Salvelinus confluentus,* Dolly Varden *Salvelinus malma,* Pygmy Whitefish *Prosopium coulteri,* and Mountain Whitefish *P. williamsoni.* This list does not include names of subspecies.

Site class
The classification of a site's productivity based on the growth of the dominant tree species. Site classes vary based on local differences in soil nutrients and moisture, light and temperature regimes, and topography. Site classes are typically described as most productive (I) through least productive (V).

Site-potential tree height
The average maximum height of the tallest dominant trees for a given age and site class.

Stochastic process
An event involving chance or probability (e.g., landslide, flood). Stochastic processes may have patterns that can be analyzed statistically but cannot be precisely predicted.

Stream order
A hierarchical stream classification system in which headwater tributaries are classified as first order; when two first order tributaries meet they form a second order tributary, when two second order tributaries meet they form a third order tributary, and so on. Low order (1st-3rd) streams make up ~88% of the state's stream miles. Below its confluence with the Snake and Yakima rivers, the Columbia River is a 10th order river.

Structure: See *Ecological structure*.

Thermal loading potential
The potential amount of solar radiation (sunlight) available at a given location. Primary factors include shading (topographic and vegetative), latitude, elevation, and date.

Thermal regime (stream)
The distribution of stream temperatures through space and time. Thermal regimes can be described by their magnitude (e.g., monthly mean, hourly maximum), timing, frequency, duration, spatial distribution, and rate of change.

Thermal sensitivity (stream reach)
The susceptibility of a stream reach to changes in temperature. Thermal sensitivity typically increases with less stream flow, less groundwater input, and a wider channel to depth ratio.

Uncertainty (scientific)
The absence of information about something. Sources of uncertainty include, but are not limited to: natural variation (i.e., because ecosystems vary in unpredictable ways through time and space), model

uncertainty (e.g., we do not understand a process), systematic error (e.g., poorly designed experiments), or measurement error.

Vegetative filter strips

A riparian buffer designed to capture nutrients, contaminant compounds, and sediment transported by run-off. Filter strips are sometimes synonymous with riparian buffers.

Water quality

Physical, chemical, and biological characteristics of water that describe its suitability to meet human needs or habitat requirements for fish and wildlife.

Watershed processes

The fluxes of energy (e.g., chemical, sunlight, wildfire) and materials (particularly water and sediment) that interact with biota (e.g., vegetation, salmon, Beavers, soil microbes) to form a watershed's physical features and characteristics, which give rise to its instream physical and ecological conditions. These processes occur within a context that reflects the watershed's climate, geology, topography, and existing human land use. Also see *Ecosystem process*.

Watershed

An area of land that drains to a common waterbody.

Wood recruitment

The process of wood moving from a riparian area to the stream channel. Sources of recruitment include bank erosion, windthrow, landslides, debris flows, snow avalanches, ice storms, Beaver, and tree mortality due to fire, insects, or disease.



Northwestern salamander/WDFW

Appendix 2: Categorization of Information Sources

Legal Requirement: RCW 34.05.271

The Revised Code of Washington (RCW) 34.05.271 requires the Washington Department of Fish and Wildlife (WDFW) to categorize sources of information used to inform technical documents that directly support implementation of a state rule or statute. Because WDFW Priority Habitat and Species documents—such as this one—are referenced in regulations for the Growth Management Act [e.g., WAC 365-190-130(4)] and Shoreline Management Act [e.g., WAC 173-26-221(5)(b)], we classify all references in the literature cited sections of Volume 1 into the following RCW 34.05.271 categories:

(i) Independent peer review: Review is overseen by an independent third party;
(ii) Internal peer review: Review by staff internal to the department of fish and wildlife;
(iii) External peer review: Review by persons that are external to and selected by the department of fish and wildlife;
(iv) Open review: Documented open public review process that is not limited to invited organizations or individuals;
(v) Legal and policy document: Documents related to the legal framework for the significant agency action including but not limited to:
(A) Federal and state statutes;
(B) Court and hearings board decisions;
(C) Federal and state administrative rules and regulations; and
(D) Policy and regulatory documents adopted by local governments;
(vi) Data from primary research, monitoring activities, or other sources, but that has not been incorporated as part of documents reviewed under the processes described in (i), (ii), (iii), and (iv) of this subsection;
(vii) Records of the best professional judgment of department of fish and wildlife employees or other individuals; or
(viii) Other: Sources of information that do not fit into categories i - vii.

Meeting the Intent of RCW 34.05.271

Assigning references to categories requires judgement where methods of peer-review are not clearly defined. We assigned all scientific journal articles, science related books by independent science book publishers, universities, the National Research Council (NRC), and the National Academy of Engineering; symposia volumes sponsored by professional organizations (e.g., American Fisheries Society); and graduate theses and dissertations to category i –*independent peer review.* Government agency documents including those published by the Fish and Wildlife Service (USFWS), Environmental Protection Agency (EPA), Geologic Survey (USGS), Forest Service (USFS), and the Canadian Wildlife Service were assigned to category *viii*. Others references were assigned as described above.



Headwater wetland that flows north to Stavis Creek and south to Tahuya River/Keith Folkerts, WDFW













Washington Department of FISH and WILDLIFE

Riparian Ecosystems, Volume 2: Management Recommendations



A Priority Habitats and Species Document of the Washington Department of Fish and Wildlife

Washington Department of FISH and WILDLIFE

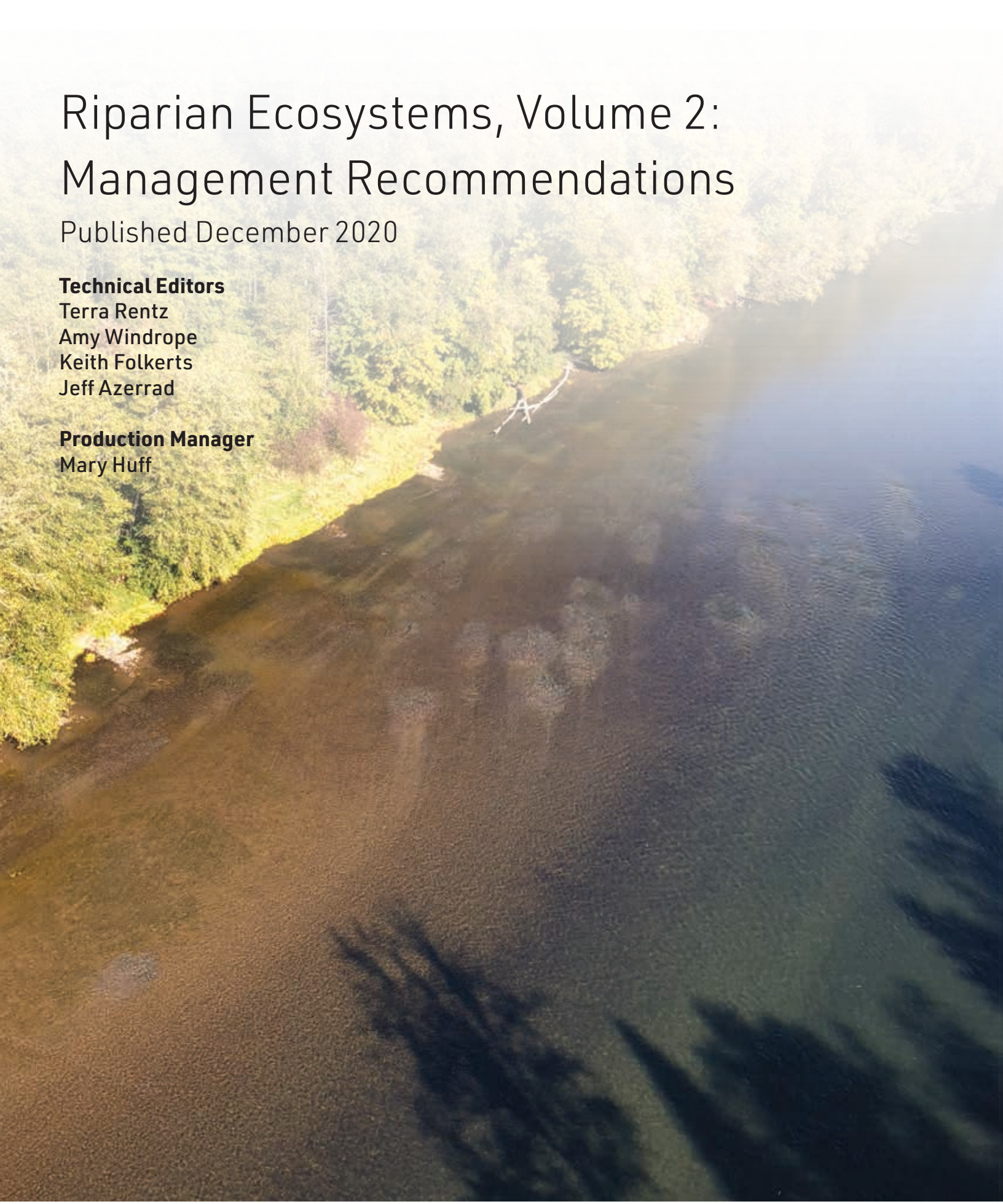
December 2020

Riparian Ecosystems, Volume 2: Management Recommendations

Published December 2020

Technical Editors
Terra Rentz
Amy Windrope
Keith Folkerts
Jeff Azerrad

Production Manager
Mary Huff



Salmon redds along the Cowlitz River, Lewis County/George Fornes, WDFW

Acknowledgements

Land Acknowledgement: We acknowledge the traditional, ancestral, territory of Washington state on which we are learning, working, and organizing today. We recognize the longstanding history that has brought us to reside on this land and seek to understand those who first lived here.

Many people were involved with creation of both Volumes 1 and 2 for Priority Habitats and Species (PHS) Riparian Ecosystems. WDFW extends our sincere appreciation to the following individuals and organizations that played important roles during development and/or review of both volumes.

The Washington Department of Ecology (Ecology) and U.S. Environmental Protection Agency (EPA) provided funds that made this document possible (Contract C1300107).

The Washington State Academy of Sciences, with coordination by Dr. Robert Bates, provided an independent peer review that improved the scientific rigor of Volume 1.

Federal (EPA and NOAA Fisheries) and tribal entities (individual tribes, the Northwest Indian Fisheries Commission, Columbia River Inter-Tribal Fish Commission, and Upper Columbia United Tribes) as well as numerous state agencies (Washington State departments of Ecology, Natural Resources, and Commerce; Recreation and Conservation Office; Washington State Conservation Commission; and Puget Sound Partnership) reviewed draft versions of this document. During the summer 2018 public comment period, local governments and members of the public provided valuable feedback that led to a more concise and user-friendly final version of Volume 2.

Within WDFW, Keith Folkerts led coordination, contract planning and budgeting for this work. Tim Quinn and George Wilhere were integral in ensuring a strong relationship with information in Volume 1 and provided additional valuable feedback on multiple drafts. Terry Johnson developed the Site-Potential Tree Height mapping tool and wrote the associated user guide information in the Appendix to this Volume 2. Alison Hart produced final graphics and ensured consistent formatting and stylistic usage throughout. Mary Huff provided editorial support, improved the document's organization, and (in late 2020) took it across the finish line.

WDFW recognizes and appreciates the significant role that tribes, local governments, conservation organizations, and others play in accomplishing our agency's mission. Indeed, we are certain that without these concerted efforts to designate and protect the riparian ecosystems that are essential for most of the state's fish and wildlife species, WDFW would be unable to fulfill its mandate on behalf of all of Washington's residents.

While we acknowledge and have deep appreciation for all the review and comments provided, WDFW bears sole responsibility for this document and any errors contained herein.

Publication should be cited as follows:

Rentz, R., A. Windrope, K. Folkerts, and J. Azerrad. 2020. Riparian Ecosystems, Volume 2: Management Recommendations. Habitat Program, Washington Department of Fish and Wildlife, Olympia.

Accessibility:

This document is available in alternative formats upon request. Please contact WDFW's ADA Program Manager at 360-902-2349, TTY (711), or ADAProgram@dfw.wa.gov.

Table of Contents

Acronyms for Volume 2 3

CHAPTER 1. OVERVIEW 4
1.1. Our Role as Washington's Conservation Agency 4
1.2. Purpose and Applicability of Volume 2 7
1.3. Science Synthesis and Management Implications (Volume 1) Summary 7
1.4. Key Findings and Recommendations 9
1.5. Relationship with Washington's Development Laws and Regulations 13
1.6. Organization of Volume 2 15

CHAPTER 2. RIPARIAN MANAGEMENT ZONE DELINEATION 16
2.1. Introduction 16
2.2. Foundational Concepts in RMZ Determinations 16
2.3. Procedures for RMZ Delineation 20

CHAPTER 3. RIPARIAN REGULATORY PROTECTIONS 28
3.1. Introduction 28
3.2. Recommendations to Local Jurisdictions 28
3.3. Riparian Management in Urban Areas 35
3.4. Managing Watersheds 37

CHAPTER 4. RESTORING RIPARIAN ECOSYSTEMS 40
4.1. Introduction 40
4.2. Restoration Actions 41
4.3. Implementing Riparian Strategies Through Incentives 42
4.4. Suggested Restoration Practices 44

CHAPTER 5. IMPROVING PROTECTION THROUGH ADAPTIVE MANAGEMENT 46
5.1. Introduction 46
5.2. Common Questions Addressed by Adaptive Management 47
5.3. Recommended Implementation Monitoring Efforts 49
5.4. Effectiveness of Regulatory Protections of Critical Areas 51
5.5. Using Land Cover Change to Understand Long-term Regulatory Protection 51
5.6. Conclusion 55

LITERATURE CITED 56

GLOSSARY OF TERMS 62

APPENDIX. SITE-POTENTIAL TREE HEIGHT MAPPING TOOL 70

Acronyms for Volume 2

CAO	Critical Areas Ordinance
CMZ	Channel Migration Zone
CREP	Conservation Reserve Enhancement Program
DFC	Desired Future Condition
DNR	Department of Natural Resources (Washington State)
EBM	Ecosystem Based Management
EPA	Environmental Protection Agency (U.S.)
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FEMAT	Forest Ecosystem Management Assessment Team
FPA	Forest Practices Act
FWHCA	Fish and Wildlife Habitat Conservation Area
GIS	Geographic Information System
GMA	Growth Management Act
HMP	Habitat Management Plan
HRCD	High Resolution Change Detection
LID	Low Impact Development
NHD	National Hydrography Dataset
NOAA	National Oceanographic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
OHWM	Ordinary High-Water Mark
OSS	On-site Sewage Systems
PHS	Priority Habitats and Species
RCO	Recreation and Conservation Office (Washington State)
RCW	Revised Code of Washington
RMZ	Riparian Management Zone
RZ	Riparian Zone
SMA	Shoreline Management Act
SMP	Shoreline Master Program
SPTH	Site-Potential Tree Height
$SPTH_{200}$	Site-Potential Tree Height (at age 200 years)
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service



Watershed lesson/Brittany Gordon, WDFW

UWCIG	University of Washington Climate Impacts Group
VSP	Voluntary Stewardship Program
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WFPB	Washington Forest Practices Board
WRIA	Water Resource Inventory Area
WSCC	Washington State Conservation Commission
WWRP	Washington Wildlife and Recreation Program

Chapter 1. Overview

1.1. Our Role as Washington's Conservation Agency

The mission of the Washington Department of Fish and Wildlife (WDFW) is to preserve, protect, and perpetuate the state's fish, wildlife, and ecosystems while providing sustainable fish and wildlife recreational and commercial opportunities. We offer the following science-based guidance to further that mission through the preservation, protection, and–where possible–restoration of healthy, intact, and fully functioning riparian ecosystems statewide. As described throughout this volume, we believe that protection *and* restoration[1] of Washington's riparian ecosystems is a foundational conservation action; considering a growing population and changing climate, it is also an urgent one.

Within the State of Washington's land use decision-making framework, WDFW's role is that of advisor. We provide information relative to our mission about the habitat needs of fish and wildlife, and the likely implications of various land use decisions on those resources over time. Through the Priority Habitats and Species (PHS) Program, we work cooperatively with land use decision makers and landowners to facilitate solutions that accommodate their needs and the needs of fish and wildlife. We provide this PHS document, *Riparian Ecosystems Volume 2: Management Recommendations* in support of that effort.

Priority Habitats are places that warrant special consideration for protection when land use decisions are made and should also be prioritized for restoration or enhancement wherever possible. To qualify as a "Priority Habitat" in WDFW's PHS program, an ecosystem or habitat component must provide unique or significant value to many species. Specifically, it must have one or more of the following attributes (WDFW 2008):

- Comparatively high fish and wildlife density
- Comparatively high fish and wildlife species diversity
- Important fish or wildlife breeding habitat
- Important fish or wildlife seasonal ranges
- Important fish or wildlife movement corridors
- Limited availability
- High vulnerability to habitat alteration
- Unique or dependent species

Riparian areas (comprised of riparian ecosystems, active floodplains, and riverine wetlands) meet all these criteria, and were among the first Priority Habitats described by WDFW. Riparian areas provide important ecological functions that help create and maintain aquatic habitats in addition to supporting terrestrial wildlife. Riparian areas alongside

[1] Restoration of riparian ecosystems is critically important because legacy of environmental impacts resulting from the ways land use has affected riparian areas over the past 200 years. In other words, what remains available for protection is not enough to provide the full functions and values Washington's fish and wildlife need.



Hundreds of fish and widlife species, like this female Wood Duck, depend on or use the state's riparian areas. This includes over 150 species of birds, mammals, amphibians, reptiles, and invertebrates designated as Species of Greatest Conservation Need in the 2015 State Wildlife Action Plan./Jeanne Hannah

rivers and streams are the focus of this document, however much of the science reviewed in Volume 1 and the recommendations in this Volume 2 are relevant for lakes, ponds, and marine shorelines as well.

As previously mentioned, one role of WDFW in land use decision making is that of advisor. In that role, recommendations like those contained in this document and in complementary PHS documents (available at https://wdfw.wa.gov/species-habitats/at-risk/phs/recommendations) provide critical information for the protection (and where necessary, recovery) of Washington's fish and wildlife. We recognize landowners and land managers most often face situations where various human needs must also be met; and thus, considerations other than fish and wildlife will be incorporated into land use decision making.

The information presented in this management recommendation document is not, in and of itself, science. Rather, it consists of policy recommendations which are informed by the best available science

WDFW's Mission

To preserve, protect, and perpetuate Washington's fish, wildlife, and ecosystems while providing sustainable fish and wildlife recreational and commercial opportunities.

WDFW'S Riparian Values

We value the protection and restoration of healthy, intact, and fully functioning riparian ecosystems statewide.

WDFW'S Recommendation

Within the context of wise watershed management, preserve, protect, and–where possible–restore the full extent of riparian ecosystems.

Ecosystem Based Management & WDFW's Conservation Principles

In 2013, WDFW adopted ecosystem-based management principles into policy (WDFW Policy 5004). Ecosystem-based management is an integrated, science-based approach to natural resource management that aims to sustain the ability of ecosystems to provide goods and services upon which humans and other species depend. Importantly, ecosystem-based management recognizes the magnitude of humans as change agents in the ecosystem, and the role of social, economic, and ecological factors in managing complex and dynamic systems.

We believe that conservation is best achieved through employing the following ecosystem-based management principles:

1. **We practice conservation by managing, protecting, and restoring ecosystems for the long-term benefit of people, and for fish wildlife and their habitats.**

2. **We work across disciplines to solve problems because of their connections among organisms, species and habitats.**

3. **We integrate ecological, social, economic, and institutional perspectives into our decision-making.**

4. **We embrace new knowledge and apply best science to address changing conditions through adaptive management.**

5. **We collaborate with our co-managers and conservation and community partners to help us achieve our shared goals.**

summarized in Volume 1[2] and which reflect WDFW's mission and legislative mandate. To that end, these recommendations represent WDFW's guidance for the protection and restoration of healthy, intact, and fully functioning riparian ecosystems and for how land managers and land use regulators can utilize best available science to protect these ecosystems within the scope of their authority and/or ability.

For example, local governments are encouraged to use information provided through PHS to guide critical area ordinance (CAO) updates and other land use policies, plans, or regulations. More specifically, WDFW advises using the information in this PHS Riparian Volume 2 for designating riparian areas as Fish and Wildlife Habitat Conservation Areas (FWHCAs) and protecting them for their inherent value, rather than just as buffers for rivers and streams. This is because riparian areas are so important for helping sustain endangered, threatened, and sensitive species; providing habitat connectivity for both aquatic and terrestrial wildlife; and for their critical role in protecting salmonid habitat (WAC 365-190-130).

In short, Volumes 1 and 2 focus on the science and management, respectively, of riparian ecosystems to support fish and aquatic wildlife species. Volume 1 characterizes riparian ecosystem functions and essential processes, while Volume 2 provides management guidance for riparian ecosystems in the context of watershed processes. To be clear, these two volumes do not provide a summary of science or recommendations regarding the contribution of riparian ecosystems for the protection of terrestrial wildlife species. However, our first generation PHS Riparian-specific document, *Management Recommendations for Washington's Priority Habitats: Riparian* (Knutson and Naef 1997) does provide terrestrial species information related to riparian areas. Further, PHS has separate, species-specific management recommendations that address the needs of many terrestrial Priority Species.

This document provides recommendations applicable across the State of Washington but does not address unusual, site-scale environmental conditions or issues specific to particular ecological communities. We strongly encourage addressing such matters at a local level with the assistance of WDFW regional habitat biologists, and other technical experts and stakeholders such as tribal biologists and conservation organizations.

2 The original manuscript of *Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications* was publicly released in May 2018. In 2020, the format of the document was professionally designed, which included making limited updates to content focused on copyediting and improving usability. In accordance with standard citation practice, Volume 1 is now cited as having a 2020 publication date, but substantively, the current document is equivalent to the original 2018 version.

1.2. Purpose and Applicability of Volume 2

The purpose of this document is to provide guidance to protect and–where possible–restore healthy, intact, and fully functioning riparian ecosystems, which are fundamental for clean water, healthy salmon populations, and climate resilient watersheds.

Volume 2 provides information to:

- Protect existing and restore degraded riparian ecosystem functions in support of aquatic and terrestrial species recovery;
- Assist local governments with their responsibilities to protect priority fish and wildlife and their habitats;
- Assist landowners and local groups in implementing voluntary restoration actions on and off working lands; and
- Incorporate monitoring and adaptive management to understand how well regulatory and non-regulatory efforts are protecting riparian functions and values.

This guidance is applicable to riparian ecosystems statewide. We offer a specific focus on lands within the purview of the Growth Management Act (GMA) and Shoreline Management Act (SMA), although a broader application by local governments and other users is also appropriate.

While many other federal, state, and tribal government programs and policies pertain to riparian ecosystems, they are not specifically addressed in this document. For instance, we do not discuss holistic protection of floodplains, nor do we discuss specific Endangered Species Act (ESA) requirements relative to listed salmonids and other species. Also, we do not address commercial forestlands that fall under the jurisdiction of the Forest Practices Act (FPA), or the Department of Ecology's clean water regulations. These other programs and policies were developed with specific goals and objectives that may be different from the goals of this document, and as such may differ with guidance provided herein.

1.3. Science Synthesis and Management Implications (Volume 1) Summary

As stated above, Volume 1 (Quinn et al. 2020; see footnote 2) provides important information integral to the development of these management recommendations. It includes both overarching as well as specific considerations important to all efforts, large and small, to protect rivers and streams for the benefit of the aquatic species associated with them. Volume 1 focuses on the science of riparian ecosystems–specifically, how riparian areas interact with large-scale drivers (e.g., topography, geology, climate, and land use) and watershed processes to create and maintain riparian and aquatic habitat in support of fish and wildlife. Thus, we provide here an explicit definition of riparian ecosystems from Volume 1 that combines a variety of conceptual riparian descriptions from the scientific literature:

> Riparian ecosystems are transitional between terrestrial and aquatic ecosystems, distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface




Many adult flying insects, such as the blue damselfly (above, left) spend their larval stage as freshwater macroinvertebrates. During this early period, some of those species, like the stonefly nymph (above, right) help fallen leaf litter to decompose by shredding it while feeding. At both life stages, these animals provide important food for fish and other aquatic and terrestrial widlife./Jim Cummins and Taylor Cotten, WDFW

hydrology connect waterbodies with adjacent uplands. They include those portions of terrestrial ecosystems (i.e., *a zone of influence*) that significantly influence exchanges of energy and matter with aquatic ecosystems and the portion of the ecosystem characterized by moist soils and plants adapted to periodically saturated soils – the *riparian zone* (RZ). The width of the riparian ecosystem is typically defined by the outer edge of the zone of influence, which, in forested regions, is based on site-potential tree height (SPTH) measured from the edge of the active channel. While our definition of riparian ecosystem does not include the water in river or streams, it does include riverine wetlands and recognizes the riparian zone as a distinctive area within riparian ecosystems.

To assist managers in understanding important implications of the science synthesized in Volume 1, we reiterate the ten overarching findings of that document below. These findings are also discussed in more detail in later chapters.

1. Protection and restoration of riparian ecosystems continues to be critically important because: (a) they are disproportionately important, relative to area, for aquatic species (e.g., salmon) and terrestrial wildlife; (b) they provide ecosystem services such as water purification and fisheries (Naiman and Bilby 2001, NRC 2002, Richardson et al. 2005); and (c) by interacting with watershed-scale processes, they contribute to the creation and maintenance of aquatic habitats.

2. Stream riparian ecosystems encompass the riparian zone; the active floodplain, including riverine wetlands and the terraces; and adjacent uplands that contribute matter and energy to the active channel or active floodplain (Gregory et al. 1991, Naiman and Bilby 1998). Such terraces and adjacent uplands are called the zone of influence.

3. The width of the riparian ecosystem is estimated by one 200-year SPTH measured from the edge of the active channel or active floodplain. Protecting functions within at least one 200-year SPTH is a scientifically supported approach if the goal is to protect and maintain full function of the riparian ecosystem.

4. Where the riparian zone is narrow (<100 ft [30 m]) and the zone of influence lacks tall trees (<100 ft), (e.g., in parts of the Columbia Plateau Ecoregion), the pollution removal function may determine the width of the zone of influence.

5. The riparian ecosystem begins at the edge of the active channel or active floodplain, whichever is wider. As the active channel moves back and forth across the channel migration zone (CMZ), the riparian ecosystem moves with it. Consequently, there are times when the riparian ecosystem lies adjacent to or overlaps the CMZ (see Figure 2.3). Hence, to maintain riparian ecosystem functions, management must anticipate and protect future locations of the riparian ecosystem.

6. A near consensus of scientific opinion holds that the most effective and reliable means of maintaining viable self-sustaining fish, especially salmon, and wildlife populations is to maintain/restore ecosystems to conditions that resemble or emulate their historical range of natural variability (Swanson et al. 1994, Reeves et al. 1995, Bisson et al. 2009). This opinion is based in part on the complexity of processes that affect the expression of habitats over time and space.

7. The protection and restoration of watershed-scale processes, especially related to hydrology, water quality, connectivity, and inputs of wood, shade, and sediment are important for aquatic system function, and help maximize the ecological benefits of riparian ecosystem protections.

8. Riparian areas and surrounding watersheds are complex and dynamic systems comprised of many interacting components. Natural disturbances (flood, fire, and landslides) across the watershed and through time create the mosaic of conditions necessary for self-sustaining populations of fish, especially salmon, and other aquatic organisms.

9. Impending changes to aquatic systems as a result of climate change increase risk to species already threatened by human activities. The effects of climate change on rivers and streams threaten to reduce fish distribution and viability throughout the Pacific Northwest (Beechie et al. 2013).

10. The use of the precautionary principle and adaptive management are particularly appropriate when dealing with complex and dynamic systems, and when we have uncertainty related to exactly how management activities affect functioning of watersheds and riparian ecosystems.

1.4. Key Findings and Recommendations

WDFW recognizes that there is a significant amount of work currently being done throughout the state to protect and restore riparian areas. This focus is longstanding and has ranged from regulatory protections that guide Washington's growing population to voluntary conservation on our working lands. Below, we highlight what we believe—based on best available science and our agency's mission—are the most important recommendations to ensure healthy, intact, and fully functioning riparian ecosystems that provide for the preservation, protection and perpetuation of Washington's fish and wildlife:



A tributary stream (lower left of photo) contributes sediment to a side channel of the Stillaguamish River as precipitation levels rise in autumn. Snohomish County/Mary Huff, WDFW

1. **Designate riparian ecosystems as critical areas:** WDFW recognizes riparian ecosystems as a Priority Habitat for fish and wildlife and recommends that local jurisdictions designate those ecosystems as Fish and Wildlife Habitat Conservation Areas (FWHCAs), a type of critical area. We define the bounds of the riparian ecosystem as the riparian management zone (RMZ), and this RMZ should be designated as the location where protection and restoration of riparian ecosystem functions and values are addressed. RMZs provide a framework for delineating, evaluating, planning, and managing functions and values. In this volume, we provide a process for RMZ delineation (Chapter 2).

2. **Include watershed–scale management considerations:** Watershed-scale management is critical to realizing the full benefits of riparian ecosystem protection and restoration. Certain types of anthropogenic changes at the watershed scale can dramatically reduce the effectiveness of riparian ecosystems to protect aquatic habitat. For example, unmitigated delivery of stormwater from impervious surfaces like roads, parking lots, and rooftops to streams, for example, dramatically increases peak stream flows, alters channel form, and short-circuits the capacity of riparian areas to remove pollutants from runoff. Similarly, road-crossing culverts that are impassible to fish can reduce stream-network connectivity and dramatically reduce amounts of otherwise suitable habitat.

3. **Use reference points to locate the inner edge of the RMZ:**

    - For streams without Channel Migration Zones (CMZs), the inner edge of the RMZ should be delineated starting at theouter edge of active floodplain, if this has or can be determined; otherwise, from the active channel, as delineated by the Ordinary High-Water Mark (OHWM)[3].

    - For streams with CMZs, the unpredictable nature of channel migration should be accommodated through delineation of an RMZ that encompasses both the entire CMZ and future locations of the riparian ecosystem. In these instances, the inner edge of the RMZ should be located at the outer edge of the CMZ.

Whether or not a stream has a CMZ, the distance from the inner edge of the RMZ to the outer edge of the RMZ should be one $SPTH_{200}$.

4. **Include CMZs in delineation of the RMZ:** CMZs are important to protect for maintaining riparian functions and values, and so are included in the delineation of RMZs. Over time, a riparian ecosystem will occupy different parts of the CMZ and uplands outside the CMZ. Lateral channel migration and related streambank erosion processes can pose risks to homes and communities located near rivers; however, when channels are constrained from moving, aquatic and riparian ecosystems may degrade over time. To maintain riparian ecosystem functions, land managers must anticipate and protect future locations of the riparian ecosystem and thus delineate the RMZ accordingly.

5. **Establish RMZ widths based on site-specific conditions:** From the perspective of those riparian ecosystem functions affecting aquatic systems, the width of the riparian ecosystem varies with ecological conditions. The most efficient way to protect riparian functions is to adopt protections that recognize these differences, rather than uniform-width (i.e., one-size-fits-all) RMZs, as these may result in over-protection in some places and under-protection in others.

3 Active floodplain delineations are rarely available, and we currently lack a repeatable, well-vetted, and widely accepted method for the delineation of active floodplains. Therefore, until such a process is developed, we recommend delineating the RMZ's inner edge using the OHWM for streams without CMZs.



Dryland ecoregion riparian area, Whitman County/Michael Townsend



Forested ecoregion riparian area, Chelan County/George Wilhere, WDFW

a. **In forested ecoregions, start with SPTH$_{200}$**: At most riparian areas in forested ecoregions, SPTH$_{200}$ is 100 feet or greater, and so the RMZ is delineated using one SPTH$_{200}$. If SPTH$_{200}$ is less than 100 feet, the RMZ is delineated by the pollution removal function (see below).In highly altered areas where soil data are not available, it may be necessary to estimate SPTH$_{200}$ values based on nearby soils.

b. **In dryland ecoregions, start with SPTH$_{200}$** (if available), or the width of the riparian vegetation community: If site conditions do not support tree species or SPTH$_{200}$ is less than 100 feet, then RMZ width is determined by the full extent of all riparian vegetation (the riparian zone) or by the pollution removal function–see below.

c. **For both forested and dryland ecoregions, use the pollution removal function when appropriate:** Where the SPTH$_{200}$ and/or the width of the riparian vegetative community is less than 100 feet, we recommend that RMZ width be delineated at a minimum of 100 feet, as this provides the width necessary for 95% pollution removal target for most pollutants (approximately 85% for surface nitrogen.)[4]

To aid with site-specific RMZ delineation, WDFW created an internet-based mapping tool that reports recommended widths for RMZs (Appendix 1) statewide based on SPTH$_{200}$. The tool also notes instances where a 100-foot RMZ should be applied to support the pollution removal function.

6. **Apply the recommended RMZ delineation steps to all streams, whether or not they are fish-bearing:** In 1997, WDFW recommended a lower level of protection for non-fish bearing streams than fish-bearing streams. In reviewing the current science literature for Volume 1, we found no evidence that full riparian ecosystem functions

[4] See Chapter 2, Section 2.3.5 for more information about surface nitrogen removal and other site-specific characteristics that may require RMZ distances greater than 100 feet in order to ensure an adequate pollution removal function.



Deer tracks and fallen leaves near Scatter Creek, Thurston County/Janet Anthony, WDFW

along non-fish-bearing streams are less important to aquatic ecosystems than full riparian ecosystem functions along fish-bearing streams. This recommendation is based on four additional considerations. Non-fish-bearing streams:

- Support a unique community of aquatic and riparian-obligate wildlife;
- Provide movement corridors for wildlife, particularly in the face of changing climate conditions;
- Provision fish-bearing streams with matter and energy; and
- Provide cool water to downstream reaches. Washington State has already experienced increased stream
- temperatures due to climate change and expect further increases, which have direct implications for the persistence of fish.

7. **Establish monitoring and adaptive management frameworks:** We believe it is critical to understand if riparian ecosystems protections are working as intended, and if not, to adjust them accordingly. We recommend the establishment of monitoring and adaptive management designed to improve (where necessary) local permit implementation and compliance, and to increase effectiveness of actions intended to protect aquatic species.

8. **Consider needs of relevant terrestrial species:** As stated earlier, a review of new literature related to the needs of terrestrial Priority Species was not a focus of Volume 1. Nonetheless, riparian areas provide important functions for threatened, endangered, and sensitive terrestrial wildlife that require consideration by landowners and land managers. WDFW regional habitat biologists, tribal biologists and/or other local habitat experts can assist in identification of site-specific terrestrial species needs. Because riparian protections benefit both aquatic and many terrestrial wildlife species, concentrating protections around riparian areas may also be an efficient use of resources.

1.5. Relationship with Washington's Development Laws and Regulations

1.5.1. Relationship with the Growth Management Act (GMA)

The GMA requires local jurisdictions to designate and protect critical areas, and in so doing, use best available science and give special consideration to anadromous species[5]. The GMA also encourages state agencies to provide technical assistance to counties and cities in the review of their critical areas ordinances (CAOs), comprehensive plans, and development regulations [RCW 36.70A.130(6)(g)]. While the Washington State Department of Commerce (Commerce) administers the GMA, WDFW is the lead state agency for advising local governments on matters related to one type of critical area: Fish and Wildlife Habitat Conservation Areas (FWHCAs), and we produce PHS Management Recommendations like this Volume 2 in support of that role.

This document provides guidance that is consistent with the GMA, under which local governments exercise their land use responsibilities: specifically, protection of the functions and values of critical areas. It also reflects the legal and policy framework within which WDFW and the PHS program operate, which includes among other things providing a source of best available science necessary to support local governments in distinguishing and delineating those critical areas (e.g., FWHCAs).

WAC 365-190-130
FISH AND WILDLIFE HABITAT CONSERVATION AREAS

(1) "Fish and wildlife habitat conservation" means land managed for maintaining populations of species in suitable habitats within their natural geographic distribution, so that the habitat is sufficient to support viable populations over the long term and isolated subpopulations are not created. This does not mean maintaining all individuals of all species at all times, but it does mean not degrading or reducing populations or habitats so that they are no longer viable over the long term. Counties and cities should engage in cooperative planning and coordination to help assure population viability.

Fish and wildlife habitat conservation areas contribute to the state's biodiversity and occur on both publicly- and privately-owned lands. Designating these areas is an important part of land use planning for appropriate development densities, urban growth area boundaries, open space corridors, and incentive-based land conservation and stewardship programs."

WDFW understands that local jurisdictions have existing critical area regulations that have been approved by elected officials and in many cases have been found to be compliant with GMA through the Growth Management Hearings Board and courts. We acknowledge that revising a critical area regulation can be a lengthy, expensive, and contentious process, and so jurisdictions frequently do not make updates to their CAOs more frequently than required by law or rule. In this volume, we aim to be more precise about where recent science has improved our certainty around the need for riparian protections, as well as for specific practices; and how to incorporate best available science and WDFW's management recommendations.

WDFW also recommends local jurisdictions continue considering PHS best available science (e.g., Volume 1; PHS maps), incorporating PHS Management Recommendations, and seeking technical assistance from WDFW's regional habitat biologists not just when updating and implementing critical area policies and regulations, but in all land use planning efforts.

5 RCW 36.70A.172(1): "In designating and protecting critical areas under this chapter, counties and cities shall include the best available science in developing policies and development regulations to protect the functions and values of critical areas. In addition, counties and cities shall give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries."

1.5.2. Relationship with the Shoreline Management Act (SMA)

As with GMA, WDFW plays a role of technical advisor under SMA, working directly through locally led development processes, with the goal of addressing needs for fish and wildlife. Under SMA, the Department of Ecology (Ecology) has a role approving Shoreline Master Program (SMP) updates when they are deemed consistent with all statutory and regulatory requirements. Ecology also has a direct role in implementation of SMPs, including issuing the final decision to approve, deny, or put conditions on locally issued conditional use permits and variances. [Under GMA, Commerce does not approve comprehensive plan updates or CAOs.]

The goal of SMA is "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines" (RCW 90.58.020). To achieve that end, WDFW recommends local jurisdictions designate riparian areas and provide the same levels of protection for them within the SMA jurisdiction areas as they do under GMA. While the SMA does not apply to streams with 20 cubic feet per second (cfs) or less mean annual flow, we recommend the application of the guidelines in this Volume 2 to all rivers and streams, regardless of size.

WAC 173-26-186 GOVERNING PRINCIPLES OF THE [SMP] GUIDELINES

(8) "Through numerous references to and emphasis on the maintenance, protection, restoration, and preservation of "fragile" shoreline "natural resources," "public health," "the land and its vegetation and wildlife," "the waters and their aquatic life," "ecology," and "environment," the act makes protection of the shoreline environment an essential statewide policy goal consistent with other policy goals of the act. It is recognized that shoreline ecological functions may be imparted not only by shoreline development subject to the substantial development permit requirements of the act but also by past actions, unregulated activities, and development that is exempt from the act's permit requirements. The principle regarding protecting shoreline ecological systems is accomplished by these guidelines in several ways, and in the context of related principles."



The Shoreline Management Act includes a goal to balance multiple uses, including protecting natural resources and providing public access to waters of the state./ Andy Walgamott






Riparian areas provide habitat for many types of birds at one or more life stages, especially during breeding season and for food year round. Photo credits: Sandpiper chicks in nest/Laura Rogers; Northern Harrier foraging low over marshy vegetation/Brad Collins; male Belted Kingfisher watching for fish from fallen tree limb/Anna Owen; Purple Martin pair resting on piling above their nest-box/Kim Eggleston

1.6. Organization of Volume 2

Chapter 1 aims to establish Volume 2's purpose and intent; articulate WDFW's values; and provide policy context regarding protection and designation of riparian ecosystems.

In Chapter 2, we define the RMZ based on $SPTH_{200}$ with special considerations for urban and dryland landscapes; and provide a stepwise process for identifying and delineating the RMZ both for requiring riparian protections and for classifying RMZs as a FWHCA under GMA.

Chapter 3 articulates policies, plans, and practices that protect riparian ecosystems. WDFW recognizes that counties and cities have a long history of providing such protections, and the responsibility to include best available science when updating CAOs. The protection recommendations described in this chapter are intended to help counties and cities moving forward with reviewing and updating their CAOs and other relevant policies and plans.

Chapter 4 explains the importance of restoration in riparian management, which is necessary for recovery of the degraded riparian functions present in many locations and is critical to recover salmon stocks and preserve Washington's riparian-dependent Priority Species. To that end, we outline voluntary approaches to improve riparian functions. Although Volume 2 is not a restoration guide, it is applicable to restoration practitioners in that it describes management actions that enhance riparian functions and values. We do not address restoration project design or standards but provide links within this chapter to resources that do.

Chapter 5 will assist with developing monitoring programs in support of adaptive management, designed to ensure transparent programs that consistently deliver sufficient protection of riparian functions. Careful monitoring and adaptive management are particularly important when a land use may harm a critical area and scientific information about the likely severity of harm is lacking. Although specific to local governments, this chapter provides valuable resources for any land manager interested in engaging in adaptive management.

Finally, this volume includes an appendix that contains a "how-to" process for utilizing WDFW's SPTH mapping tool to help determine recommended minimum RMZ widths around the state. The tool itself is available at wdfw.maps.arcgis.com/apps/MapSeries/index.html?appid=919ea98204eb4f5fa70eca99cd5b0de1.

Chapter 2. Riparian Management Zone Delineation

2.1. Introduction

We define the extent of the riparian ecosystem as the area that provides full ecological function for bank stability, shade, pollution removal, contributions of detrital nutrients, and recruitment of large woody debris. For the purposes of management or regulatory protection, the riparian management zone (RMZ) encompasses the riparian ecosystem, and–when present–the channel migration zone (CMZ) to account for lateral movement of the riparian ecosystem over time. RMZs can also provide habitat for many terrestrial wildlife species including movement corridors. WDFW categorizes the riparian ecosystem as a Priority Habitat, and thus recommends local jurisdictions designate all riparian areas as critical areas: specifically, Fish and Wildlife Habitat Conservation Areas (FWHCAs), as mentioned in Chapter 1.

The RMZ provide an initial framework for delineating, assessing, planning, and managing riparian ecosystems. The RMZ as defined here is not necessarily the same as setbacks or buffers. Setbacks are areas meant to protect an important feature (e.g., a stream or wetland) from certain types of adjacent activities, e.g., the area separating a building from the bank of a river. Setbacks are not typically designed to provide ecological function. On the other hand, buffers, which also protect important features, are commonly undeveloped, naturally vegetated areas that can contribute habitat and in the case of a stream, to riparian functions. In this document, we reserve the use of the term RMZ to mean the area capable of providing full function and managed to that end.

2.2. Foundational Concepts in RMZ Determinations

2.2.1. Desired Future Condition

A major goal in fulfilling WDFW's mission to preserve, protect, and perpetuate Washington's fish, wildlife, and ecosystems is the protection and restoration of healthy, intact, and fully functioning riparian areas. More specifically, the goal will be achieved through management strategies that result in ecosystem composition and structure that provides the five key ecological functions associated with riparian ecosystems. A useful benchmark for this goal is desired future condition (DFC) for riparian areas. DFC describes what land managers are attempting to achieve, often in terms of composition and structure (e.g., vegetation or land-use), over a period of time in a given geographic area. The DFC we recommend results in fully functioning riparian ecosystems as measured by the five key ecological functions (bank stability, shade, pollution removal, contributions of detrital nutrients, and recruitment of large woody debris) in western

Washington. The DFC for composition and structure is old, structurally complex conifer-dominant forest. Such forests exhibit large diameter trees, contain numerous large snags and logs, and have multi-layered canopies and canopy gaps, which promote understory plant diversity.

Throughout the Columbia Plateau, differences in hydrology and geomorphology manifest substantial site-level differences in composition and structure of riparian vegetation, and hence, the DFC for composition and structure is more site-dependent in the Columbia Plateau than in western Washington. Nonetheless, the DFC in the Columbia Plateau is based on the same concepts of ecosystem composition and structure that support the same five key ecological functions in forested regions; specifically, biologically diverse vegetation communities consisting of native trees, shrubs, grasses and forbs. In addition, the DFC for the upland portion of the riparian ecosystem which serves as the zone of influence and contributes to the pollution removal function in the Columbia Plateau is often intact native shrub-steppe or prairie vegetation.

2.2.2. Site-Potential Tree Height (SPTH) Background

A fundamental component of our recommendation is the use of site-potential tree height (SPTH). In this section, we provide background information on its origin, applicability, and usefulness (see also Volume 1, Chapter 9).

In 1993, a group of experts (Forest Ecosystem Management Assessment Team [FEMAT]) was convened to develop a conceptual model to determine how to protect riparian areas in forested landscapes. This model has come to be known as the FEMAT curves (FEMAT 1993). Though this model is over 25 years old, it continues to be one of the most useful conceptual models informing riparian management.

The FEMAT curves provide a conceptual model of important riparian functions and how those functions change with increased distance from the stream channel (Figure 2.1). The model conveys two important points: (1) four of the five riparian ecosystem functions or processes occur within one 200-year SPTH; and (2) the marginal return for each function or process decreases as distance from the stream channel increases. Thus, designating a riparian area based on at least one $SPTH_{200}$ is a scientifically supported approach if the goal is to protect and maintain full function of the riparian ecosystem for aquatic habitat and species, including salmon.

The FEMAT curves and SPTH have been used to describe the lateral extent of riparian ecosystems, and accordingly, the width of the RMZ needed to provide full riparian ecosystem function.

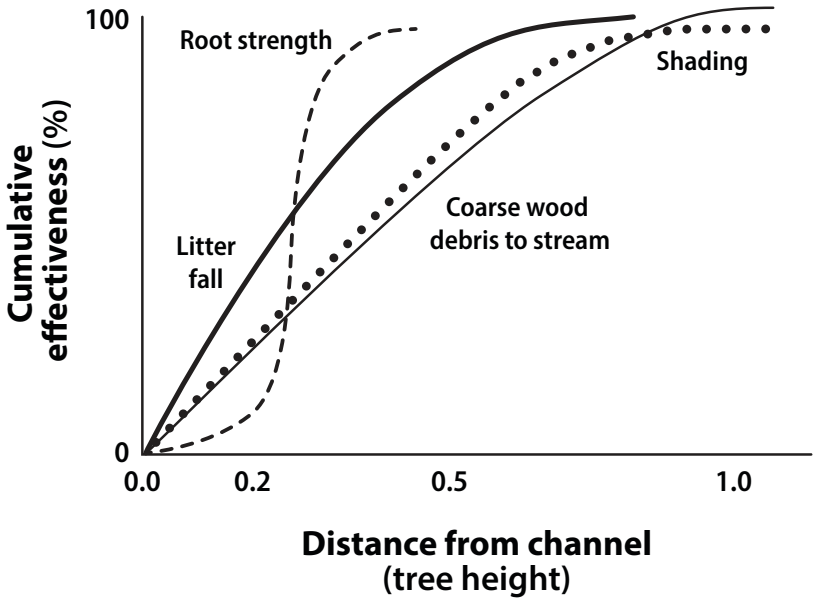


Figure 2.1. The "FEMAT Curves" (FEMAT 1993): a generalized conceptual model describing contributions of key riparian ecosystem functions to aquatic ecosystems as the distance from a stream channel increases. "Tree height" refers to average height of the tallest dominant tree (200 years old or greater); referred to as site-potential tree height (SPTH).

FEMAT (1993, p. V-34) defined SPTH as "the average maximum height of the tallest dominant trees (200 years or more) for a given site class." The key phrase in this definition is "200 years or more" which refers to the approximate minimum age of old-growth forests. This reflects FEMAT's underlying assumption that old-growth forest conditions are needed for full riparian ecosystem functions. WDFW uses SPTH at 200 years (abbreviated $SPTH_{200}$) in our recommendations in this Volume 2.

FEMAT defined Site potential tree height (SPTH) as "the average maximum height of the tallest dominant trees (200 years or more) for a given site class."

"200 years or more" is the approximate minimum age of old-growth forests which are thought to be necessary for full riparian ecosystem functions.

Given its utility, the height of site-potential trees has been described for a variety of tree species and can be readily found in silvicultural literature. Mean heights of dominant trees in riparian old-growth forest of Washington range from 100 to 240 feet (Fox 2003). The wide range of heights reflects differences in site productivity, i.e., local differences in soil nutrients and moisture, light and temperature regimes, and topography. Site productivity is described quantitatively through a site index, which is the average height that dominant trees of a species are expected to obtain at a specified tree age at a given location.

2.2.3. The Importance of Channel Migration Zones (CMZs)

Not all streams have CMZs, but where CMZs are present, it is necessary to map the CMZ in order to establish an RMZ. The Washington Forest Practices Board Manual (DNR 2004) provides a useful definition of the CMZ as "the area where the active channel of a stream is prone to move and this results in a potential near-term loss of riparian function and associated habitat adjacent to the stream, except as modified by a permanent levee or dike" (DNR 2004, Section M2).

Protecting the CMZ from incompatible land uses (e.g., development) is important for providing riparian ecosystem functions. Human alterations to river channels that limit channel migration and bank erosion can degrade aquatic and riparian habitats. For these reasons, geomorphologists have developed protocols for delineating CMZs. Further, RMZ delineation along streams with CMZs ensures that riparian functions do not degrade as a channel moves. Proper delineation also helps landowners avoid siting homes and infrastructure in CMZs that coincide with geologically hazardous critical areas and floodplains (**WAC 365-190-120[6f]**).

2.2.4. Relationship of CMZs and Floodplains

This document does not include guidance on the integration of floodplains into RMZ delineation (see footnote 4 for a brief explanation about the active floodplain). However, a general understanding of floodplains and their relationship to CMZs is valuable, as the two often overlap.



Beavers are considered to be ecosystem engineers. The dams they build, the resulting ponds created, and the surrounding areas from which they fell trees all provide habitat for many other animals./Liz Bocksteigel, WDFW

Both federal and state regulations establish floodplain protections. Floodplain data and **maps** (typically 100-year floodplains) are readily available through the Federal Emergency Management Agency's National Flood Insurance Management Program. Ecology is the state's authority as lead on floodplain management and we support their recommendations for management of **Frequently Flooded Areas** (another type of critical area specified in GMA) and the use of the **Floodplains by Design** grant program to reduce hazards and restore natural functions. Proper floodplain delineation and protection helps landowners and land managers avoid placing homes and infrastructure in areas at high-risk of flooding.

The Bureau of Land Management provides common clues to help determine the presence of an active floodplain (BLM 2015) such as visual evidence of frequent inundation, which may include but is not limited to:

- Fresh deposits of fine sediment;
- Floodplain vegetation matted down or lying flat on floodplain from overbank flow or by deposition or overbank sediment;
- Debris piled on the upstream side of tree trunks; or
- High water marks seen on rocks, trees, or other stationary objects; and ice-rafted deposits on the floodplain.

However, BLM advises caution when relying on these visual clues. Furthermore, looking for signs that an active floodplain is present is only the first step toward delineating the outer edge of an active floodplain. We recommend reviewing BLM's technical reference titled *Proper Functioning Condition Assessment for Lotic Areas* (BLM 2015) and to consult Ecology for assistance regarding floodplain delineation and protections.

Good floodplain management is not only beneficial for human communities, it is also good for fish and wildlife. Although we do not describe use of the 100-year floodplain to measure the RMZ in Volume 2, we recommend that landowners and land use decision makers treat floodplains similarly to RMZs due to their importance to instream health, as habitat, and for their ecological services.

2.3. Procedures for RMZ Delineation

To conserve riparian habitat, one must first establish the lateral extent (i.e., width) of the RMZ. In Chapter 1, we noted that an RMZ encompasses the riparian zone and zone of influence (Figure 2.2), and, where present, considers the CMZ (Figure 2.3). In this section, we outline general steps for collecting site-specific information essential to map an RMZ. These steps will help you identify a site's proximity to streams as well as essential site characteristics. With this information, we then explain how to delineate an RMZ.

In the rest of this section, we explain how to:

- Identify the ecoregion in which the riparian ecosystem is located (e.g., forested or dryland);
- Verify the presence of a stream;
- Identify the inner edge of the RMZ; and finally
- Determine the RMZ width.

2.3.1. Determining Ecosystem Location

We have identified two distinct types of ecoregions statewide, each with a slightly different RMZ delineation procedure: (1) Forested, and (2) Dryland. In general, forested ecoregions dominate western Washington, northeastern Washington, and portions of southeast, north central, and eastern Cascades. Dryland ecosystems are more readily contained in the Columbia Plateau Ecoregion east of the Cascade Range.

Landowners and land use planners should utilize the SPTH mapping tool, described in Appendix 1, to determine the ecoregion where the river or stream lies. Appendix 1 also provides instructions for using this tool to determine the 200-year site-potential tree height ($SPTH_{200}$) at a given location.



Site visits are important because small streams are often unmapped, including in GIS tools commonly used for planning and permitting. Shaner Creek, Thurston County/Janet Anthony, WDFW

2.3.2. Verifying the Presence of a Stream

Once you have identified which ecoregion you are in (e.g., Columbia Plateau), a qualified professional[6] should visit the site to verify the stream's location on or near the project area. It is very important not to rely solely on "stream maps" (e.g., DNR stream layer, National Hydrography Dataset) in place of a site visit (which is also important for mapping RMZs) because existing mapped stream layers often have errors, including streams whose locations are mapped inaccurately on the landscape, and streams actually present on the landscape that are missing from maps. Instead, use the site visit to validate existing stream maps.

[6] Qualified professionals can be entities and individuals identified by the jurisdiction, WDFW regional habitat biologists, tribal biologists, Ecology staff, and/or other individuals familiar with stream verification and who have local expertise (e.g., Conservation District staff, Stream Teams, etc.).

2.3.3. Identifying the Inner Edge of the RMZ

Once you have verified a stream's location, proceed to locate the inner edge of the RMZ. Accurate RMZ delineation is dependent on using the correct starting point. In this section, we describe how to determine the location of the RMZ's inner edge using either the Channel Migration Zone (CMZ), if one is present; or the Ordinary High-Water Mark (OHWM). Ecology, as the state's water quality lead, provides extensive guidance and resources associated with OHWM or CMZ, and those resources are referenced here forward.

2.3.3 (A). Identifying Ordinary High-Water Mark (OHWM)

Delineate the RMZ's inner edge by identifying the OHWM along both sides of the stream following the procedure in Chapter 3 of Ecology's **OHWM delineation manual** (Anderson et al. 2016).

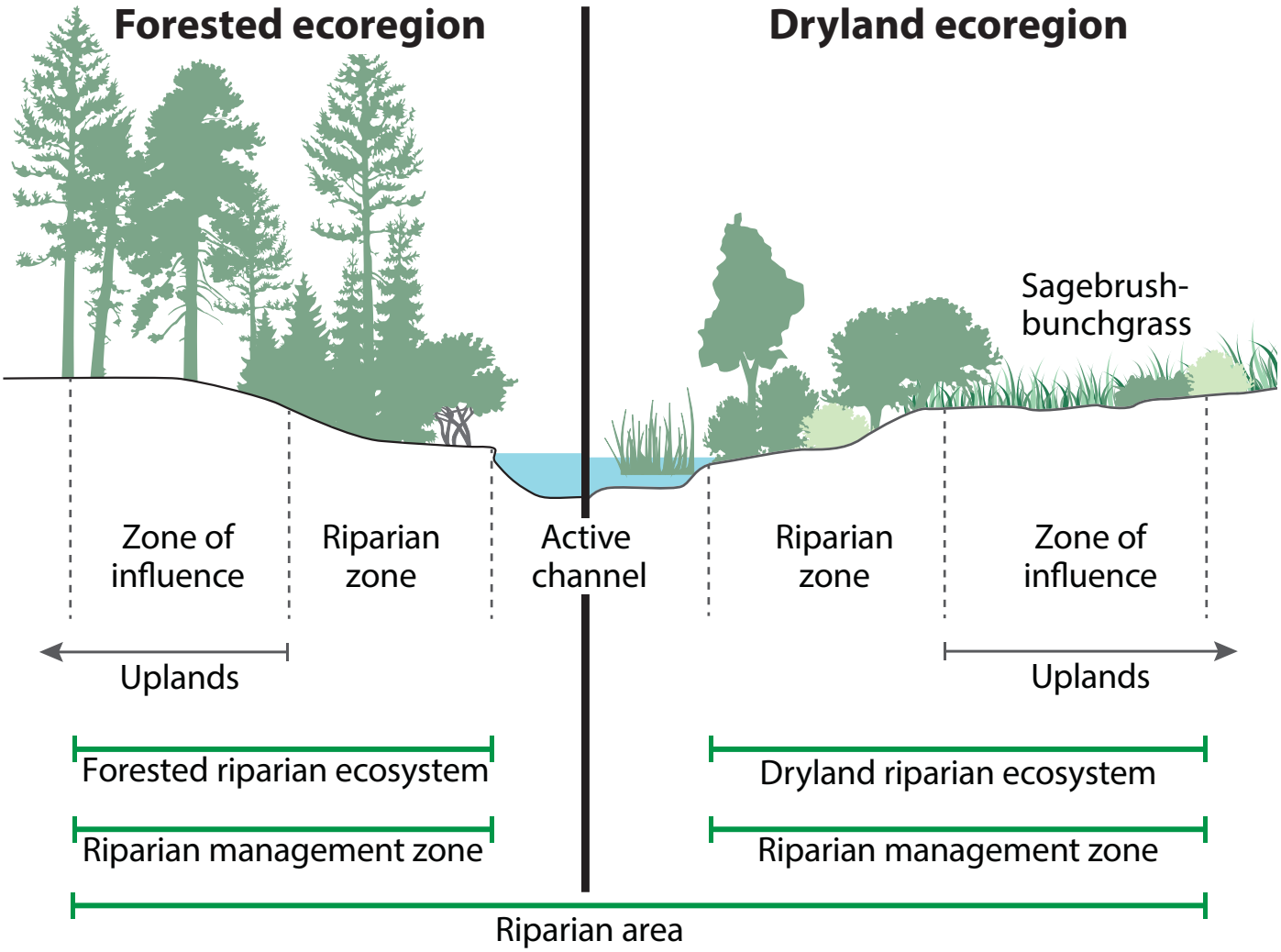


Figure 2.2. The diagram depicts the riparian management zone (RMZ) for both forested (left) and dryland (right) ecoregions. The RMZ is coincident with the riparian ecosystem, *which consists of the* riparian zone *(riparian vegetative community) and the* zone of influence. *The* riparian zone *extends from the edge of the active channel towards the uplands and it includes areas where vegetation is influenced at least periodically by flowing waters. The* zone of influence *includes areas where ecological processes significantly influence the stream, at least periodically.*



A drone photo showing an area of the Nooksack River in Whatcom County. Taken during summertime low flows, the existence of multiple braided channels is evident./Ross Zimmerman, Department of Natural Resources

2.3.3 (B). Identifying the Channel Migration Zone

Delineate the RMZ's inner edge by identifying the edge of the CMZ. Information about CMZs is available for certain streams in the state. For example:

- **SMA-Covered Shorelines** – During Shoreline Master Program comprehensive updates, many jurisdictions map the general location of CMZs associated with shorelines that fall under the jurisdiction of SMA (RCW 36.70A.480). Note that even smaller streams not subject to SMA jurisdiction can have CMZs. In these cases, we recommend jurisdictions still identify and analyze CMZs to protect riparian ecosystems and public health and safety.
- **Puget Sound Streams** – The federal Endangered Species Act may require CMZ delineation in Puget Sound basin streams under the FEMA National Flood Insurance Program Biological Opinion for Puget Sound.
- **Other Local Examples** – Check with your jurisdiction to see if they have more detailed CMZ maps.

Ecology provides the following resources which can help landowners and land managers assess the presence and extent of CMZs where maps and data on CMZs do not currently exist:

- CMZ Home Page provides a high-level look at CMZ identification, and references useful documents;
- Channel Migration Processes and Patterns in Western Washington (Legg and Olson 2014) describes the general channel migration processes that occur in western Washington;
- A Methodology for Delineating Planning-Level Channel Migration Zones (Olson et al. 2014) provides a process for delineating "planning-level" CMZs and gives a few good examples in the appendices;
- A Framework for Delineating Channel Migration Zones (Rapp and Abbe 2003) is a more in-depth guide on how to develop "detailed" CMZs; and
- Screening Tools for Identifying Migrating Stream Channels in Western Washington (Legg and Olson 2015) outlines the "CHAMP" (channel migration potential) GIS layer with guidance on using it to identify high-risk CMZs.

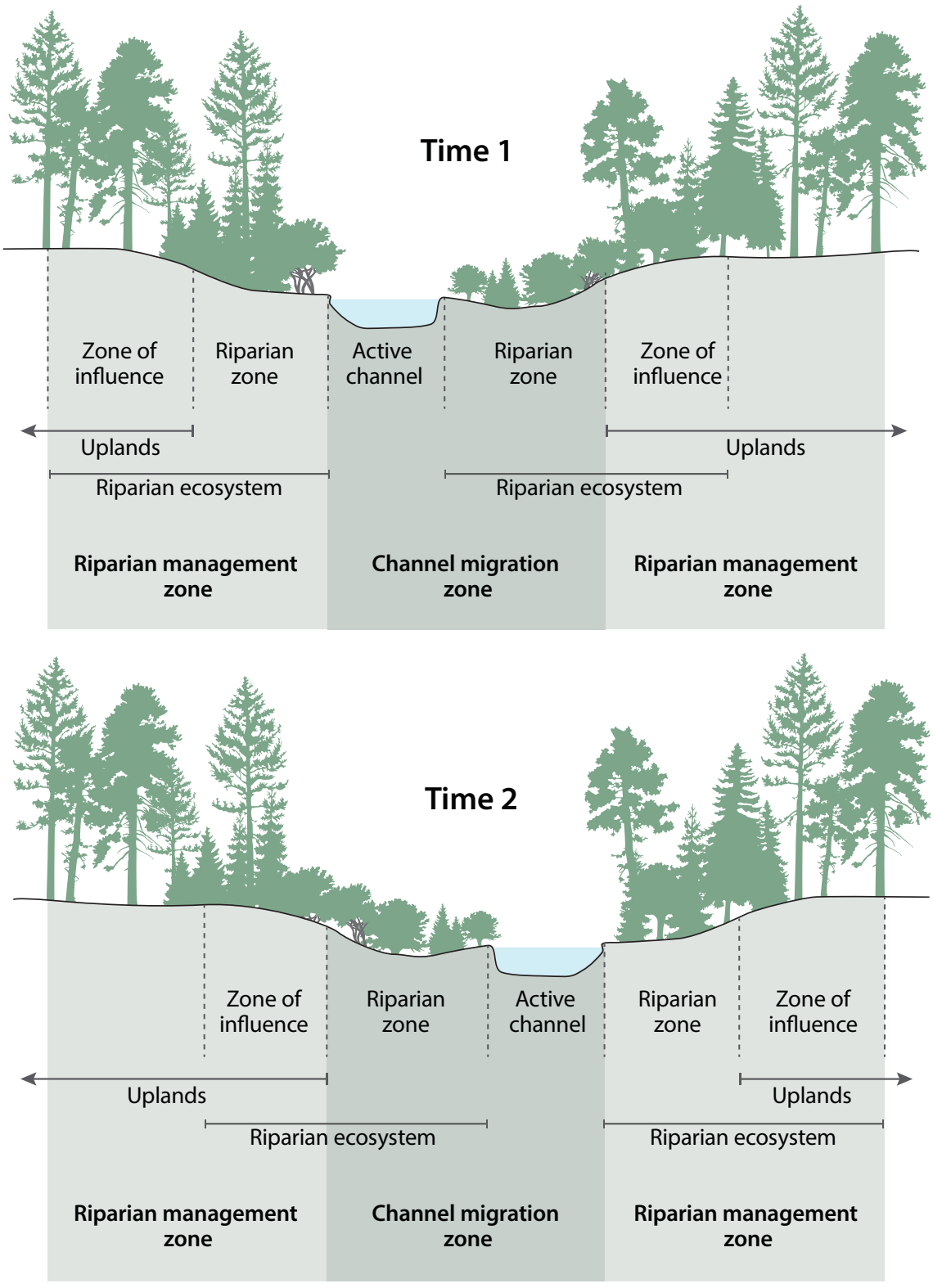


Figure 2.3. This diagram depicts the spatial relationship between the riparian management zone (RMZ) and channel migration zone (CMZ) over time. As the active channel moves laterally within the CMZ, the riparian ecosystem moves with it. As a result, when considering the establishment of an RMZ, delineation should occur at the edge of the CMZ to account for the full extent of both the present day and future riparian ecosystems. Time 1 and Time 2 could be separated by days or centuries. This depiction of a forested system is one representation of a CMZ, which are also present in dryland systems: both should be managed for accordingly.

2.3.4. Determining RMZ Width

Once you have determined the location of the RMZ's inner edge, you then establish the width of the RMZ. The following stepwise process aims to establish recommended minimum delineation distances based on $SPTH_{200}$, vegetation composition, and pollution removal function (Figure 2.4). We say "recommended minimum" because upland adjacent land uses may require further adjustment of the RMZ to provide adequate pollution removal functions. Landowners and land use regulators should also consider additional actions to support wildlife connectivity and/or to protect riparian adjacent Priority Habitats.

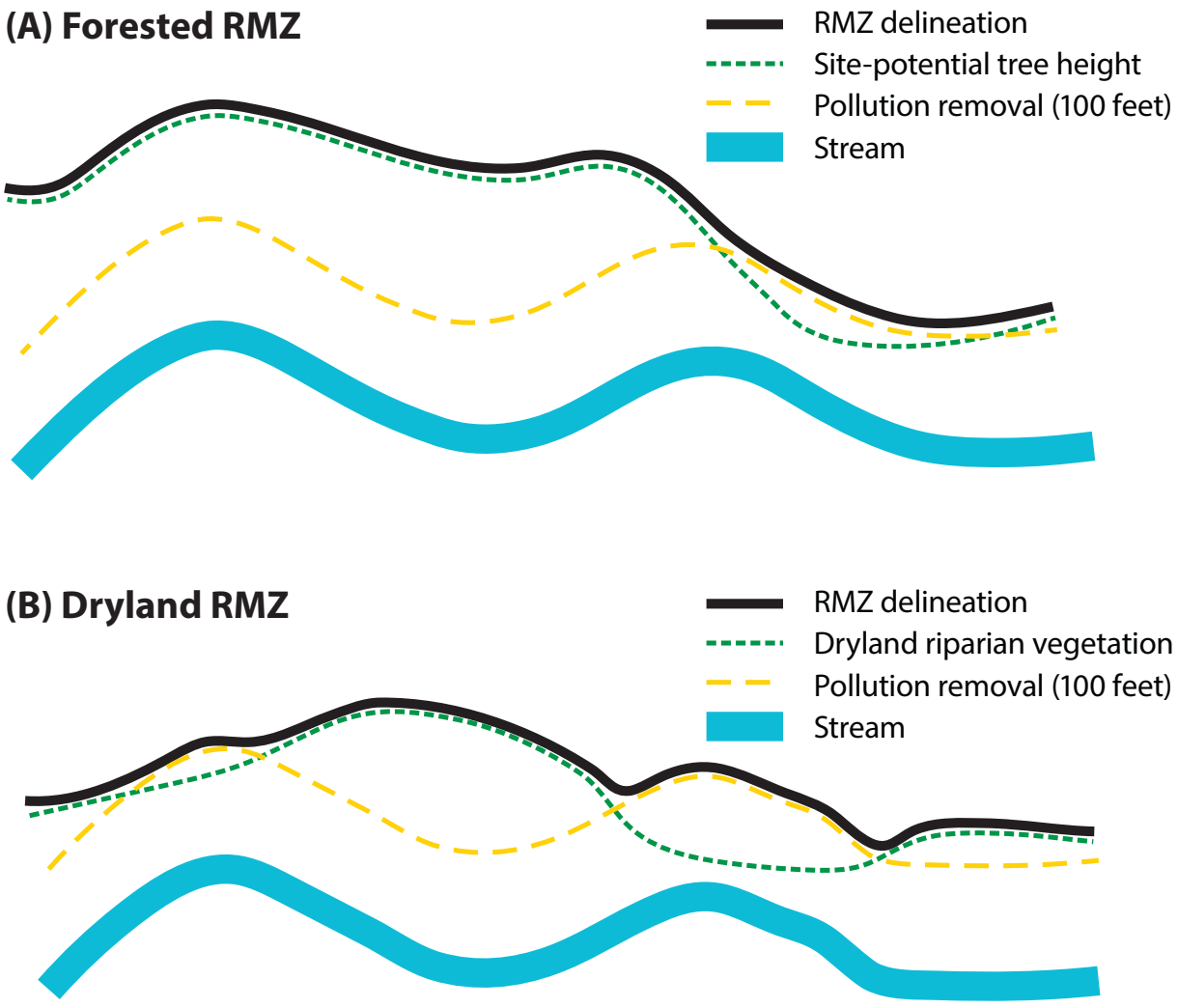


Figure 2.4. Aerial view of variable width RMZ delineation process for forested (A) and dryland (B) systems.

- *Step 1: Identify the SPTH or full extent of the riparian vegetative community (green);*
- *Step 2: Overlay a 100-foot pollution removal distance (yellow);*
- *Step 3: Delineate the RMZ (black) as the greater of the two distances.*

We tailor the following guidance based on two types of ecoregion: (1) Forested and (2) Dryland.

2.3.4 (A). Forested Ecoregions

Forested ecoregions are well-suited for using $SPTH_{200}$ consistently to establish RMZ widths, and so for these areas, landowners and land managers can rely on the $SPTH_{200}$ information provided in the SPTH mapping tool (see Appendix 1). The tool provides the derived average height attained by the dominant tree species at age 200 years ($SPTH_{200}$) using the U.S. Natural Resource Conservation Service (NRCS) forest productivity site index values, which we recommend for delineation of RMZs (see Sec 9.3 in Volume 1 for background on the origin and use of $SPTH_{200}$). In forested ecoregions, contributions of large wood as a riparian ecosystem function often define the farthest lateral extent of the RMZ.

Occasionally, the $SPTH_{200}$ may be less than 100 feet, in which case the pollution removal function (described in more detail in Section 2.3.5 below) defines the lateral extent of the RMZ.

In Washington, $STPH_{200}$ can be as large as 260 feet: therefore, be sure to evaluate each soil polygon within 260 feet of the stream channel to ensure that RMZ delineation is in fact being driven by the largest dominant tree species.

2.3.4 (B). Dryland Ecoregion

Riparian ecosystems in arid and semi-arid regions of North America (also referred to as the dryland ecoregion) make up less than 1 to 3 percent of the landscape (Patten 1998). Dryland riparian ecosystems are hydrologically linked to and influenced by adjacent surface waters; as a result, surface waters sustain riparian vegetation that is clearly distinct from upland vegetation.

Riparian ecosystems in dryland environments are highly variable due to various site-level conditions. While these ecosystems may support large trees in low gradient floodplains, tree presence in riparian ecosystems throughout the dryland ecoregion is much more varied than in forested ecoregions, and so in many cases, the contribution of large wood no longer serves as the outermost ecological function for RMZ delineation. Further, riparian vegetation may be minimal or even non-existent, particularly along degraded, incised streams. In dryland ecoregions, the outermost of

Protecting Columbia Plateau's Priority Habitats Supports Riparian Health

Native shrub-steppe vegetation and other drought-tolerant plant communities dominate Washington's dryland environments. Approximately 450 plant community associations occur in this region, with over 20% of these associations considered vulnerable (WDFW 2005, p. 523). Among the most imperiled ecosystems in North America, historical shrub-steppe has been greatly reduced due to conversion to other land uses (Vander Haegen 2007).

Riparian areas are critical to most animal species using shrub-steppe. Biodiversity in these vegetative communities increases dramatically where surface water occurs, and riparian areas directly support numerous species found only in or near water (Rogers et al. 1988, Johnson and O'Neil 2001). Linking and protecting upland adjacent Priority Habitat(s) not only aims to support Washington's wildlife and their associated habitat conservation goals, but also works to protect and maintain riparian ecosystem integrity.

three factors drives delineation of the RMZ: (1) $SPTH_{200}$ (if trees are present); (2) riparian vegetative community; or (3) pollution removal function.

2.3.4 (C). Considerations in Highly Modified and Urban Systems

In some locations, riparian systems have been substantially modified, and current site-specific conditions may not provide adequate indication of where riparian vegetation would naturally occur. On the whole, this is particularly true of riparian systems in dryland ecoregions. In these instances, we recommend considering nearby sites with unaltered vegetation or selecting a representative site with similar bank height and gradient conditions to identify adequate riparian vegetation delineation for both protection and restoration.



A modified riparian area within an agricultural landscape in Kittitas County. The stream channel was likely straightened decades ago. More recently, small bridges were built across the stream for pivot sprinklers to move back and forth. To allow ease of sprinkler movement, no woody vegetation is allowed to grow./Jennifer Nelson, WDFW

Similarly, four major urban areas (Seattle, Spokane, Tacoma, and Bellingham) in forested ecoregions lack NRCS soils data. For these areas, WDFW identified nearby NRCS soils polygons and calculated weighted averages as estimates reflective of the surrounding environment ("imputed $SPTH_{200}$"). Much like in forested areas where $SPTH_{200}$ data are available, we recommend using the imputed $SPTH_{200}$ values specified for each of these urban areas to delineate RMZs within them.

2.3.5. Width delineation steps

Step 1: Use $SPTH_{200}$ if it is at least 100 feet.

In **forested ecoregions,** WDFW recommends full protection within one $SPTH_{200}$, identified with the use of our SPTH mapping tool (https://arcg.is/1ueq0a). The mean $SPTH_{200}$ in western Washington ranges from 100 to 240 feet (Fox 2003). Some soil polygons have $SPTH_{200}$ information for multiple tree species; therefore, each soil polygon within one $SPTH_{200}$ should be evaluated to ensure RMZ delineation is driven by the largest dominant tree species. Occasionally the $SPTH_{200}$ in forested ecoregions is less than 100 feet; for example, red alder is a fairly common riparian tree species, yet the $SPTH_{200}$ for this species does not always exceed 100 feet. If red alder is the only species for which $SPTH_{200}$ information is available for a certain location, and it is less than 100 feet, then skip to Step 3.

In **dryland ecoregions,** it is less common, but still possible to find riparian vegetation which includes–and may even be dominated by–large trees. Examples of large tree species in these areas are black cottonwood (*Populus trichocarpa*) and ponderosa pine (*Pinus ponderosa*). If $SPTH_{200}$ in dryland ecoregions exceeds 100 feet, then it should be used for the RMZ width.

Step 2: In dryland ecoregions, if $SPTH_{200}$ is less than 100 feet or if no large trees are present, identify the extent of the riparian vegetative community.

In **dryland ecoregions,** the riparian vegetative community is often comprised of shrubs, sedges, grasses, and forbs that are distinct from upland communities. For example, in the Columbia Plateau, vegetation within riparian ecosystems often exhibits an abrupt demarcation between the riparian zone and zone of influence. Phreatophytic[7] trees and shrubs and hydrophytic[8] herbaceous plants are confined to moist streamside areas, but the upland zone of influence may consist of sagebrush or bunchgrass communities [for more information, see Volume 1, Chapter 7 (Section 7.1.1)]. Where trees are not present or consist only of small species (less than 100 feet tall), WDFW recommends full protection of the entire riparian vegetative community. In some places the community may only be a few feet wide but in others it may extend up to several hundred feet, particularly when associated with a wetland or floodplain (Bermingham et al. 2013). Where the riparian vegetative community is less than 100 feet wide, go to step 3.

Step 3: Overlay 100-foot pollution removal delineation

The following applies to both **forested and dryland ecoregions.**

Our recommendation to protect full riparian function recognizes the importance of the pollution removal function of riparian ecosystems. Because pollution removal depends on multiple factors, including slope, soils, plant community composition, and upland uses, establishing a standard RMZ width for 100% pollution removal even at the site scale was impractical.

Where neither $SPTH_{200}$ nor the extent of the riparian vegetative community is at least 100 feet, we recommend RMZ delineation of a *minimum* distance of 100 feet, because this distance will achieve 95% or more removal efficacy of phosphorous, sediment, and most pesticides. To be clear, we value a similar removal efficacy for nitrogen, and at a 100-foot width, an RMZ would achieve only 80% removal efficacy for surface runoff containing excess nitrogen. However, the literature reflects that both the actual risk posed by excess nitrogen, as well as the efficacy of its removal, are very site-specific. In recognition of this, we strongly recommend that, where upland uses contribute nitrogen, the 100-foot minimum pollution removal distance be extended accordingly when determining the appropriate RMZ width.

Further, if RMZ widths are being based on a minimum pollution removal function at locations with steep slopes or poorly drained soils, distances greater than 100 feet should also be considered: this applies for all pollutants. Additionally, WDFW recommends cities and counties identify high intensity land uses that may be located adjacent to riparian areas within their jurisdiction and establish wider RMZs to enhance the pollution removal function in these locations as well, following guidance from Ecology.

When dealing with variables such as those outlined above, it may be necessary to seek expert assistance in determining the appropriate adjustments to RMZ widths based on the pollution removal function.

7 A phreatopyhtic plant is a species that obtains water from the subsurface zone of saturation either directly or through the capillary fringe (Thomas 2014).
8 Hydrophytic plants are those that are adapted to growing conditions associated with periodically saturated soils. They include obligate wetland plants that almost always occur in wetlands under natural conditions, facultative wetland plants that usually occur in wetlands but are occasionally found in non-wetlands, and facultative plants that equally likely to occur in wetlands or non-wetlands (Lichvar et al. 2012).

Chapter 3. Riparian Regulatory Protections

3.1. Introduction

This chapter gives guidance to help local governments review, develop, and implement regulatory tools to protect riparian ecosystems as critical areas, i.e., Fish and Wildlife Habitat Conservation Areas (FWHCAs). We describe key steps toward creating effective programs to protect riparian ecosystems consistent with the goals of the Growth Management Act (GMA), Shoreline Management Act (SMA), and Voluntary Stewardship Program (VSP). More specifically, this chapter describes recommendations for carrying out common land use activities and provides steps for developing Habitat Management Plans (HMPs). The riparian management zone (RMZ) should serve as the focal area to apply our recommendations.

Parcel-scale regulations are foundational to Washington's traditional land use regulatory approaches for protecting rivers and streams and their adjacent riparian ecosystem. However, sole reliance upon a regulatory approach at this site scale may result in loss of aquatic system function over the long term (see Volume 1). Thus, we believe that site-scale regulations must work in coordination with watershed-scale planning (Chapter 4) and that both should be monitored and adaptively managed (Chapter 5). In this chapter, we present considerations and recommendations for managing and protecting riparian ecosystems at both site- and watershed-scales.

3.2. Recommendations to Local Jurisdictions

Protection of watersheds commonly falls under the purview of agencies other than WDFW. Nonetheless, we encourage local jurisdictions (and their long-range planners in particular) to consider how land use patterns at all scales collectively affect fish and wildlife and other important ecosystem services.

The scientific literature review (see Volume 1) informs WDFW's position that protecting the area within one $SPTH_{200}$ from the edge of a stream channel maintains full riparian ecosystem functions for all aquatic species, including salmon, and promotes healthy, intact riparian ecosystems. This recommendation provides the greatest level of certainty that land use activities do not impair functions and values of riparian ecosystems. We recommend the use of monitoring and adaptive management (see Chapter 5) to inform regulations and evaluate the complement of both regulatory and voluntary conservation measures in achieving outcomes.

Land use decision makers should ensure all programs that can affect riparian habitat (e.g., CAOs; SMPs; and ordinances for clearing and grading, fire hazard reduction, and tree protection) are coordinated to optimize the ability of local policies, rules, and management activities to protect those habitats. Further, jurisdictions should look for gaps

such as inconsistencies, exemptions and loopholes, or inefficient practices (e.g., inspection and monitoring protocols) that could impede protection of or cause harm to riparian ecosystems.

To that end, we provide important questions to consider when reviewing CAOs, Comprehensive Plans, or other plans that can affect riparian ecosystems:



The Coweeman River Joint Wetland and Conservation Bank in Cowlitz County includes riparian areas as a focus for both restoration and preservation./Chuck Stambaugh-Bowey, WDFW

1. Conservation Strategies:

- What external strategies exist (e.g., salmon recovery plans, reach-scale assessments, and incentive-based plans) to maintain, protect and restore riparian areas?
- Which of these strategies (if any) currently inform your regulatory, planning, and/or voluntary processes or programs?
- If these strategies are not in your current programs, could they be incorporated to provide additional benefits to riparian ecosystems? Are there other strategies that could also (or instead) benefit riparian ecosystems?
- Which of these strategies may help your jurisdiction satisfy mitigation obligations?
- How are riparian restoration and/or enhancement programs informed by these strategies?

2. Regulatory Buffers:

- Does your jurisdiction rely on $SPTH_{200}$ for delineating regulatory riparian buffers?
- If your jurisdiction does not rely on $SPTH_{200}$ for delineating those buffers, does your jurisdiction currently have regulatory buffers for riparian areas that are equal to or greater than the distance equal to $SPTH_{200}$?
- Are there buffer exemptions? If so, how do those affect riparian function across your jurisdiction?
- Do your buffers consider the CMZ?
- Do your buffers consider adjacent wetlands and appropriate wetland delineation methodology as prescribed by Ecology?
- If your jurisdiction's CAO or SMP buffers are less than $SPTH_{200}$, can you use the RMZ to identify areas to do mitigation or areas impacted that will require mitigation?

3. Restoration and Adaptive Management (see also Chapter 5):

- Can your jurisdiction use the RMZ to identify areas for incentive-based restoration?
- Do you have a monitoring and adaptive management program for improving permit implementation?

- Is your jurisdiction collecting information on effectiveness of protecting riparian areas?
- If you collect effectiveness information, what programs (e.g., incentives, regulations) could you improve to increase riparian conservation?

4. Other Programs and Regulations

- What other regulations separate from CAOs, may inadvertently affect riparian areas (e.g., clearing and grading ordinance that lack safeguards for riparian protection)?
- Are there opportunities to connect riparian areas with other protected areas (e.g., frequently flooded areas, geologically hazardous areas, green belts, parks, wetlands, and aquifer recharge areas)?

3.2.1. Recommendations for Common Activities in the RMZ

Local governments should regulate all land use activities that are likely to impact functions of a riparian ecosystem found within the RMZ to ensure, at a minimum, that the existing functions and values are protected from development actions. For the purposes of meeting requirements under GMA, SMA, and VSP, we describe the RMZ as the area in which functions and values are contributed to the riparian ecosystem: providing a delineated space not just for protection, but also for mitigation and management. We also recommend prioritizing the RMZ as the space for restoration[9]. We provide specific information and recommendations for the following ten common activities: (Note that neither the list of activities nor the recommendations themselves are exhaustive; for more information, contact your WDFW regional habitat biologist.)

1. On-site Sewage Systems (OSS)
2. Bank hardening
3. Clearing, grading, and placement of fill
4. Removal of noxious weeds
5. Forest practices and conversions
6. Firewise and wildfire hazard reduction
7. Removal of hazard trees
8. Non-compensatory restoration and enhancement
9. Emergency activities
10. Educational or Recreational Areas

1. **On-site Sewage Systems (OSS)** – Historically, developers sited OSS at lower elevations bordering streams, lakes and wetlands in order to use passive gravity flow. The disadvantage of these systems is that when drain fields are located near water features, they can more easily contaminate water with high loads of nutrients and toxic pollutants, causing significant impacts to flora, fauna and water quality. The State Department of Health adopted rules establishing public health standards for location, design, installation, operation, maintenance, and monitoring of OSS, including requiring setbacks from waterbodies (WAC 246-272A) which modern OSS systems, using pump systems, can support. Some OSS may meet public health standards even if located within RMZs; nevertheless, jurisdictions should exercise authority to require HMPs to ensure project proponents protect habitat functions of riparian critical areas.

[9] As explained previously, many riparian areas had already experienced a substantial degree of degradation before laws like GMA, SMA, and VSP were passed, so while protecting what level of riparian functions and values remain is essential, protection alone will not be sufficient for meeting the needs of the state's fish and wildlife species.

2. **Bank Hardening** – We recommend jurisdictions avoid allowing new development that requires bank protection now or is likely to in the future (consider channel migration, wind and wave action, and climate change), unless it addresses an imminent threat as an emergency activity (*see* Emergency Activities in this section below). Always look to alternative places to site a project so that no bank protection measures are needed. If measures cannot be avoided, require that a project proponent evaluate the effectiveness of bioengineering alternatives (also known as soft armoring) prior to proposing hard armoring. Follow bank protection recommendations in the Washington State Integrated Streambank Protection Guidelines (Cramer et al. 2002) when bank protection is unavoidable.

3. **Clearing, Grading, and Filling** – We recommend jurisdictions acknowledge impacts of clearing, grading, and filling on riparian areas in their CAOs by limiting these activities to areas outside the RMZ (unless directly related to restoration) as they can negatively affect riparian areas. If a clearing, grading, or filling project must encroach in an RMZ, limit disturbance and minimize effects to the greatest extent possible. Require that a qualified professional prepare an HMP describing how the project proponent will follow the mitigation sequence.

   Jurisdictions that exempt small areas from filling or grading ordinances in riparian ecosystems should calculate cumulative impacts from these exemptions. They should also mitigate impacts and subsequently establish monitoring to ensure that mitigation measures are effectively negating potential losses to habitat function.

4. **Invasive and/or Noxious Plant Removal** – Many CAOs do not require a permit for control and removal of invasive and/or noxious weeds within riparian ecosystem. We support this when weed control efforts (1) employ hand weeding with light equipment; (2) use only Ecology-approved aquatic herbicides and adjuvants (a substance added to herbicides to improve application); avoid use of hazardous substances; and (3) do not result in soil compaction. Local governments should retain some oversight authority for more extensive invasive and/or noxious plant control projects to ensure adequate protections of riparian functions, especially water quality. Most communities issue an exemption letter or permit, which should include conditions to ensure impacts to fish, wildlife, and habitat are minimal. It is important to note that even plants native to the region can, in certain circumstances, be detrimental to riparian areas. An example is in Puget Sound Prairies, where in the absence of periodic fire events (typically prescribed fire), common western Washington conifer species like Douglas fir outcompete native deciduous species (primarily Oregon white oak). In these circumstances, conifer removal and re-establishment of historical riparian conditions (oak and prairie vegetation) should occur under an approved HMP. WDFW regional habitat biologists can assist in preparing, reviewing, and implementing such a plan.

5. **Forest Practices and Conversions** – The state's Forest Practices Act (RCW 76.09 and WAC 222) regulates forest practice activities on forestland. We recommend that the proponent always contact DNR prior to conducting forest practice activities and seek technical assistance from a WDFW regional habitat biologist to ensure protections for Priority Habitats and Species. When conducting commercial forest practice activities, the forest practice rules—not the CAO—apply for protection of resources on site. Lands converted from forestry to another use require a special forest practice permit, and when converting land, local CAOs are applied. If conversion occurs, WDFW recommends timber harvests not be allowed within $SPTH_{200}$.

6. **Wildfire Hazard Reduction** – Wildfire is a concern in Washington, though the threat varies across the state. Local regulations to reduce wildfire hazards should be coordinated with a Firewise program in order to require landowners to consult with a Firewise professional (http://www.dnr.wa.gov/firewise) before removing trees or

manipulating vegetation in an RMZ. Understanding the composition of historical forest stands and shrub-steppe can help ensure retention of riparian functions when carrying out wildfire hazard reduction activities. When fuel (vegetation) reduction efforts involve the removal of merchantable trees, the proponent should check with the local jurisdiction and DNR, which may require a permit for tree removal.

7. **Removing Hazard Trees** – Tree trimming or removal in RMZs is sometimes necessary to address public safety concerns but should be balanced with the potential impacts to riparian ecosystem function. Jurisdictions should define a "hazard tree" (sometimes referred to as a "danger tree") as a threat to life, property or public safety, and require that the method of tree removal not adversely affect riparian ecosystem functions if possible. Specifically, we recommend that any removal of hazard trees involve an avoidance and minimization of damage to remaining trees and vegetation within the RMZ. We further recommend that local governments require a qualified arborist to evaluate requests for hazard tree removal.

   The qualified arborist should be able to establish when a tree presents an imminent threat to life, property or public safety. It is important to note that snags (dead trees) are a Priority Habitat feature for wildlife, and so should be preserved if not hazardous.



Like many dead and dying trees, this snag along the Chehalis River shows evidence of woodpecker activity. Grays Harbor County/Mary Huff, WDFW

   Some local governments use Forest Practice Rules (WAC 222-21-010[4]), which define a hazard tree as "any qualifying timber reasonably perceived to pose an imminent danger to life or improved property." This applies to any tree within 1.5 tree-lengths of the structure. A DNR forester can verify during a site visit that a tree is a hazard based on this definition, and thus removing the hazard would not be subject to the Forest Practice jurisdiction or require a Forest Practice Application.

8. **Restoration and Enhancement** – We encourage local governments to include in their CAOs allowances for restoration and/or enhancement of the riparian ecosystem, including in-channel or streamside work, especially on lands set aside for conservation. To the extent possible, jurisdictions should promote incentives and set up a streamlined review process for restoration or enhancement projects to help facilitate project proponents not just meeting the minimum requirements of the local CAO, but instead going "above and beyond". Significant resources are available to jurisdictions that address limiting factors in riparian areas or undertake high priority restoration activities that benefit salmon or other listed species (see Chapter 4 for information on restoration).

9. **Emergency Activities** – Local codes typically have provisions for emergency activities (e.g., bank stabilization to address imminent threats to homes) that provide relief from time delays related to procedural code requirements.

Local regulations should distinguish the immediate need to permit an emergency activity from the need to compensate for its impacts after-the-fact.

10. **Educational or Recreational Areas** – Public access to shorelines is a priority use under the SMA and providing educational and/or recreational developments such as trails, viewing platforms, or similar facilities may also enhance the public's understanding and appreciation of riparian areas, streams, and habitats. Thus, some focused use of the RMZ for educational and recreational activities may be desirable, if it does not create significant disturbances. Most CAOs include allowances for unpaved access to a stream for aesthetic or recreational enjoyment with defined limits on clearing to avoid impacts and minimizing soil, vegetation, and habitat disturbances: this is an allowance we support. That said, construction of trails could allow greater access for pets and other high intensity recreation, which may increase predation on, and/or disturbance of fish and wildlife species. Regulations should minimize impacts from recreational trails and interpretive facilities to the extent practicable, informed by PHS data and associated management recommendations.



A sculpture titled "The Indian Chief" greets visitors at the entrance to the Beebe Springs Natural Area along the Columbia River near Chelan./Alan Bauer

3.2.2. Project-specific Riparian Habitat Management Plans

When reviewing proposed projects near streams, local governments typically require applicants to provide detailed site-specific HMPs (often called a Critical Area Report). Here we describe six aspects of Riparian HMPs that we recommend be addressed in CAOs:

1. When HMPs are required;
2. Which additional critical areas must be delineated, and how;
3. Which specific land use actions must be identified, and how;
4. Mitigation requirements;
5. Monitoring and Adaptive Management requirements; and
6. Articulate who must prepare and review the HMP.

1. **When required** – We recommend jurisdictions require an HMP whenever someone proposes a land use activity in an RMZ (regardless of the jurisdiction's regulatory RMZ delineation) or when a proposal likely could affect riparian or aquatic functions. In cases where there is less confidence in the spatial accuracy of the RMZ, consider requiring a Riparian HMP when impacts occur adjacent to the RMZ's zone of influence.



It is not uncommon for riparian areas to overlap with other types of critical areas, including geologically hazardous areas, where landslides may bring input like large wood to streams./ Terra Hegy, WDFW

Maps, DNR's stream layers, the National Hydrography Dataset (NHD), and other (e.g., local) stream layers are important for triggering HMPs. An HMP should be required whenever a stream is present near proposed development activities, including but not limited to subdivisions (plats, short plats, and large lot subdivisions), land/vegetation disturbing activities (e.g., clearing and grading, septic drain field siting), and stormwater routing.

2. **Critical Area Delineation** – HMPs should have the extent of critical areas within and adjacent to a proposed project site identified, along with ecosystem functions that need protection. Follow the RMZ delineation procedure outlined in Chapter 2, along with locations of other critical areas on or near the site (e.g., wetlands, geologic hazards, frequently flooded, critical aquifer recharge areas; informed by Ecology). Also, identify salmon and other priority aquatic species that use the stream network in the immediate vicinity as well as up- and downstream. Likewise, HMPs should identify Priority Species that may use the riparian corridor and any other Priority Habitats to which the corridor is connected. Attach the delineation map (1) to the property's title to inform future property owners of the site's critical areas, and (2) use it to update the jurisdiction's critical areas maps.

3. **Land Use Action Identification** – A complete HMP should describe relevant management recommendations for Priority Habitats and Species found on or near the site. Include a map in the HMP showing the location of proposed land use actions. It should identify and quantify current and proposed disturbances to the RMZ and other FWHCAs.

4. **Mitigation** – The HMP should have a description of the project proponent's mitigation sequencing. It should describe in detail measures to avoid impacts and minimize unavoidable impacts (e.g., clustering, conservation easements, and seasonal construction restrictions). If mitigation or compensation is necessary, the HMP should identify ways to improve riparian ecosystem function by enhancing riparian corridor connectivity (e.g., removal of stream barriers) or by improving the quality of the riparian area (e.g., replacing invasive vegetation with appropriate native vegetation).

5. **Monitoring and Adaptive Management** –The HMP should describe requirements for monitoring and adaptive management. In addition, it should identify measurable standards and expectations to monitor compliance (e.g., areal extent of vegetative cover, composition of riparian tree species, maximum invasive plant cover). The HMP should identify frequency of visits to monitor the site (e.g., at year 1, 2, 3, 5, 8, and 10) as well as measurable triggers for requiring more actions (e.g., maximum percent area coverage of invasive plants). The HMP should specify who is responsible for preparing, reviewing, and submitting reports. Finally, if deemed necessary by the jurisdiction, the report should include a cost estimate for monitoring, and the project proponent should post a bond for this amount or more to allow for overages.

6. **Preparer and Reviewer** – A qualified professional biologist, botanist, or ecologist should prepare the HMP; additional expertise related to CMZs, unstable slopes, and wetlands may also be necessary. Additionally, an independent professional with similar qualifications should review the HMP. WDFW's regional habitat biologists can often serve in this role, especially for larger projects. USFWS or NOAA Fisheries should also review the HMP if the project might affect a federally listed fish or wildlife species.

3.3. Riparian Management in Urban Areas

Some people have raised questions about the applicability of RMZs to urban and urbanizing areas. These concerns generally fall into two categories: (1) the science on RMZs comes largely from agricultural and forestry settings, and so is perceived to be irrelevant to urban areas; and (2) there is a belief that the need to maximize density of development in urban areas is in direct conflict with the protection of riparian areas.

Concerns over the relevancy of literature on riparian functions to urban areas is largely unfounded. While most riparian ecosystem studies are from non-urban settings, the principles are the same. Functions of shade, bank stability, large wood recruitment, nutrient inputs, and pollutant removal operate similarly in urban areas as they do in other settings. However, within urban areas, these riparian ecosystem functions are often greatly diminished or even absent altogether.



Fish-bearing stream within an urban area of King County/Elizabeth Torrey, WDFW

The role that urban RMZs play in delivering habitat functions for aquatic and many terrestrial species is also like that in non-urban areas. Factors that may be different in urban areas are that urban riparian ecosystems may perform some functions at reduced levels due to their position in developed watersheds, which are often heavily degraded. However, intact RMZs in urban areas function as wildlife corridors that link habitat patches, which is critical for many species. In fact, sometimes RMZs in urban areas may be more important from a habitat standpoint, because within urban areas, adjacent uplands are often even more degraded than the RMZs, which then are often the only remaining areas where habitat functions are provided. Thus, a key element to maintain in urban RMZs is connectivity, both in and along streams.

Many Puget Sound salmon move through channelized streams, traversing heavily urbanized areas prior to reaching spawning grounds and as juveniles on a reciprocal journey to marine waters. Salmon must pass through a wide spectrum of development. For example, adults returning to spawn often start in urban cores (e.g., downtown Seattle), where streams are often channelized; then pass through areas with small lots and high urban density and into suburban

creeks where larger lots allow for more riparian protection; and finally, to rural lots with less development and better ecosystem health. When juveniles make their journeys in reverse, they generally spending more time in each of these areas than their parents did, and yet because of their small size, they are also at much greater risk of not surviving any of them. While the decades-long decline of many of our native salmon stocks illustrate just how challenging this is, their persistence—especially the subspecies which are showing signs of improvement—shows us what is possible. Therefore, it is critical that the urban environment maintain and enhance the ability of different species and ages of salmon to not just survive, but thrive, while in these disturbed areas.

Many of the actions we recommend urban communities focus on are the same or similar to those appropriate in less densely developed areas. For example, it is critical to maintain connectivity through properly sized culverts such that all fish can pass through at all relevant life stages. Additional riparian function can be achieved through revegetation efforts using native plants and by improving connectivity between habitat patches. A landscape analysis can help identify existing connections to protect, as well as areas where restoring connectivity is a priority. On the other hand, some actions are particularly well-suited to urban jurisdictions, like standards for Low Impact Development (LID) and state-of-the-art stormwater management. Further, when changes are made to urban infrastructure, this may create opportunities to improve riparian functions while contributing to new or improved public open spaces.

Recommendations for urban riparian ecosystems:

1. Delineate urban RMZs to protect what areas remain and to highlight lost or degraded areas to target for restoration.
2. Quantify current conditions, with a goal of maintaining and improving functions through regulatory and voluntary means.
3. Identify and prioritize restoration opportunities and projects within the RMZ:
    - Protect riparian functions that remain, especially in places that are relatively high functioning; implement actions that enhance degraded functions (see Chapter 4).
    - Prioritize opportunities to maintain and restore in-stream and riparian connectivity.
    - Adopt a stormwater design manual equivalent to Ecology's most current manual for western and eastern Washington.
    - Manage stormwater by adopting Ecology's latest manual regarding LID for new development, redevelopment and retrofit projects.

4. When replacing or removing existing infrastructure within an RMZ:
    - Map RMZ to pinpoint the best sites to restore – consider connectivity and adjacency to other Priority Habitats;
    - Improve aquatic connectivity by replacing culverts and removing barriers to movement;
    - Revegetate with native plants and consider improvements for wildlife by integrating structures necessary for nesting, breeding, and foraging;
    - As infrastructure is remodeled or replaced, incorporate additional setbacks from streams;
    - Control access to RMZ to limit soil compaction;
    - Avoid operating equipment near the stream to reduce sedimentation and soil compaction; and
    - Avoid using chemicals in the RMZ which are not approved for use there by Ecology.

3.4. Managing Watersheds



Tieton River on Oak Creek Wildlife Area in Yakima County, looking west toward the Cascade Mountains./Justin Haug, WDFW

As described in Chapter 8 of Volume 1, land use activities in a watershed can affect the stream network, even when the riparian ecosystem itself is relatively undisturbed. "Watershed management" is a land management approach that seeks to minimize negative effects of upland land uses on aquatic systems, which include riparian areas. The remainder of this chapter focuses on key watershed elements important to managing and protecting functional aquatic systems. Many of the approaches we outline here are non-regulatory and can complement regulatory efforts; as previously stated, we recommend cities and counties inventory current conditions of critical areas and, based on that inventory, develop watershed scale management plans accordingly.

Fully functional riparian ecosystems, in combination with targeted watershed protections, provide significant benefits to humans. These benefits, often described as ecosystem goods and services, include clean water; decreased flooding; increased nutrient cycling, sediment and pollutant filtering; reduced erosion; carbon sequestration; and cultural services such as recreational, spiritual, and other nonmaterial benefits. These services provide real but often unquantified economic benefits to individuals and society that largely go unnoticed until they are lacking.

3.4.1. Watershed-Scale Recommendations to Protect Aquatic Systems

To achieve desired ecosystem goods and services watershed managers should focus on influencing watershed processes that act upon water, wood, sediment, nutrients, vegetation, and pollutants at both the site- and watershed-scale. This section focuses on watershed-scale management.

Restore and Protect Watershed Processes – Efforts to improve watershed conditions should first focus on protecting and restoring watershed processes (e.g., natural disturbances) that create and retain habitat for fish and wildlife. Maintain the frequencies, magnitudes, and durations of natural disturbances (flood and fire being the most common) to the greatest extent that surrounding land uses can tolerate.

Manage Land for Stormwater – Stormwater runoff can change the timing, quality, and quantity of water provided to streams. Land uses should avoid/minimize changes to surface water flows. Protection and restoration efforts should focus on attenuating peak flows and reducing pollutants. Primary tools available to local governments include land use designations/zoning code, and stormwater regulations. See City of Redmond Watershed Management Plan (City of Redmond 2013).



Chum salmon gathered at a blocked culvert in Kitsap County./Brittany Gordon, WDFW

Manage Land for Stream Temperatures – Reduced riparian vegetation cover, decreased streamflow, and simplified stream channels (e.g., increased width-to-depth ratio and reduced groundwater exchange) can lead to increased water temperature (Volume 1, Chapter 4). Modifications like these are often the result of land use activities such as riparian vegetation removal; water diversions; unmanaged livestock grazing; and stream channelization associated with roads, levees, and other forms of development. Identify and restore thermally sensitive stream reaches at the watershed scale to maintain optimal stream temperatures for sensitive aquatic species such as salmonids.

Restore and Protect Connectivity – Manage watersheds to avoid creating longitudinal (e.g., dams, road crossings), lateral (e.g., levees and roads/buildings that cut off riparian areas and floodplains from their stream), and vertical (water withdrawals, reductions of floodplains) barriers to fish and wildlife movement and fragmentation of their habitat. This is especially important for highly mobile species that require a variety of habitat components across large areas. For example, where CMZs interact with floodplains, dikes and levees restrict the movement of the river or stream and also serve as a barrier for fish and many forms of wildlife.

Restoration to correct existing barriers to movement of water, wood, sediment, and species (e.g., removing blocking culverts) is a high priority with proven benefits for salmon. Connectivity to achieve nearly or completely contiguous RMZs is important to water quality and to achieve connectivity among patches. Ensuring connectivity both for terrestrial and aquatic wildlife works towards a more interconnected and healthy riparian system.

Plan for Climate Change – Impending changes to aquatic systems caused by climate change increases risk to species already threatened, and riparian ecosystem protection is one of the most useful responses to ameliorate those risks. For example, because more intense rainfall events will lead to wider streams, larger culverts will be necessary to support fish passage. WDFW, in collaboration with the University of Washington's Climate Impacts Group, created an online tool (UWCIG 2017) that estimates how much a stream's channel width will increase with climate change in the years 2040 and 2080. Connectivity within the RMZ allows voluntary migration for species and helps minimize temperature change and increase off-channel storage of water to reduce low flows.

Conduct Monitoring and Adaptive Management – Monitoring and adaptive management are important elements to both site-scale and watershed-scale; this is addressed further in Chapter 5.

3.4.2. Tools and Key References for Assessing Current Watershed Conditions

Washington's State agencies, including WDFW, have developed multiple tools to assist local government in assessing watershed conditions. Jurisdictions can utilize these resources—many available at no cost—to quantify changes in land cover, tailor planning for specific species, coordinate monitoring activities, inform restoration, and assess watershed health.

WDFW's High Resolution Change Detection (HRCD) is a spatial dataset that characterizes changes in land cover. This tool allows jurisdictions to evaluate in specific ways how watersheds are changing at a sub-parcel scale over 2- to 3-year intervals. This dataset is currently available throughout the entire Puget Sound basin and in some Eastern Washington watersheds. HRCD data is available at https://hrcd-wdfw.hub.arcgis.com/.

WDFW's Priority Habitats and Species program has several resources of interest to watershed planners. In addition to this two-volume document on riparian ecosystems, readers will find useful ideas in Land Use Planning for Salmon, Steelhead and Trout: A land use planner's guide to salmonid habitat protection and recovery (Knight 2009) and Landscape Planning for Washington's Wildlife: *Managing for Biodiversity in Developing Areas* (Azerrad et al. 2009).

Since 2004, the Pacific Northwest Aquatic Monitoring Partnership has collaborated with West Coast federal, state, and tribal agencies to coordinate monitoring activities and develop common approaches. This partnership provides best practices, mapping tools, and protocols, and serves as a voluntary clearinghouse for a wide variety of monitoring projects.

Since 2009, Ecology's Watershed Health Monitoring Project has been monitoring sites throughout the state to assess watershed health. This project's protocols can be adapted by jurisdictions and scaled to watersheds of various sizes. Data is stored in the Environmental Information Management database. This sophisticated database allows users to input and retrieve data via the web, reliably store it, and make it available for analysis. Quality assurance/quality control measures ensure data put into the database are of high quality.

Ecology's Puget Sound Watershed Characterization is a Puget Sound-wide tool that compares areas based on their suitability and value for restoration and protection. This tool informs two fundamental questions: (1) where to focus protection and restoration on the landscape first, and (2) what types of activities and actions (i.e., restoration, protection, conservation, or development) are most appropriate to that place. With insights gained by this tool, decision-makers can incorporate information regarding watershed processes to improve plans (e.g., comprehensive plans, subarea plans, CAOs, stormwater plans) and conservation efforts (e.g., in-lieu fee programs, open space tax credits, open space land acquisitions).

In 2016, the Washington Department of Commerce (Commerce) published Building Cities in the Rain (Ballash 2016) to help communities improve watersheds while redeveloping and revitalizing urban areas. The guidance describes an optional three-step process for prioritizing watersheds for stormwater retrofits in urban areas. Commerce's Puget Sound Mapping Project uses an interactive map to help users develop insights about how current and expected development patterns might affect the region's environmental health. The tool is designed to help decision makers consider information from the Puget Sound Watershed Characterization (described above) when making decisions regarding development projects, urban growth boundaries, and compensatory mitigation.

Finally, the University of Washington's Climate Impacts Group has developed a suite of tools, many in concert with WDFW, which may be useful for landowners and land use decision makers including climate trends, culvert design projections, and habitat connectivity.

Chapter 4. Restoring Riparian Ecosystems

4.1. Introduction

This chapter provides high-level guidance to landowners, land use decision makers, and conservation partners to promote restoration of riparian areas. Despite recent efforts to protect existing riparian systems, imperiled salmon stocks and other riparian dependent endangered species are not recovering as hoped (Table 4.1). Since non-indigenous settlement of Washington began in the 1800s, between 50 percent and 90 percent of riparian ecosystems have been lost or extensively modified (RCO 2019). While two subspecies (Hood Canal summer chum and Snake River fall Chinook) are moving towards recovery, most listed salmon in Washington are below recovery goals (Table 4.1).

The lack of recovery is also evidenced in the ongoing decline of salmon fishing, which affects the long-term health of Washington's tribes, Washington's economy, and our shared cultural heritage. The lack of salmon is one of the primary reasons Southern Resident Killer Whales are at risk of extinction, in addition to other impacts such as vessel disturbance and pollutants. (Lacy et al. 2017, Murray et al. 2019)

Table 4.1. Non-statistical evaluation of natural origin (wild) fish that returned to spawn with consideration for threats and factors affecting health including habitat, harvest, and hydropower. (Adapted from RCO 2019; Data sources: WDFW, Indian tribes, NOAA).

Below Goal (Endangered Species Act-Listed Salmon in Washington)			**Near Goal**
Getting Worse	*Not Making Progress*	*Showing Signs of Progress*	*Approaching Goal*
Upper Columbia River Spring Chinook	Upper Columbia River Steelhead	Mid-Columbia River Steelhead	Hood Canal Summer Chum
	Lower Columbia River Chum	Lake Ozette Sockeye	
	Lower Columbia River Coho	Lower Columbia River Steelhead	
Puget Sound Chinook	Lower Columbia River Fall Chinook	Snake River Steelhead	Snake River Fall Chinook
	Lower Columbia River Spring Chinook	Puget Sound Steelhead	
	Snake River Spring Chinook		
	Snake River Summer Chinook		



Former lake-bed above the area where the Glines Canyon Dam once stood on the Elwha River, Clallam County. Following dam removal, salmonids returned even faster than expected./Rachel Blomker, WDFW

Given the extent of historical loss, WDFW recognizes that protection alone of remaining riparian ecosystems, will not recover salmon or the Southern Resident Killer Whale population. Therefore, WDFW recommends restoring and enhancing riparian ecosystems to achieve healthy, intact, and fully functioning riparian systems statewide. Continued investments in restoration will be required at all levels of government and in concert with Washington tribes.

4.2. Restoration Actions

Although this section focuses on restoring riparian areas for the benefit of salmon, emulating historical conditions benefits many other aquatic and terrestrial species as well. WDFW is available to provide technical assistance and species-specific guidance for terrestrial species-focused restoration and recovery efforts. To recover salmon, we must protect all remaining existing riparian and watershed functions, while seeking opportunities to restore functions that have been lost over time. We provide the following information to assist the restoration community[10] in understanding what is important to restore.

4.2.1. Developing a Restoration Strategy

Aquatic restoration strategies typically start with a clear set of goals and objectives. The selection of appropriate restoration strategies is informed by the political, social, and ecological context of the watershed, and bounded by the extent of opportunities and constraints. It is important in ecosystem restoration to consider the habitat attributes and scale necessary for a desired suite of species, be they aquatic or terrestrial. At a watershed scale, restoration efforts should focus first on projects that offer the greatest potential for success. The Stream Habitat Restoration Guidelines (Cramer 2012) suggest the following prioritization of stream habitat restoration strategies that are specific to instream related activities most often geared at anadromous fish:

1. **Protect existing habitat.** Protect areas that provide healthy, high-quality habitat functions (strongholds, refugia, and key sub-watersheds) to prevent further degradation. Secure, expand, and link protected areas.

2. **Connect habitat.** Connect and provide access to isolated habitat, including instream, off-channel, and estuarine habitat made inaccessible by culverts, levees, fragmentation, or other man-made obstructions.

3. **Restore habitat-forming processes.** Employ land use recovery and watershed restoration techniques to restore processes that create, maintain, and connect habitats (including restoring sediment dynamics, large wood dynamics, and flow regimes; avoiding/removing manmade disturbances within the riparian ecosystem; and maintaining water quality, floodplain connectivity, and channel evolutionary processes). Employ a combination of active or passive restoration techniques, as necessary. Active restoration involves accelerating processes or attempting to change the trajectory of succession; passive restoration simply involves ceasing environmental stressors such as agriculture, grazing, or timber harvest, and then allowing nature to take its course.

10 Many watersheds in Washington have salmon recovery restoration goals that can be obtained from regional Salmon Recovery Boards or Lead Entities for Salmon Recovery. Lead Entities and Salmon Recovery Boards are in every region of the state, including those areas without salmon or other anadromous fish (https://www.rco.wa.gov/salmon_recovery/regions/regional_orgs.shtml).

4. **Create new or enhance existing habitat.** Improve existing or create new habitat for specific species by installing instream structures such as large woody debris; reconfiguring channel shape, cross-section, or profile to reduce incision or restore flow; or constructing one or more new side channels.

In conjunction with other state agencies and partners, WDFW provides multiple technical guidance documents to help design and implement riparian restoration projects that have proven successful in different types of landscapes, including on marine shorelines, and on river- and streambanks. These are part of a suite of Aquatic Habitat Guidelines found at https://wdfw.wa.gov/licenses/environmental/hpa/application/assistance. They include:

- Water Crossing Design Guidelines (Barnard et al. 2013)
- Stream Habitat Restoration Guidelines (Cramer 2012)
- Integrated Streambank Protection Guidelines (Cramer et al. 2002)
- Land Use Planning for Salmon, Steelhead and Trout: A land use planner's guide to salmonid habitat protection and recovery (Knight 2009)
- Draft Fishway Guidelines for Washington State (Bates 2000)
- Draft Fish Protection Screen Guidelines for Washington State (Nordlund and Bates 2000) Marine Shoreline Design Guidelines (Johannessen et al. 2014)
- Your Marine Waterfront (WDFW 2016)
- Protecting Nearshore Habitat and Functions in Puget Sound (AHGP 2010)

4.3. Implementing Riparian Strategies Through Incentives

There are several types of conservation incentives available to individuals and local governments:

- **Financial assistance:** grant programs that provide funding for conservation activities
- **Tax adjustment:** tax reductions for landowners undertaking conservation activities
- **Technical assistance:** advice and/or hands-on help for landowners on tools or techniques
- **Recognition:** promotion of landowners who undertake conservation actions

Each of these will be described (and examples provided) in more detail, below.

4.3.1. Financial Assistance

State and federal grant funds are available for riparian ecosystem conservation and restoration projects on public and private lands through the Recreation and Conservation Office (RCO) and Salmon Recovery Funding Board. To access these funds and to learn more, go to https://www.rco.wa.gov. Grant programs include:

- Aquatic Lands Enhancement Account
- Washington Wildlife and Recreation Program (Farmland, Forestland, Habitat, and Recreation categories)
- Estuary and Salmon Restoration Program—a program of WDFW
- Land and Water Conservation Fund
- Salmon Recovery and Puget Sound Acquisition and Restoration

Land trusts also help land owners conserve habitat for key aquatic and terrestrial species, often leveraging funds from foundations and other non-governmental sources; see www.walandtrusts.org for a county-specific list of land trusts.

For agricultural property owners, local conservation districts and the Washington State Conservation Commission (WSCC) can provide technical assistance to find an approach that works for the farmer and improves riparian ecosystem function. Technical assistance is also available from the federal Natural Resources Conservation Service (NRCS), Washington State University Extension, and WDFW. Additionally, a host of state and federal financial incentives to expand and maintain riparian functions within the riparian management zone (RMZ) are available, some of which are listed below. For example, the Conservation Reserve Enhancement Program (CREP) provides funding to landowners for riparian preservation and is the most successful riparian buffer program in Washington. Since CREP's 1999 inception in our state, more than 900 miles of stream buffers have been planted, and as of October 2020, producers had over 13,500 acres actively enrolled in CREP. Contact your local conservation district or the RCO to learn more.

- Conservation Reserve Enhancement Program (NRCS)
- Environmental Quality Incentives Program (NRCS)
- Conservation Stewardship Program (NRCS)
- Conservation Reserve Program (NRCS)
- Regional Conservation Partnership Program (NRCS)
- Agricultural Conservation Easement Program (NRCS)
- Agricultural Land Easements (NRCS)
- WWRP Farmland Preservation Grants (RCO)

Timber landowners have access to a variety of forestry-oriented conservation incentive programs (see list, below) and can also receive technical assistance from DNR's Forest Stewardship Program (foreststewardship@dnr.wa.gov, 360-902-1428):

- Forestry Riparian Easement (DNR)
- Rivers and Habitat Open Space Program (DNR)
- Healthy Forests Reserve Program (NRCS)
- Family Forest Fish Passage Program (DNR)
- Forest Legacy (USFS)
- WWRP Forestland Preservation Grants (RCO)



The federal Conservation Reserve Enhancement Program (CREP) funded this vegetation planting project along a stream in Skagit County./Wendy Cole, WDFW

4.3.2. Tax Reduction Incentives

Landowners can receive a substantial tax reduction by converting land into "open space" status because of the Open Space Taxation Act (WAC 458-30), enacted in 1970. Lands with riparian areas often qualify for this incentive; see your county assessor and local planning department for details.

4.3.3. Technical Assistance

Local governments and individual landowners who want to improve riparian habitat for a suite of species can request land use advice from a variety of sources, including:

- WDFW regional habitat and district wildlife biologists. Go to http://arcg.is/1SgsHqk to find the names and direct contact information for your local biologists, or call the regional office in your area:
  - Region 1 – Eastern: 509-892-1001
  - Region 2 – North Central: 509-754-4624
  - Region 3 – South Central: 509-575-2740
  - Region 4 – North Puget Sound: 425-775-1311
  - Region 5 – Southwest: 360-696-6211
  - Region 6 – Coastal: 360-249-4628
- Salmon Recovery Lead Entities or Regional Fisheries Enhancement Groups
- Tribal natural resource departments
- Local Conservation Districts



4.4. Suggested Restoration Practices

The following section provides a series of suggested restoration practices promoted by WDFW, other state and federal agencies, and conservation partners. We encourage consideration of these activities and others within and adjacent to the RMZ, as delineated in accordance with our recommendations in Chapter 2. Further, it is not unusual to find other types of Priority Habitats (e.g., wetlands, shrub-steppe) adjacent to riparian areas. In such cases, restoration practices should not degrade or disturb the adjacent habitat, but rather—if feasible—improve it in addition to improving the riparian habitat. The same approach should be used where riparian-adjacent Priority Species areas are present.

Like most restoration practices, the ones recommended below can range in complexity, both biologically and technically, so landowners are strongly encouraged to seek technical assistance from WDFW and other experts before taking any action: This will help save money, time, and greatly increase the likelihood of success for any restoration activity. Landowners should also be aware that many of these activities may require permits[11,12] issued by one or more

11 The Governor's ORIA Office provides additional assistance for general permitting questions (https://www.oria.wa.gov/site/alias__oria/347/Permitting.aspx)
12 Larger projects may also trigger permit requirements with federal agencies, such as the U.S. Army Corps of Engineers (USACE).

agencies such as WDFW for the Hydraulic Code rules, and DNR for the Forest Practices rules; as well as permits from the local jurisdiction.



Cooperative riparian enhancement project led by the Lower Columbia Fish Enhancement Group along the Toutle River, Cowlitz County/Josh Nicholas, WDFW

1. Improve quality of vegetation for both aquatic and terrestrial wildlife by removing invasive species wherever present. Further, to avoid the likely return of invasive species, cleared areas should be replaced with native riparian vegetation: specifically, native vegetation that provides needed ecosystem functions as described in Volume 1 and throughout this document (e.g., shade, large wood, pollution removal).

2. Where riparian areas already possess some native vegetation, enhance them with a greater mixture of native plants that provide necessary habitat components (forage, cover, breeding, roosting, etc.) for a diversity of species and multiple riparian functions (e.g., streambank stability, wood recruitment, organic litter input, and pollutant removal). The specific mix of vegetation will vary by ecoregion and local needs, but likely includes conifers, grasses, and herbaceous plants.

3. Increase off-channel habitat and improve natural flow regimes by removing dikes or levees and restoring access to and within the floodplain.

4. In areas of incised channels, reintroduce beaver or construct beaver dam surrogates to store sediments, raise streambed elevation, raise water table elevation, and restore riparian vegetation.

5. Remove reed canary grass, which can greatly inhibit channel morphology and aquatic species movement. (Management techniques for reed canary grass vary and are often site-specific: contact your local WDFW regional habitat biologist for technical assistance.)

6. Through proper consultation with WDFW and tribal biologists, increase the presence of large wood in streams and rivers to improve habitat for salmon, resident fish species, and aquatic amphibians.

7. Increase connectivity through removal of non-fish passing culverts. If replacement culverts are needed, ensure they are adequately sized and climate-change-resilient; see WDFW's online resource on Incorporating Climate Change into the Design of Water Crossing Structures (Wilhere et al. 2016).

8. Reduce soil erosion by increasing vegetation complexity and density, excluding (or substantially minimizing) soil compacting activities, and implementing upland soil management techniques where applicable.

9. For agricultural operators: add and/or improve fencing structures to increase the amount of riparian area acreage from which livestock are excluded to reduce compaction, erosion, and overgrazing.

Chapter 5. Improving Protection Through Adaptive Management

5.1. Introduction

Adaptive management is widely recognized as an essential component of effective natural resource management because it provides a systematic process for continually improving policies and management through outcome-based learning. The adaptive management process is a continual cycle of planning, acting, monitoring, evaluating, and adjusting (Figure 5.1). This feedback loop provides information for making adjustments that focus on improving decisions in all phases of resource management. The utility of adaptive management programs should be considered by conservation practitioners, landowners, and land use planners to ensure that conservation actions achieve desired outcomes: in the case of this document, that means preserving, protecting, and restoring healthy, intact, and fully functioning riparian areas. In addition to improving ecosystem outcomes, adaptive management should improve clarity of regulations–resulting in increased transparency to all stakeholders.

All cities and counties are currently protecting critical areas, including riparian ecosystems, through a variety of regulatory and non-regulatory mechanisms. One regulatory challenge is understanding how well these mechanisms meet their intent of protecting ecosystem functions and values and how to make improvements where they are falling short. This chapter was written in collaboration with the Washington Department of Commerce (Commerce) and relies heavily on the Commerce's 2018 update of the Critical Areas Ordinance Handbook (Bonlender 2018), with one exception, as noted.

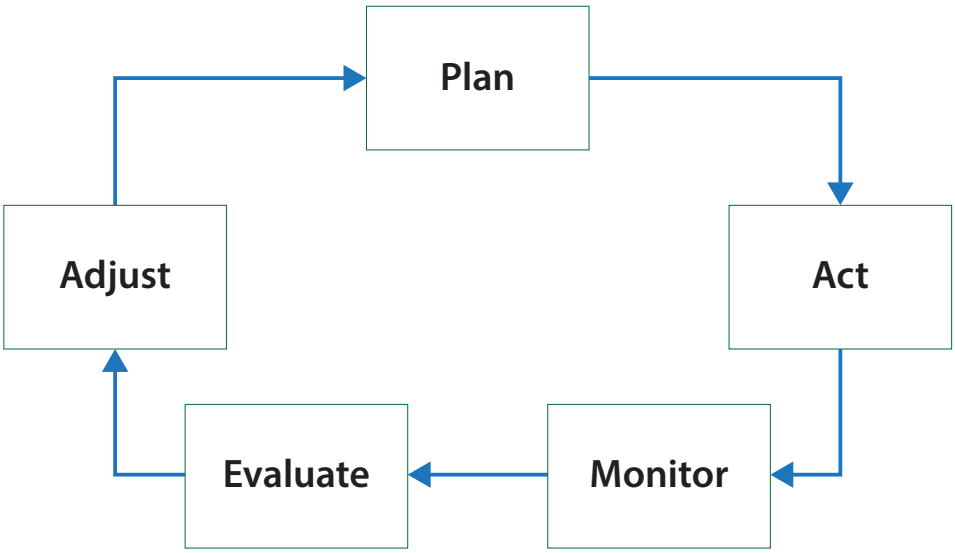


Figure 5.1. A simple depiction of the adaptive management cycle (modified from Bormann et al. 1994).

The process for monitoring we describe here supports both local and larger-scale actions that improve our collective efforts to protect riparian ecosystems throughout the state. For example, the Puget Sound Partnership (Partnership) uses "Vital Signs" of ecosystem health and recovery, such as riparian forest cover, to understand ecosystem condition, articulate shared goals and progress, and inspire action towards meeting those goals.

Adopting an adaptive management program can allow local governments to respond more quickly and meaningfully as new information become available. A willingness to address issues identified through this process is critical to the idea of adaptive management.

5.2. Common Questions Addressed by Adaptive Management

Adaptive management does not have to be expensive or complicated to be useful. We believe local jurisdictions can maximize their investment in adaptive management by focusing on two types of monitoring related to their own regulatory process (explained in more detail in the next section).

We begin by discussing three basic types of monitoring because we have found it instructive to understand how different monitoring types can be hierarchically or sequentially staged, based on the types of questions they seek to answer: implementation monitoring[13], effectiveness monitoring , and validation monitoring.

5.2.1. Implementation Monitoring

Implementation monitoring typically helps the permit issuer (permittor) answer the following questions about its permitting system, by looking at the outcomes of individual permits:

- Are permits consistent with regulations?
- Do permits contain all necessary conditions or provisions for a project?
- Does the permittor issue consistent permits (same requirements) for all permittees?

Implementation monitoring can also include:

- Permit *compliance monitoring,* which asks if the permitte followed or complied with each permit condition or provision and refrained from conducting unpermitted activities. Compliance monitoring usually takes place very soon after completion of permitted work.
- Keeping track of unpermitted activities; that is, finding changes in land use or management that require a permit but where no permit of any kind was issued.

13 As explained further in Section 5.2.2, we describe and use the term effectiveness monitoring somewhat differently than how it is described in Commerce's 2018 Critical Areas Handbook.



Fast-growing alder trees, like these shown in a low area along the Methow River in Okanogan County, can improve bank stability and increase summer shade more quickly than most conifers./Scott Fitkin, WDFW

5.2.2. Effectiveness Monitoring

In Commerce's 2018 Critical Areas Handbook, effectiveness monitoring is a form of long-term implementation monitoring. In other words, effectiveness monitoring looks at permit compliance as a while to determine whether permit conditions/provisions (e.g., buffer widths) are followed over time.

For the purposes of this document, we describe effectiveness monitoring a bit differently: Specifically, effectiveness monitoring is a way to determine whether permit conditions/provisions are working relative to intended environmental outcomes. For example, "Are permit conditions/provisions leading to the riparian function(s) (e.g., shade, bank stability) that they were intended to provide?" Effectiveness monitoring typically involves some on-the-ground measurement of environmental variables affected by land use activities.

5.2.3. Validation Monitoring

Research within the adaptive management framework is often referred to as validation monitoring. In the context of land use regulations, the questions relate to how management of critical areas (e.g., riparian) affects the specific environmental resource it was intended to protect (e.g., water quality, salmon). Validation monitoring may be beyond the fiscal means of most local governments. Moreover, it often involves questions that must be addressed over large spatial extents (e.g., at watershed or multi-watershed scale). In comparison, implementation and effectiveness monitoring are often tied to local jurisdiction's regulatory processes at the site scale: For these reasons, the next two sections focus more on these two types of monitoring.

5.3. Recommended Implementation Monitoring Efforts

We advise local governments to focus first on using implementation monitoring to evaluate their regulatory processes that affect riparian ecosystems. Implementation monitoring tracks execution of the permitting system from the perspective of both the permit issuer (permittor) and permit holder (permittee) (Figure 5.2). This effort can result in regular status reports that help demonstrate how well local governments and permittees are working together to meet resource objectives in a fair and consistent manner.

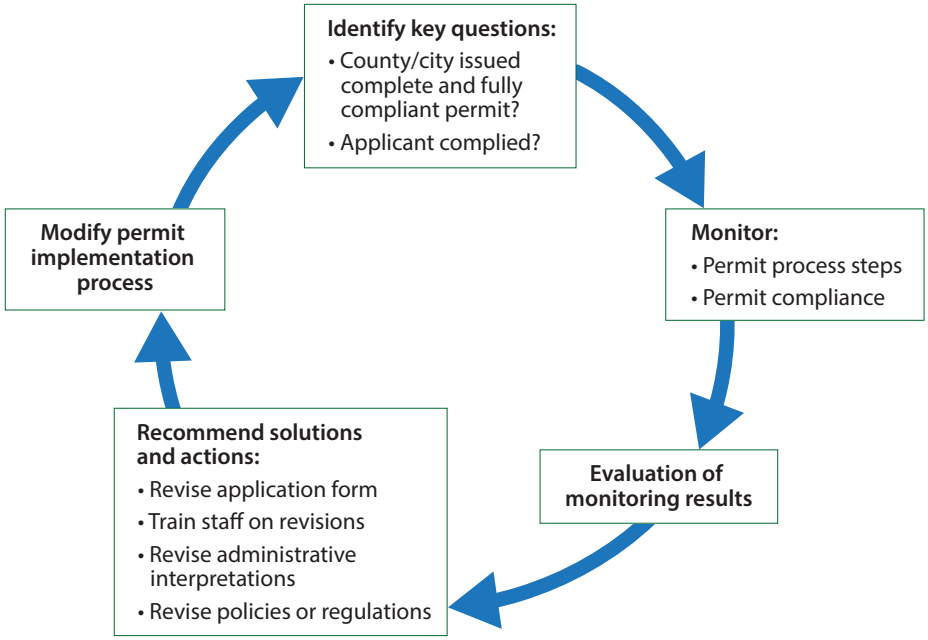


Figure 5.2. Depiction of the adaptive management cycle specific to permit compliance.

Implementation monitoring provides key information for permitting process improvement (5.2; Table 5.1). Even in situations where local governments cannot monitor all steps in their permitting process, monitoring any step—regulations to permit conditions/provisions, permit provisions to construction, construction to inspections, or inspections to enforcement—can provide valuable feedback about the quality of regulatory processes.

Monitoring does not have to be complicated. Even if a city or county chooses to do only permit implementation monitoring, this will provide key information that can improve the permit process, and an individual landowner can check whether choices like enhancing native plantings produce the desired results.

Table 5.1. Key questions for implementation monitoring during the Critical Areas permit review process.

Process Steps	Key study questions to evaluate permit implementation	Proposed metrics
Application	Was adequate information gathered from the permit applicant? Did the local government provide timely and necessary technical assistance to the permit applicant?	Number and percent of complete applications. i.e., include all information necessary to issue a permit. Number and percent by type of permit applications missing information.
Permit	Do permit provisions follow the local government code?	Number and percent of permit provisions by type consistent with code.
Permit	Do permit provision identify intent of protection and how it can be accomplished? (e.g., area of tree retention, distance of structure from stream, clearing, grading, or storm water provisions, replanting requirements, extent of impervious surface.)	Number and percent of (complete) permits (i.e., include all provisions that enable a permittee to be fully compliant with the permit). Number, percent, and type of missing provision/ information.
Permit (variance)	If a variance was granted, is the reason for the variance clearly stated?	Percent of variances by type justified by code or policy. Percent of permits with variances by type.
Permit (mitigation)	If compensatory mitigation was required, were the unavoidable impacts clearly identified/quantified? Was the rationale clearly stated?	Number and percent of permits by type with unavoidable impacts. Percent of permits by type with quantified mitigation requirements
Compliance	Post-Construction Visit: Did the permittee comply with the permit? (Requires field measurements of some or all the provisions in the permit. For riparian ecosystems, key provisions to inspect include RMZ width, retention of trees, replanting, structure distances from stream, area of impervious surface, and implementation of storm water provisions.)	Number and percent by type of provision that were out of compliance.
Enforcement	Are enforcement actions necessary to meet permit provisions and/or the regulations?	Number and percent by type of permit enforcement actions.

Because little or no fieldwork is required, the easiest and least expensive step to monitor is the link between regulations and permit provisions: that is, whether local land use regulations have been translated into permit provisions that can be understood easily by permittees. We recommend that some implementation monitoring become part of all local regulatory programs, even if it only on a relatively small subset of permits selected at random. A database for storing information on each step (i.e., a permit tracking system–see Table 5.1, Figure 5.3) is a critical tool for creating a complete system of accountability.

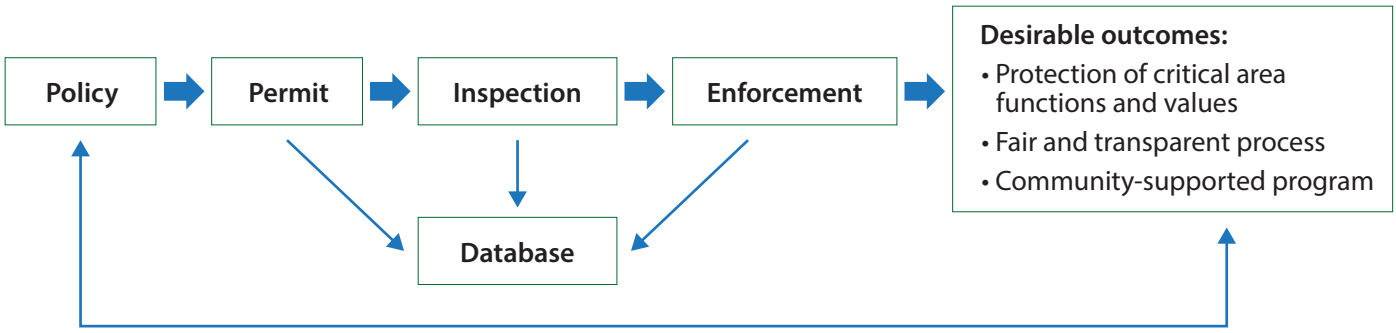


Figure 5.3. One system of permit accountability that includes implementation monitoring of internal permit processes, inspection for permit compliance, a database from which to judge outcomes, and a feedback loop connecting outcomes with policy intent.

Long-term implementation monitoring can help answer additional questions, such as: "Are rules/regulations intended to provide long-term protection of critical areas (e.g., RMZs) actually followed or maintained over time?" One way to answer this is by looking at changes in land cover, which describes the type and amount of vegetation, roads, and buildings occurring on the landscape. By comparing high quality aerial photographs taken of the same locations over time, change can be quantified and attributed to specific activities, both from natural disturbances (e.g., wildfires, river channel migration) and human activities (e.g., timber harvesting, residential subdivision construction, highway widening). In Section 5.5, we describe one such process WDFW developed and for which information for many parts of the state are already available.

5.4. Effectiveness of Regulatory Protections of Critical Areas

Where implementation monitoring has been successful, that is, either documenting a highly functional permitting process or improving poorly performing permitting process, we encourage additional effort on effectiveness monitoring. As described above, our primary goal for effectiveness monitoring would focus on understanding how well the permit conditions/provisions lead to measurable outcomes on the ground (e.g., protection/restoration of one or more riparian functions or values) over an extended period.

5.5. Using Land Cover Change to Understand Long-term Regulatory Protection

High Resolution Change Detection (HRCD) is a tool that is useful for detecting changes in two specific types of land cover (tree canopy and impervious surfaces) over set time periods. Land cover change analysis like HRCD can show jurisdictions the degree to which critical area regulations are maintaining RMZs as intended. This information can then help shape if, where, why, and how adjustments to permitting processes should occur. By combining land cover change analysis with targeted questions about permitting processes, jurisdictions can begin to adaptively manage changes to their overall regulatory system.

Adaptive Management Framework in the Voluntary Stewardship Program

The Voluntary Stewardship Program (VSP) was authorized by the Legislature in 2011 through RCW 36.70A.705. The goals of VSP are to protect and enhance critical areas where agricultural activities are conducted, maintain and improve the long-term viability of agriculture in the State of Washington, and reduce conversion of farmland to other uses. The program provides counties with an alternative approach from traditional development regulations that require protection (and encourage enhancement) of critical areas at the individual parcel scale. Instead, VSP relies upon voluntary practices and incentive programs to protect (and enhance) at a watershed scale. Counties "opted-in" to VSP, and as of 2019, 27 of the state's 39 counties are participating.

Under VSP, local workgroups created work plans that include benchmarks for protection and enhancement of critical areas designed to be achieved through voluntary and incentive-based actions. VSP requires monitoring and adaptive management to maintain and enhance critical areas, including riparian ecosystems, and directs workgroups to monitor at the watershed or sub-watershed scale. Key requirements for county-level programs include:

1. Establishing a durable system to track and report goals, benchmarks, and performance metrics.
2. Developing implementation and effectiveness monitoring programs and conducting monitoring on a pre-determined schedule.
3. Establishing an adaptive management program with (a) "triggers"; (b) subsequent actions to take; and (c) a process to review/update both the triggers and actions over time.
4. Reporting on the achievement of protection and enhancement goals and benchmarks at specified intervals.

Numerous counties have utilized WDFW's recommended VSP Adaptive Management Matrix in approved VSP Work Plans. Examples include:

- Chelan County, Appendix I (Approved April 2017)
- Grant County, Tables 5-7 through 5-10 (Approved June 2017)
- Asotin County, Tables 5-3 through 5-5 (Approved May 2018)
- Okanogan County, Chapter 6 (Approved September 2018)
- Spokane County, Section 4 (Approved November 2018)

Jurisdictions can adapt matrices as templates for connecting goals, benchmarks, performance metrics, monitoring, and adaptive management for other uses beyond VSP. These matrices can be modified as frameworks to identify specific elements of any adaptive management plan.

The example in the following section is adapted from Commerce's Critical Areas Handbook (Bonlender 2018). Chapter 7 of that document provides a number of similar monitoring program examples, nearly all of which were developed by cities or counties.

5.5.1. Example: WDFW/Thurston County Shoreline Master Program

In 2015, Thurston County and WDFW utilized a National Estuary Program grant to quantify shoreline vegetation, land cover change, and evaluate land use permit compliance. Specifically, Thurston County used WDFW's HRCD data to monitor compliance within the County's Shoreline Master Program (SMP) jurisdiction. This project developed a protocol manual for using HRCD for this purpose, available to all jurisdictions within the Puget Sound region.

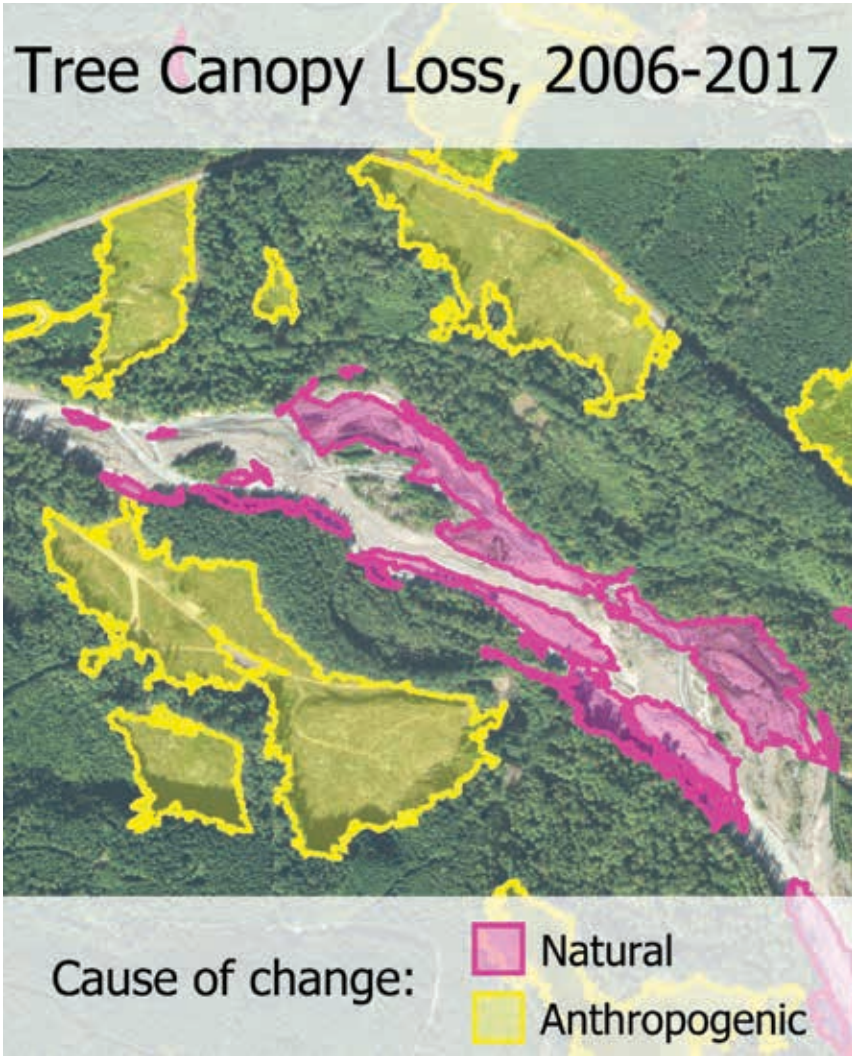
One goal of the pilot project was to answer several related sets of questions:

For Thurston County:

- What land cover change is happening within designated SMP areas? What change is happening throughout the Deschutes River watershed (WRIA 13)?
- How does change known by permit records compare with detected changes by HRCD?
- What changes, if any, can be made to the land use permits or permitting process that could increase the relevancy or efficacy in utilizing the HRCD in compliance monitoring?

For WDFW:

- How well can HRCD detect changes relative to land use permit records?
- Using Thurston County's SMP area as an example test area, what land cover changes are happening which HRCD is not capturing?
- With the development of a HRCD user manual, can HRCD be successfully utilized by other entities in the absence of direct assistance by WDFW?



High Resolution Change Detection (HRCD) analysis showing changes in tree canopy along and above a river in Thurston County. Pink polygons show where trees that existed prior to 2017 are no longer standing, apparently due to natural causes (e.g., where the river meandered). Yellow polygons show places where trees were removed as a result of timber harvesting./HRCD team, WDFW

The pilot quantified increases in impervious surfaces and decrease in tree canopy within marine areas of the SMP jurisdiction and checked for relevant permits issued. It consisted of five phases:

Phase 1: Initial SMP Change Analysis: Staff from WDFW's Habitat Program and the County's Long-Range Planning Department intersected the HRCD dataset with the County's SMP area and tax parcel data within ArcGIS for three time periods of HRCD availability (2006 to 2009, 2009 to 2011, and 2011 to 2013). Staff compared known areas of change to those locations with the county's land use permit records to find locations of observed change via HRCD without any permit record. During this phase, land cover change statistics were also produced, including total area of change and discrete occurrences of land cover change events.

Phase 2: Learning What the HRCD Misses: Using the SMP area in the County, WDFW staff manually looked for land cover changes not captured by the HRCD analysis, to understand how accurate HRCD was in capturing all land cover change situations (rates of omission error).

Phase 3: Developing a Standardized Method for Utilizing the HRCD: A major goal of this project was to develop support materials for others to be able to utilize HRCD to answer land use management questions independent of WDFW staff assistance. Using lessons learned in Phases 1 and 2, WDFW and the County agreed upon a recommended method for applying HRCD to a specific management question, and collaboratively developed a "how-to" manual. In this phase, WDFW staff also developed a web-based service (https://hrcd-wdfw.hub.arcgis.com) where users can download the HRCD dataset, detail the methodology of HRCD construction, find WDFW contact information, and more.

Phase 4: Testing the Manual through Remaining SMP Analysis in WRIA 13: Using only the HRCD dataset and the manual produced in Phase 3, County staff examined land cover change within the remaining SMP areas within WRIA 13 successfully for the same three time periods that HRCD data was available and utilized in the earlier phase.

Phase 5: Training and Outreach: With the lessons learned and products derived from Phases 1 through 4 of the project, staff worked in conjunction with the Coastal Training Program, managed by Ecology, to develop and deliver a workshop for planning staff within other state agencies, local governments, and some non-governmental organizations. WDFW also used this opportunity to train internal staff on the benefits, limitations, and uses of HRCD.

The evaluators analyzed land cover change within Thurston County's SMP area between 2006 and 2013, pulling permit records from timeframes that corresponded with the available HRCD datasets. The project's findings were very helpful, not only because of the information collected, but also in providing proof of concept for several of the steps/tools. For example: The utility of HRCD in analyzing patterns of land cover change in a specific geographic area of concern were well demonstrated. The HRCD analysis found that, from 2006 to 2013, less than half of one percent (0.39%) of the riparian area contained within the SMP had land cover change – approximately two-thirds of this was due to canopy loss, with one-third due to new impervious surfaces. The HRCD analysis did not find any permitted developments that were out of compliance, though it did find unpermitted events (e.g., tree removal) in each time period studied.

Furthermore, the HRCD dataset proved to be relatively simple to use. With the development of standard application methods, Thurston County was able to complete an analysis of their remaining SMP area without any further assistance from WDFW.

On the flip side, Thurston County found that comparing actual permit compliance with HRCD data was "tedious and difficult" because of limitations with the county's permit tracking database. For example, in many cases, land use permits did not include enough information to determine conclusively that a parcel with observed change via HRCD was out of compliance or determine that the parcel had a permit record during the study's timeframe in question.

Local governments can use HRCD analysis at the start to find land cover changes that are otherwise unknown; as they begin to understand patterns, HRCD analysis provides indications to identify locations that warrant closer investigation through other methods.

5.6. Conclusion

Implementation and effectiveness monitoring are important parts of adaptive management and can be undertaken relatively easily by local governments. Many of our riparian ecosystems are already degraded and stressed, so it is worth our while to investigate whether the actions put in place to protect them are being carried out as required and leading to the specific environmental responses that were intended. This is now more important than ever, because in spite of advances in science and efforts to improve regulatory processes, climate change and population pressures are increasingly confronting many parts of the state. Using monitoring and adaptive management to track successes and failures and then learning from both will make our challenges easier to overcome.



To install the lawn seen on the right of this photo, all vegetation was removed from the riparian area except a single row of cottonwood trees at the water's edge./Jennifer Nelson, WDFW

Literature Cited

Volume 1 serves as the primary source and citation for this document:

Quinn, T., G. Wilhere, and K. Krueger (managing editors). 2020. Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications. Habitat Program, Washington Department of Fish and Wildlife, Olympia, Washington.

Anderson, P.S., S. Meyer, P. Olson, and E. Stockdale. 2016. Determining the ordinary high water mark for Shoreline Management Act compliance in Washington State. Publication No. 16-06-029. Washington State Department of Ecology, Olympia, Washington. (https://fortress.wa.gov/ecy/publications/documents/1606029.pdf)

Arid Lands Initiative. 2014. The Arid Lands Initiative: shared priorities for conservation at a landscape scale. Summary prepared by S.A. Hall and the Arid Lands Initiative Core Team. SAH Ecologia LLC, Wenatchee, Washington. Available at (https://www.sciencebase.gov/catalog/file/get/546d0a6ae4b0fc7976bf1db0?f=__disk__ab%2Fd6%2F7d%2Fabd67df8a73f48f87922d184ffec6e9b8dac635c)

Ashcroft, M.B. 2010. Identifying refugia from climate change. Journal of Biogeography 37:1407-1413.

Azerrad, J., J. Carleton, J. Davis, T. Quinn, C. Sato, M. Tirhi, G. Wilhere, and S. Tomassi. 2009. Landscape planning for Washington's wildlife: managing for biodiversity in developing areas. Habitat Program, Washington Department of Fish and Wildlife. Olympia, Washington. (https://wdfw.wa.gov/publications/00023)

Ballash, H. 2016. Building cities in the rain. Washington State Department of Commerce. Olympia, Washington. (https://www.ezview.wa.gov/site/alias__1780/overview/34828/overview.aspx)

Barnard, R. J., J. Johnson, P. Brooks, K. M. Bates, B. Heiner, J. P. Klavas, D.C. Ponder, P.D. Smith, and P. D. Powers. 2013. Water crossings design guidelines. Habitat Program, Washington Department of Fish and Wildlife, Olympia, Washington. (https://wdfw.wa.gov/publications/01501)

Bermingham, B., C. Douglas, B. Floyd, D. Koellmann, P. Mugunthan, and J. Small. 2013. Final draft semi-arid riparian functions and associated regulatory protections to support shoreline master program updates. Anchor QEA LLC., Kennewick, Washington.

Bonlender, B. 2018. Critical area handbook: A handbook for reviewing critical areas regulation. Washington State Department of Commerce, Olympia, Washington. (https://www.commerce.wa.gov/serving-communities/growth-management/growth-management-topics/critical-areas/)

Bormann, B.T., P.G. Cunningham, M.H. Brookes, V.W. Manning, and M.W. Collopy. 1994. Adaptive ecosystem management in the Pacific Northwest. PNW-GTR-341. U.S. Forest Service, Pacific Northwest Research Station, Portland, Oregon.

BLM (Bureau of Land Management). 2015. Riparian area management: proper functioning condition assessment for lotic areas. Technical Reference 1737-15. BLM, National Operations Center, Denver, Colorado.

City of Redmond. 2013. City of Redmond, Washington citywide watershed management plan. Prepared by Herrera Environmental Consultants, Inc. Seattle, Washington. (https://www.redmond.gov/DocumentCenter/View/11707/Watershed-Management-Plan-2013-PDF)

Cordell, H. K., D. Murphy, K.H. Ritters, and J.E. Harvard III. 2005. The natural ecological value of wilderness. Pages 205-249 in H.K. Cordell, J.C. Bergstrom, J. M. Bowker (editors). The Multiple Values of Wilderness. Venture Publishing, State College, Pennsylvania.

Cramer, M.L. (managing editor). 2012. Stream habitat restoration guidelines. Co-published by the Washington Departments of Fish and Wildlife, Natural Resources, Transportation, and Ecology, Washington State Recreation and Conservation Office, Puget Sound Partnership, and the U.S. Fish and Wildlife Service, Olympia, Washington.

Cramer, M., K. Bates, D. Miller, K. Boyd, L. Fortherby, P. Skidmore, and T. Hoitsma. 2002. Integrated streambank protection guidelines. Washington Department of Fish and Wildlife, Olympia, Washington. (https://wdfw.wa.gov/publications/00046)

DNR (Washington Department of Natural Resources). 2004. Forest Practices Board Manual, Section M2: standard methods for identifying bankfull channel features and channel migration zones. DNR, Forest Practices Division, Olympia, Washington. (https://www.dnr.wa.gov/publications/fp_board_manual.pdf?amcgpv)

EnviroVision, Herrera Environmental, and Aquatic Habitat Guidelines Working Group. 2010. Protecting nearshore habitat and functions in Puget Sound, revised edition. Washington State Department of Fish and Wildlife, Olympia, Washington. (https://wdfw.wa.gov/publications/00047)

Fetherston, K.L., R.J. Naiman, and R.E. Bilby. 1995; Large woody debris, physical process, and riparian forest succession in montane river networks of the Pacific Northwest. Geomorphology 13:133-144.

Fox, M.J. 2003. Spatial organization, position, and source characteristics of large woody debris in 2485 natural systems. Ph.D. Dissertation. University of Washington, Seattle, Washington.

Harris, R.R. 1987. Occurrence of vegetation on geomorphic surfaces in the active floodplain of a California alluvial stream. American Midland Naturalist 118:393-405.

Hilty, J.A., and A.M. Merenlender. 2004. Use of riparian corridors and vineyards by mammalian predators in northern California. Conservation Biology 18:126-135.

Johannessen, J., A. MacLennan, A. Blue, J. Waggoner, S. Williams, W. Gerstel, R. Barnard, R. Carman, and H. Shipman. 2014. Marine shoreline design guidelines. Washington Department of Fish and Wildlife, Olympia, Washington. (https://wdfw.wa.gov/publications/01583)

Johnson, D.H., and T.A. O'Neil. 2001. Wildlife Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, Oregon.

Keppel, G., K.P. Van Niel, G.W. Wardell-Johnson, C.J. Yates, M. Byrne, L. Mucina, A.G.T. Schut, S.D. Hopper, and S.E. Franklin. 2012. Refugia: identifying and understanding safe havens for biodiversity under climate change. Global Ecology and Biogeography 21:393-404.

Knight, K. 2009. Land use planning for salmon, steelhead and trout: a land use planner's guide to salmonid habitat protection and recovery. Habitat Program, Washington Department of Fish and Wildlife, Olympia, Washington. (https://wdfw.wa.gov/publications/00033)

Knutson, K.L., and V.L. Naef. 1997. Management recommendations for Washington's Priority Habitats: riparian. Habitat Program, Washington Department of Fish and Wildlife, Olympia, Washington. (https://wdfw.wa.gov/publications/00029)

Krosby, M., D.M. Theobald, R. Norheim, and B.H. McRae. 2018. Identifying riparian climate corridors to inform climate adaptation planning. PLOS ONE 13(11): e0205156.

Lacy, R.C., Williams, R., Ashe, E., Balcomb III, K.C., Brent, L.J., Clark, C.W., Croft, D.P., Giles, D.A., MacDuffee, M. and Paquet, P.C. (2017). Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. Scientific reports, 7(1), 1-12.

Legg, N.T., and P.L. Olson. 2015. Screening tools for identifying migrating stream channels in western Washington – geospatial data layers and visual assessments. Publication No. 15-06-003. Washington State Department of Ecology, Olympia, Washington. (https://fortress.wa.gov/ecy/publications/documents/1506003.pdf)

Legg, N.T., and P.L. Olson. 2014. Channel migration processes and patterns in western Washington: A synthesis for floodplain management and restoration. Publication No. 14-06-028. Washington State Department of Ecology, Olympia, Washington. (https://fortress.wa.gov/ecy/publications/documents/1406028.pdf)

Lichvar, R.W., N.C. Melvin, M.L Butterwick, and W.N Kirchner. 2012. National wetland plant list indicator rating definitions. ERCD/CRREL TN-12-1. U.S. Army Corps of Engineers, Washington, D.C.

Murray, C.C., Hannah, L.C., Doniol-Valcroze, T., Wright, B., Stredulinsky, E., Locke, A., and R. Lacy. (2019). Cumulative Effects Assessment for Northern and Southern Resident Killer Whale Populations in the Northeast Pacific. Department of Fisheries and Oceans, Canadian Scientific Advisory Research Document 2019/056. x. + 88 pp.

Naiman, R. J., and R. E. Bilby. 1998. (editors) River ecology and management: lessons from the Pacific Coastal Ecoregion. Springer Science & Business Media, New York.

Naiman, R.J., H. Decamps, and M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3:209-212.

Nordland, B., and K. Bates. 2000. Draft fish protection and screen guidelines for Washington State. Habitat Program, Washington Department of Fish and Wildlife, Olympia, Washington. (https://wdfw.wa.gov/publications/00050)

NRC (National Research Council). 2002. Riparian areas: functions and strategies for management. The National Academies Press, Washington, D.C. https://doi.org/10.17226/10327.

Olson, P. L., N. T. Legg, T. B. Abbe, M. A. Reinhart, and J. K. Radloff. 2014. A methodology for delineating planning-level channel migration zones. Publication No. 14-06-025. Washington State Department of Ecology, Olympia, Washington. (https://fortress.wa.gov/ecy/publications/documents/1406025.pdf)

Patten, D.T. 1998. Riparian ecosystems of semi-arid North America: diversity and human impacts. Wetlands 18:498-512. https://doi.org/10.1007/BF03161668.

Puget Sound Partnership. 2020. Puget Sound Vital Signs. Available: https://www.psp.wa.gov/evaluating-vital-signs.php (December 2020).

Quinn, T., et al. 1998. Habitat Associations of the riparian-dependent amphibian, reptile, mammals, and mollusks in commercial forest lands of Washington State: a report to the Timber, Fish & Wildlife policy committee. Washington Department of Natural Resources, Olympia, Washington.

Rapp, C.F., and T.B. Abbe. 2003. A framework for delineating channel migration zones. Publication No. 03-06-027. Washington State Department of Ecology, Olympia, Washington. (https://fortress.wa.gov/ecy/publications/documents/0306027.pdf)

RCO (Recreation and Conservation Office). 2019. State of Salmon. RCO, Olympia, Washington. https://stateofsalmon.wa.gov/exec-summary/ Retrieved July 23, 2019.

Richardson, J.S., R.J. Naiman, F.J. Swanson, and D.E. Hibbs. 2005. Riparian communities associated with Pacific Northwest headwater streams: assemblages, processes, and uniqueness. Journal of American Water Resources Association 41:935-947.

Rogers, L.E, R.E. Fitzner, L.L. Cadwell, and B.E. Vaughan. 1988. Terrestrial animal habitats and population responses. Pages 182-257 in W.H. Rickard, L.E. Rogers, B.E. Vaughan, and S.F. Liebetrau (editors). Shrub-steppe: balance and change in a semi-arid terrestrial ecosystem. Elsevier, New York.

Rosgen, D.L. 1996. Applied river morphology: Second edition. Wildland Hydrology Books, Fort Collins, Colorado.

Seavy, N.E., T. Gardali, G.H. Golet, F.T. Griggs, C.A. Howell, R. Kelsey, S.L. Small, J.H. Viers, and J.F. Weigand. 2009. Why climate change makes riparian restoration more important than ever: recommendations for practice and research. Ecological Restoration 27:330-338.

Shared Strategy Development Committee. 2007. Puget Sound salmon recovery plan. Shared Strategy for Puget Sound, Seattle, Washington.

Smith, D. 2005. Off-channel habitat inventory and assessment for the upper Skagit River basin. Report to non-flow coordinating committee of the Skagit River Hydroelectric Project (FERC No. 553). Skagit River System Cooperative, La Conner, Washington.

Thomas, F.M. 2014. Ecology of phreatophytes. Progress in Botany 75:335-375.

Thomas, J.W. (technical editor]). 1979. Wildlife Habitats in Managed Forests: The Blue Mountains of Oregon and Washington. Agriculture Handbook No. 553. U.S. Forest Service, Washington, D.C. (https://www.srs.fs.usda.gov/pubs/gtr/uncaptured/gtr_pnw080.pdf)

Thomas, J.W., J.F. Franklin, J. Gordon, and K.N. Johnson. 2006. The Northwest Forest Plan: Origins, components, implementation experience and suggestions for change. Conservation Biology 20:277-87.

USFS (U.S. Forest Service). 2008. Stream simulation: an ecological approach to providing passage for aquatic organisms at road-crossings. National Technology and Development Program, San Dimas, California.

USFS (U.S. Forest Service). 2001. Selway and Middle Fork Clearwater Rivers Subbasin Assessment. Nez Perce, Clearwater, and Bitterroot National Forests, Idaho. Retrieved August 26, 2019.

Vander Haegen, M.W. 2007. Fragmentation by agriculture influences reproductive success of birds in a shrub-steppe landscape. Ecological Applications 17: 934-947.

Ward, J.V., and J.A. Stanford. 1995. Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. Regulated Rivers: Research & Management 11:105-119.

Washington Sea Grant. 2009. Protection of marine riparian functions in Puget Sound, Washington. Washington Department of Fish and Wildlife, Olympia, Washington. (https://wdfw.wa.gov/publications/00693)

WDFW (Washington Department of Fish and Wildlife). 2005. Washington's comprehensive wildlife conservation strategy, final draft. WDFW, Olympia, Washington.

WDFW (Washington Department of Fish and Wildlife). 2016. Your marine waterfront: A guide to protecting your property while promoting healthy shorelines. WDFW, Olympia, Washington. (https://wdfw.wa.gov/publications/01791)

Williams, P.B., E. Andrews, J.J. Opperman, S. Bozkurt, and P.B. Moyle. 2009. Quantifying activated floodplains on a lowland regulated river: its application to floodplain restoration in the Sacramento Valley. San Francisco Estuary and Watershed Science 7(1).

Wolman, M.G., and L.B Leopold. 1957. River flood plains: some observations on their formation. Geological Survey Professional Paper 282-C. U.S. Government Printing Office, Washington, D.C.



Riparian area below the south slope of Mt. St. Helens. The area is still recovering from the mountain's volcanic eruption in May 1980. Skamania County/Brendan O'Doherty

Glossary of Terms

Active channel: The active channel is defined by the lower limit of continuous riparian vegetation (Naiman et al. 1998) and may be delineated by absence of both moss on rocks and rooted vegetation (USFS 2008). The upper most elevation of the active channel is sometimes equated with the ordinary high-water mark.

Active floodplain: Located between the active channel and adjacent terrace or hillslopes (Fetherston et al. 1995; Harris 1987). Depending on the watershed, the flood return interval of the active floodplain varies between 1 and 10 years (Wolman and Leopold 1957; Ward and Stanford 1995; Lichvar et al. 2006; Williams et al. 2009; BLM 2015).

Adaptive management: The systematic acquisition and application of reliable information to improve management over time. It often includes treating management decisions as experiments in order to address critical uncertainties and learn more quickly from experience. It involves setting objectives, monitoring conditions, and adjusting management based on results. Hallmarks of a sound adaptive management program include: (1) adequate funding for monitoring and research, (2) a willingness to change course when pre-established triggers are reached, and (3) a commitment to gather data and evaluate conditions at appropriate spatial extents and time scales. See Ecosystem-based management and WAC 365-195-920(2).

Anadromous fisheries: The commercial, recreational or subsistence harvest of fish that are born in freshwater, rear at sea, and return to freshwater to spawn. Anadromous fisheries of Washington include salmon (Chinook, coho, chum, sockeye, and pink), steelhead, bull trout, coastal cutthroat trout, green sturgeon, white sturgeon, eulachon, longfin smelt, and Pacific lamprey.

Aquatic species: Wildlife species that live in marine or freshwater including fish, shellfish (e.g., clams, snails, mussels), amphibians (e.g., frogs, salamanders), reptiles (e.g., turtles), crustaceans (e.g., crayfish), insects (e.g., larval mayflies, stoneflies, caddisflies, dragonflies) and various other invertebrates.

Best Available Science: Information produced through a valid scientific process that WDFW or another local, state or federal agency has determined represents the best available science consistent with criteria set out in WAC 365-195-900 through 365-195-925. (Volume 1 of this document is an example of Best Available Science regarding riparian ecosystems.)

Biota: The animal and plant life of a region, habitat, or geological period.

Buffer: The area around a critical area that separates the critical area from incompatible uses. For example, a 200m buffer may be established around a heron-nesting colony (the critical area) to keep suburban land uses from disrupting the colony. See WAC 365-190-130(3)(a). Riparian ecosystems are both buffers (for instream habitat) and critical areas on their own merit.

Channel Migration Zone: The area within which a river channel is likely to migrate and occupy over a specified time period (e.g., 100 years).

Channel slope or gradient: The average steepness of a stream segment measured as its change in elevation divided by its length. Typically, a segment's gradient is considered low if less than 2%, moderate between 2% and 4%, and high if greater than 4%.

Classification (critical area): Defining categories to which critical areas are assigned. The Priority Habitats and Species (PHS) program provides WDFW's recommended classification scheme for Fish and Wildlife Habitat Conservation Areas. Classification precedes designation in counties' and cities' effort to protect critical areas. *See* WAC 365-190-040(4).

Complexity: The complicated state seen in dynamic environments that contain multiple components and processes that interact with one another in a web of interactions whose outcomes are often unpredictable. Complexity can be described with conceptual models; outcomes of well-understood complex phenomena can be partially predicted using computer models.

Connectivity: Landscape connectivity is the physical relationship between landscape elements. Functional connectivity describes the degree to which landscapes facilitate or impede the movement of organisms between areas of habitat.

Critical Aquifer Recharge Area: Areas with an essential recharging effect on aquifers used for potable water. One of five types of Critical Areas identified in the Growth Management Act.

Critical Area(s): Places that the Growth Management Act requires all counties and cities to designate and protect, specifically, (1) Wetlands; (2) Critical Aquifer Recharge Areas; (3) Fish and Wildlife Habitat Conservation Areas (e.g., Riparian Management Zones); (4) Frequently Flooded Areas; and (5) Geologically Hazardous Areas. In developing policies and regulations to protect the functions and values of critical areas, counties and cities are required to include best available science and give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries. *See* RCW 36.70A.172(1). The presence of a critical area may limit some land development options. *See* WAC 365-190-040(6).

Delineation (critical area): The act of applying definitions or performance standards in the field to identify the boundary of a critical area.

Designation (critical area): Assigning critical areas into established categories and specifying their general distribution, location, and extent. Designation can be made by maps (which are useful for public awareness and for identifying if a proposal may affect a critical area) and by performance standards or definitions (which allow for specific identification and site-scale delineation during permit review). WDFW's Priority Habitats and Species (PHS) program provides the agency's recommended designation maps and performance standards/definitions for Fish and Wildlife Habitat Conservation Areas. Designation occurs after classification in counties' and cities' efforts to protect critical areas. *See* WAC 365-190-040(5).

Disturbance regime: The frequency, magnitude, and duration of disturbance events.

Disturbance: A pronounced, temporary change in environmental conditions within an ecosystem. Disturbances often act quickly and can alter ecosystem composition, structure, and function.

Ecological (biological) **integrity:** Ability of an ecological system to support and maintain a community of organism that has species composition, diversity, and functional organization comparable to those of natural habitats within a region. An ecological system has integrity when its dominant ecological characteristics (composition, structure, function, and processes) occur within their historical ranges of natural variability. See Historical condition and Range of natural variability.

Ecosystem(s): A spatially explicit unit of the Earth that includes all the organisms, along with all components of the abiotic (chemical and physical) environment. Ecosystems have composition, structure, and functions.

Ecosystem composition (or ecological composition): All living (biotic) and nonliving parts of an ecosystem.

Ecosystem function(ing) (or ecological function): (1) The process or cause and effect relationship underlying two or more interacting components, e.g., terrestrial plant material as food/substrate for aquatic invertebrates. (2) The sum of processes that sustain the system. (3) The capacity of natural processes and components to provide goods and services that satisfy human needs, either directly or indirectly. Ecosystem functions can be conceived as a subset of ecological processes (See *Ecosystem process*).

Ecosystem process (or ecological process): Interactions among components of an ecosystem, biotic (living organisms) and abiotic (chemical and physical) components. Many processes involve transfer, conversion, or storage of matter or energy (See *Ecosystem process*).

Ecosystem structure (or ecological structure): The arrangement of and relations among the parts or elements (components) of an ecosystem.

Ecosystem-based management (EBM): Management driven by explicit goals; executed by policies, protocols, and practices; and made adaptable by monitoring and research; based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function. EBM acknowledges that humans are an important ecosystem component and focuses on managing human activities within ecosystems. EBM often involves balancing ecological, economic, and social objectives within the context of existing laws and policies.

Enhance: To improve a critical area's existing ecosystem processes, structure, and/or functions so that its ecological integrity is more like its historical condition.

Erosion: The loosening and transport of soil particles and other sediment by water. Terrestrial erosion includes raindrop splash erosion, overland flow sheet erosion, surface flow rill (shallow) and gully (deeper) erosion. Channel erosion includes streambank erosion and channel incision (gouging). Rill and gully erosion diminish the ability of the riparian area to trap sediment and pollutants and can often be avoided with intact riparian vegetation.

Fish and Wildlife Habitat Conservation Areas (FWHCA): A type of Critical Area specified in the Growth Management Act. The intent of FWHCAs are to maintain populations of species in suitable habitats within their natural geographic distribution so that (1) the habitat available is sufficient to support viable populations over the long term, and (2)

isolated subpopulations are not created. FWHCAs come in a variety of types including waters of the state, places with which listed species have a primary association, habitats and species of local importance, and riparian ecosystems. See WAC 365-190-130.

Flow regime (stream): The distribution of stream flow through space and time. Flow regimes can be described by their magnitude (e.g., mean annual, hourly maximum), timing, frequency or return periodicity, duration, spatial distribution, and rate of change. The pathways that water takes to reach a stream (e.g., surface runoff) and within a stream exert a strong influence on the flow regime.

Function: Physical, chemical, or biological processes that occur within an ecosystem. WAC 365-196-830 says, "Functions are the conditions and processes that support the ecosystem. Conditions and processes operate on varying geographic scales ranging from site-specific to watershed and even regional scales." See also *Ecosystem function(ing)* and *Ecosystem process.*

Habitat: The resources and conditions presented in an area that support the functional needs of a species (e.g., hiding, migration, resting, feeding, breeding, and rearing), and which are necessary for its survival and reproduction. Habitat is species-specific, scale dependent, and more than vegetation composition or structure.

Hazard Tree: A tree that a jurisdiction's building official or other recognized professional (e.g., certified arborist, registered landscape architect, or certified forester) has determined poses a near-term hazard to public safety or to an existing permanent structure or public utility.

Herbaceous: Non-woody plants such as grasses and ferns.

Historical condition: *See* Ecological integrity and Range of natural variability.

Hydrology: Description of the properties, distribution, movement, and storage of water on and below the Earth's surface.

Impervious surface: Ground surfaces that resist or prevent water infiltration, e.g., roofs of houses, roadways.

Imputed: Estimated; a value assigned to missing data by inference from the values of data within the same dataset.

Infiltration: The rate or process by which water on the ground enters the soil.

Instream: Within flowing freshwater; also, the area waterward of the Ordinary High-Water Mark.

Large Woody Debris: Large dead woody material (such as fallen trees and branches) in various stages of decomposition that provide nutrient capital to forest and aquatic resources and serve as habitat in forest and riparian ecosystems. Large wood is usually defined as having diameter greater than 4 in (10 cm) and length greater than 6 ft (≈ 2 m).

Low Impact Development (LID): A storm water and land-use management strategy that tries to mimic natural hydrologic conditions by emphasizing pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation, and transpiration.

Mitigation: General category of measures that a proponent may take to avoid, minimize, and compensate for impacts.

Mitigation sequence: The stepwise process of protecting a critical area through, first (1) avoiding harm to the critical area to the maximum extent practicable, then (2) minimizing unavoidable harm to the maximum extent practicable, and finally (3) providing compensation for all unavoidable harm by restoring, creating, enhancing, or preserving the critical area's ecological functions and values to replace those impacted or lost through permitted activities.

Monitoring: The process of observing and checking the progress or quality environmental conditions for the purposes of adaptive management. Often described as having three types – implementation, effectiveness, and validation.

Morphology (stream channel, aka fluvial geomorphology): A stream channel's shape and how it changes over time. Channel morphology is influenced by the abundance and variation in sediment sources, the ability of water to transport sediment downstream, and interactions of sediment with riparian vegetation and woody debris.

Off-Channel Habitat: Overflow channels, sloughs, alcoves, wetlands, and small streams found within the floodplains of larger river channels. Off-channel habitat consists of waters connected to and draining into rivers and streams by inundation during peak flow events (Smith 2005; WAC 222-16-031). Off-channel habitat provides habitat for salmonids and other aquatic species which often afford (1) spawning habitat that does not experience scouring high flows; and (2) summer rearing habitat that does not experience loss of stream flow.

Ordinary High Water Mark (OHWM): (1) That mark that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland (Washington Department of Ecology 2016). (2) That line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas (U.S. Army Corps of Engineers, 2014).

Organic litter: Plant, leaf, tree, or soil litter, and duff are dead plant materials that have fallen to the ground. In this document, organic litter is referenced as available for contributions to the stream system.

Passive Restoration: Allowing natural succession to occur in an ecosystem after removing a source of disturbance.

Population viability (local): The likelihood that a population of a species will persist for some length of time.

Precautionary principle: Erring on the side of not harming resources when faced with uncertainty, especially for potential harm that is essentially irreversible. Utilizing a precautionary approach in land use planning involves: (1) taking preventive action (avoiding impacts); (2) shifting the burden of proof to the project proponents; (3) exploring a wide range of potential alternatives; and/or (4) including multiple stakeholders and disciplines in decision making.

Priority Area: The area within a Priority Species' natural geographic distribution within which protective measures and/or management actions are needed to (1) support viable populations over the long term and (2) avoid creating isolated subpopulations.

Priority Habitat: A State of Washington habitat type with unique or significant value to many species; an area with one or more of the following attributes: (1) comparatively high fish and wildlife density; (2) comparatively high species diversity; (3) important breeding habitat; (4) important seasonal ranges; (5) important movement corridors; (6) limited availability; (7) high vulnerability to habitat alteration; or (8) unique or dependent species. Examples of Priority Habitats include but are not limited to instream, riparian, shrub steppe, Oregon white oak woodlands, freshwater wetlands, and marine nearshore.

Priority Habitats & Species (PHS): WDFW's primary means of transferring fish and wildlife information from resource experts to local governments, landowners, and others for the protection of fish, wildlife, and habitat. Includes endangered, threatened, sensitive, candidate, and vulnerable species and habitats deemed priorities of WDFW and reflective of best available science. See WAC 365-190-130.

Priority Species: A State of Washington fish or wildlife species requiring protective measures and/or management actions to ensure its survival. A Priority Species fits one or more of the following criteria: (1) is a state-listed endangered, threatened, sensitive, or candidate species, (2) has vulnerable aggregations, or (3) is of recreational, commercial, and/or tribal importance. Examples of Priority Species include but are not limited to steelhead/rainbow trout, bull trout/Dolly Varden, great blue heron, cavity-nesting ducks, sage grouse, fisher, orca, and elk.

Process: See *Ecosystem process.*

Protect: To prevent the degradation of existing ecosystem functions and values.

Range of natural variability (or Historical range of natural variability): Refers to the range of ecological conditions (components, structures and functions) in a time period before widespread anthropogenic changes.

Recruitment (wood): The process of wood moving from a riparian area to the stream channel. Sources of recruitment include bank erosion, windthrow, landslides, debris flows, snow avalanches, and tree mortality due to, for example, fire, ice storms, beavers, insects, or disease. Dominant factors include, but are not limited to, channel width, slope steepness, slope stability, forest composition and structure, and local wind patterns.

Refugia (singular Refugium): sites to which biota retreat, persist in and potentially expand from under changing environmental conditions (Keppel et al. 2012).

Riparian: An adjective meaning alongside a waterbody: stream, river, lake, pond, bay, sea, and ocean. Riparian areas are sometimes referred to by different names: riparian ecosystems, riparian habitats, riparian corridors, or riparian zones. Depending on the contexts, these terms may have somewhat different meanings.

Riparian area: A defined area encompassing both sides of a water body, composed of aquatic ecosystems (i.e., the river or stream), riparian ecosystem, and riverine wetlands. Riparian areas are three dimensional: longitudinal up and down streams, lateral to the width of the riparian ecosystem, and vertical from below the water table to above the canopy of mature site-potential trees (NRC 2002).

Riparian buffer: Buffer refers to its purpose, which is to reduce or prevent adverse impacts to water quality, fisheries, and aquatic biodiversity from human activities occurring upslope of the buffer. Riparian buffers managed specifically for pollutant removal may also be called a vegetated filter strip.

Riparian ecosystem: Riparian areas are transitional between terrestrial and aquatic ecosystems and distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of the ecosystem distinguished by gradients (i.e., riparian zones) and portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., the Zone of Influence). Our definition of riparian ecosystem does not include adjacent waters (i.e., rivers or streams, but does include riverine wetlands) and recognizes the riparian zone as a distinctive area within riparian ecosystems.

Riparian Management Zone: A delineable area defined in a land use regulation; often synonymous with riparian buffer. For the purposes of this document, we define the RMZ as the area that has the potential to provide full riparian functions. In many forested regions of the state this area occurs within one 200-year site-potential tree height measured from the edge of the stream channel. In situations where a CMZ is present, this occurs within one site-potential tree height measured from the edges of the CMZ. In non-forest zones the RMZ is defined by the greater of the outermost point of the riparian vegetative community or the pollution removal function, at 100-feet.

Riparian values: The benefits that riparian ecosystems provide to society, including but not limited to flood damage reduction, water quality improvement, provision of harvestable populations of salmon, and provision of recreational opportunities. Riparian values have direct economic consequences to local communities through fishing opportunities, and flood and water quality protection, among others.

Riparian zone: A distinctive area within riparian ecosystems. The riparian zone contains wet or moist soils and plants adapted to growing conditions associated with periodically saturated soils. See *Riparian ecosystem.*

Risk: A situation involving exposure to danger, harm, or loss. Risk reflects the magnitude of the adverse impact and its probability of occurring. Risk is appropriately managed by applying the precautionary principle (especially for irreversible losses) and through adaptive management.

Salmonid: A family of fish comprised of salmon, trout and whitefish. Native salmonid species in Washington State include: Chinook Salmon (*Oncorhynchus tshawytscha*), Chum Salmon (*O. keta*), Coho Salmon (*O. kisutch*), Pink Salmon (*O. gorbuscha*), Sockeye Salmon/Kokanee (*O. nerka*), Steelhead/Rainbow Trout (*O. mykiss*), Cutthroat Trout (*O. clarki*), Bull Trout (*Salvelinus confluentus*), Dolly Varden (*S. malma*), Pygmy Whitefish (*Prosopium coulteri*), and Mountain Whitefish (*P. williamsoni*). This list does not include names of subspecies. (See *Anadromous* fisheries).

Site class: The classification of a site based on the productivity of its dominant tree species. Site classes vary based on local differences in soil nutrients and moisture, light and temperature regimes, and topography. Site classes are typically described as most productive (I) through least productive (V).

Site-Potential Tree Height: The average maximum height of the tallest dominant trees for a given age and site class.

Stronghold: Habitat strongholds are refugia watersheds that contain high quality habitat with depressed or weak populations. The habitat in these areas has a high to very high potential to support these species. The population level in these areas is not considered to be a function of habitat, but other factors (USFS2001).

Structure: See *Ecosystem structure.*

Succession: Ecological succession is the process by which the biological community composition recovers over time following a disturbance event.

Uncertainty (scientific): The absence of information about the state of something or a relevant variable. Sources of uncertainty include, but are not limited to natural variation (i.e., because outcomes vary in difficult-to-predict ways through time and space), model uncertainty (i.e., we do not understand how things interact with each other), systematic error (e.g., poorly designed experiments or calibrated instruments), or measurement error. See *Risk*.

Values: The level of benefits that the space, water, minerals, biota, and all other factors that make up a natural ecosystem provide to support native life forms, including humans (Cordell et al. 2005).

Vegetative filter strips: A riparian buffer designed to capture nutrients, contaminant compounds, and sediment transported by run-off. Filter strips are sometimes synonymous with riparian buffers.

Water quality: Physical, chemical, and biological characteristics of water that describe its suitability to meet human needs or habitat requirements for fish and wildlife.

Watershed processes: The fluxes of energy (e.g., sunlight, wildfire) and materials (particularly water and sediment) that interact with biota (e.g., vegetative cover, salmon, beavers, soil microbes) to form a watershed's physical features and characteristics, which give rise to its instream physical and ecological conditions. These processes occur within a context that reflects the watershed's climate, geology, topography, and existing human land use. See *Ecosystem process.*

Watershed: A land area that drains to a common waterbody.

Wetland: Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support—and that under normal circumstances do support—a prevalence of vegetation typically adapted for life in saturated soil conditions. Examples include but are not limited to swamps, marshes, and bogs.

Zone of Influence: The portions of terrestrial ecosystems that significantly influence exchanges of energy (e.g., sunlight) and matter (e.g., large wood, sediment, nutrients) with aquatic ecosystems.

Appendix. Site-Potential Tree Height Mapping Tool

The Site-Potential Tree Height (SPTH) Mapping Tool helps users find information they need to conserve, protect, and restore riparian ecosystems within a project site. The SPTH mapping tool works on personal computers (PCs) and mobile devices (tablets and smartphones).

Site-Potential Tree Height Map Data

The SPTH mapping tool contains several GIS data layers, explained below:

1. Site-potential Tree Height at 200 Years ($SPTH_{200}$),
2. Imputed[14] $SPTH_{200}$ Values for Urban areas,
3. Dryland Ecosystems – No SPTH Values, and
4. Other Lands – No SPTH Values.

Site-potential Tree Height at 200 Years ($SPTH_{200}$)

WDFW derived the $SPTH_{200}$ values from forest productivity site index information using Natural Resource Conservation Service (NRCS) soil polygons and its Soil Data Viewer tool for ArcGIS. The NRCS-provided forest productivity site index values, in feet, were for ages 50 years in Western Washington and typically 100 years in Eastern Washington. WDFW determined $SPTH_{200}$ values using tree site index equations. Each soil polygon has one or more tree species records with associated $SPTH_{200}$. When multiple tree species records with associated $SPTH_{200}$ are available, WDFW recommends using the largest $SPTH_{200}$ value of the tree species historically present at the site (such trees may currently be found on the site, but also may not). For example, if a project site contains mostly red alder but Douglas-fir is present (or was present prior to modern human alterations), use the Douglas-fir $SPTH_{200}$ for that soil polygon.

Imputed $SPTH_{200}$ Values

Four large urban areas (Seattle, Spokane, Tacoma, and Bellingham) lacked NRCS soil polygons; therefore, forest productivity information could not be mapped for most locations within those areas. Similarly, numerous soil polygons labelled as "Urban Land" lacked forest productivity information. For each of these four urban areas, WDFW calculated an imputed $SPTH_{200}$ by using an area-weighted average for 200-year site index values within a two-mile buffer around the perimeter. WDFW recommends the use of this imputed $SPTH_{200}$ as a guide for delineating RMZs in these urban areas. At the time of publication, WDFW had calculated imputed $SPTH_{200}$ information for those large urban areas. WDFW expects to continue to update the map.

[14] Imputed: estimated; a value assigned to something by inference from the value of the products or processes to which it contributes.

Dryland Ecosystems and Other Lands

Not all soil polygons are forested, or have forest productivity information from NRCS; therefore, not all of them have associated $SPTH_{200}$ values. In addition, Benton, Franklin, Grant, and Adams counties had no forest productivity information in their NRCS soil polygons. These areas without $SPTH_{200}$ values were classified in one of two ways: as "dryland ecosystems", or "other lands."

- WDFW approximated the area contained within "dryland ecosystems" using the Arid Lands Initiative study area boundary (Arid Lands Initiative, 2014) and have developed associated process steps that we recommend be used to derive RMZ widths (Volume 2, Section 2.2.3).

- The "other lands" comprise the remaining soil polygons and are small and dispersed across the landscape. These polygons include the NRCS soil map unit name, if applicable, and often represent soils that do not support tree growth, such as beaches and wetlands, as well as certain types of heavily modified sites like gravel pits. Please consult with a WDFW regional habitat biologist on deriving RMZs for "other lands" and consider following a similar process for delineation in dryland ecosystems.

Using the Site-Potential Tree Height Mapping Tool

The mapping tool can be accessed from several locations:

- WDFW website (https://wdfw.wa.gov/species-habitats/at-risk/phs/recommendations),
- Washington Geospatial Open Data Portal (http://geo.wa.gov/), and
- ArcGIS Online (AGOL) (https://wdfw.maps.arcgis.com/apps/MapSeries/index.html?appid=919ea98204eb4f5fa70eca99cd5b0de1).

The mapping tool consists of the statewide map with the four riparian datasets described above; user tools; and a sidebar explaining map contents, how to use the map, and links to supporting documents.

The four riparian datasets have unique colors indicating where the information occurs.

- **Green:** Area where $SPTH_{200}$ has been calculated.
- **Orange:** Areas where $SPTH_{200}$ values have been imputed.
- **Pale brown:** Dryland ecosystems where there is no tree height information.
- **Beige:** Places for which no SPTH site index information is available.

Tribal and publicly owned/managed lands federal and tribal lands are typically subject to different riparian regulations. Tribal, federal, and state lands are displayed in shades of grey. County-owned lands are shown in lavender, and city-owned lands are light blue.

The mapping tool contains the following tools (Figure A1):

- **Zoom slider:** zoom in or out on the center of the map.
- **Address search tool:** zooms to a street address, place name, or latitude and longitude.
- **Legend:** displays the map layers currently visible. For example, map layers displayed at a site-specific scale will not appear in the legend when zoomed out to the statewide extent.
- **Home icon:** resets map to statewide extent.
- **Target icon:** allows the user to zoom directly to their current location.
- **Measurement tool:** use this to measure the distance between objects (e.g. edge of stream to another point), or to measure an area (square feet of an area surrounding a project site).
- **Basemap selector:** change the basemap to show a different view of the landscape: aerial imagery (default), topographic map, open street map, terrain with labels, and USGS national map.
- **Scale bar:** shows the scale that the map is zoomed to. At a statewide extent, the scale bar will show 0 to 60 miles. When zoomed to a scale where you can view the project area, the scale bar will show 0 to 100 feet or 200 feet.
- **Coordinates:** latitude and longitude (decimal degrees) are shown where the cursor is located on the map.
- **Panning:** move the map by placing the cursor over a desired location and dragging it to the center of the map display.

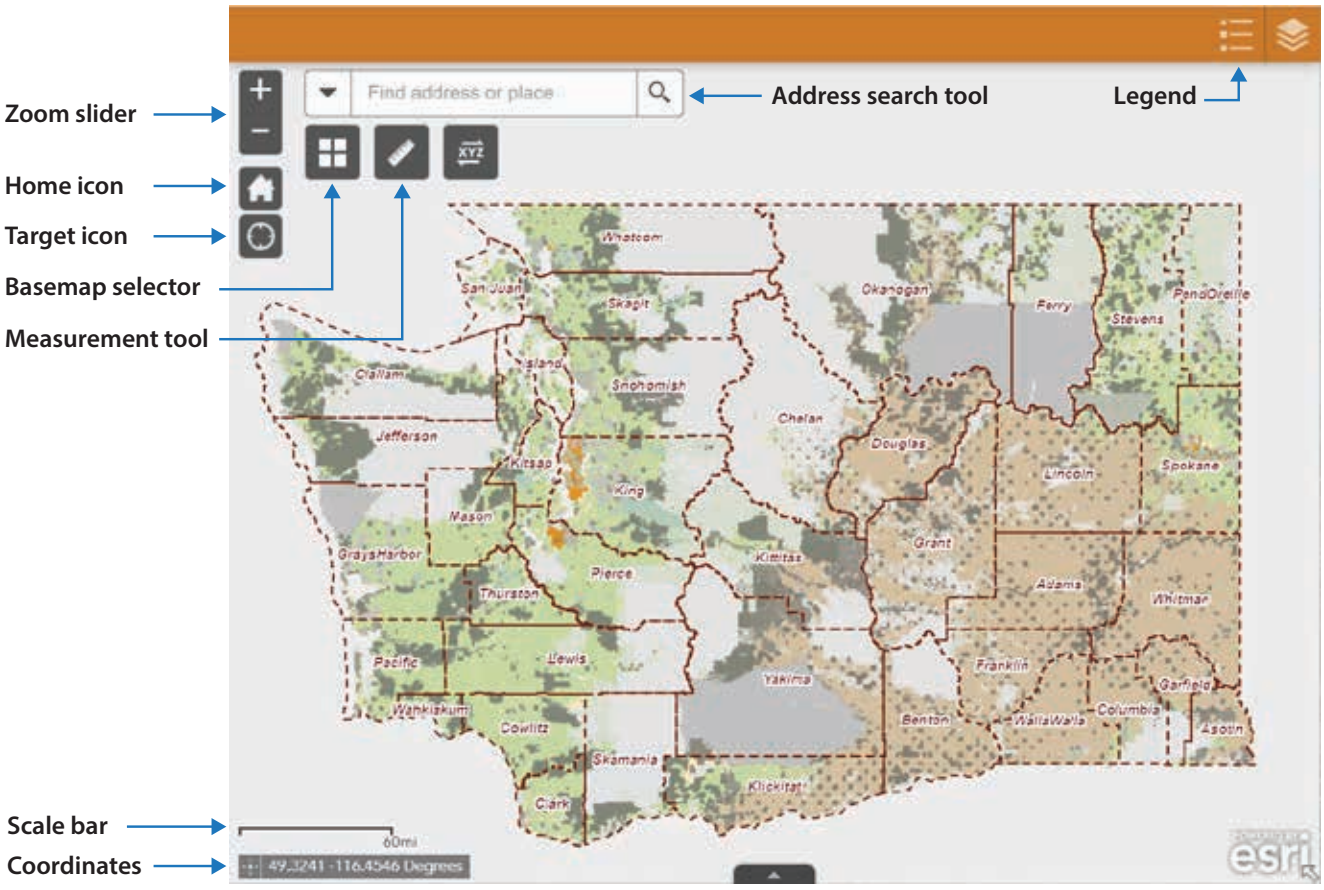


Figure A1. Tools available on the SPTH200 and RMZ Online Map.

To zoom to a site location, use the Address Search tool or use a combination of the Zoom Slider and panning. (If using the Address Search tool, select the "ArcGIS World Geocoding Service" from the dropdown menu to the left of the search field for faster results.) Once the site is located, a click (on PCs) or tap (on mobile devices) of the cursor will open a popup window with information about that location. Be sure to review each window if multiple records are selected.

The NRCS soil polygons form a complex mosaic across the landscape, so you must zoom in close enough to clearly see your project site. Clicking (or tapping, on mobile devices) on the map when it is zoomed out will result in erroneous returns of the $SPTH_{200}$ values. Below is an example of using these tools to obtain riparian information at a project site.

Mapping Tool Example #1

1. Start up the Online Map.

2. Type the project location into the Address Search tool (Figure A2). If the address is unknown, use a nearby place name or latitude and longitude. This example uses 16018 Mill Creek Boulevard, Mill Creek, Washington.

3. Select the correct address from the drop-down menu or continue to enter manually. Click (on a **PC**) or tap (on a **mobile device**) the search button. The map will zoom to that location, shown as a small blue box and a popup titled "Search result" (Figure A3).

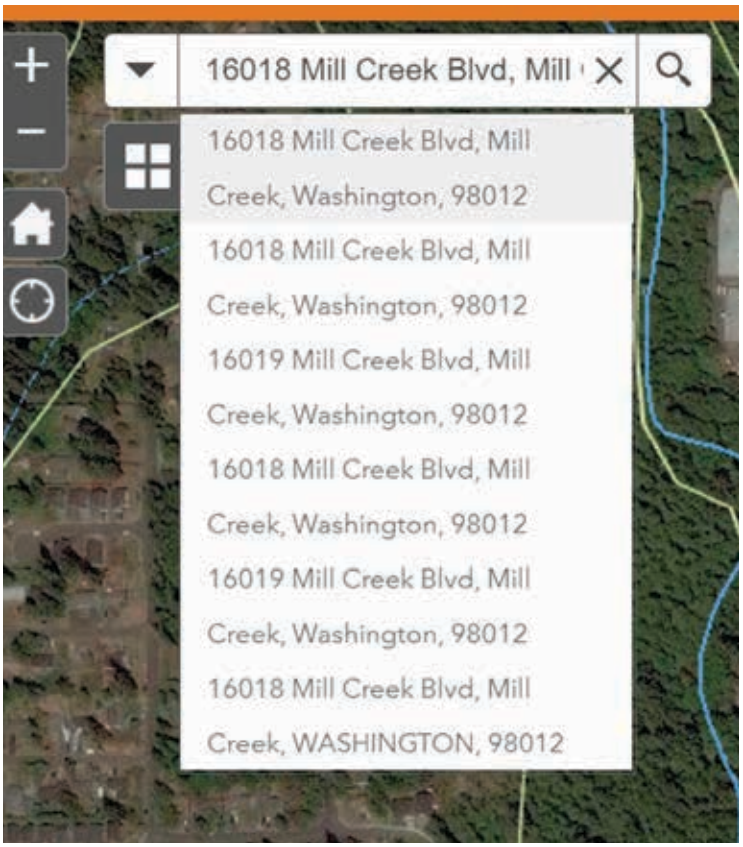


Figure A2. Using the Address Search tool.

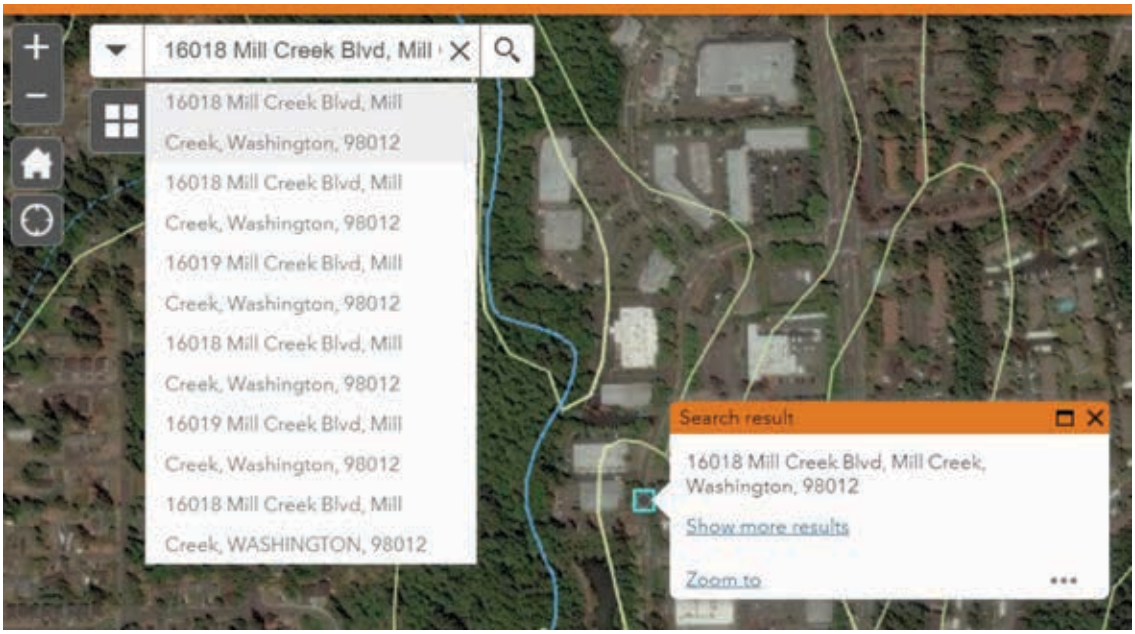


Figure A3. Zoomed in aerial image of the site address.

4. Click (or tap) on the "X" in the Address Search tool to close the popup. Zoom and pan until you can clearly see where the project site is on the landscape (Figure A4).

   In this example, the project site lies in a wooded area to the west of the address selected in the previous screen. We panned west to center the map display over the project site. In this screen, you can see outlines of the soil polygons.



Figure A4. Adjusting the map display over the project site.

5. Click (or tap) near a stream on the project site. The outline of the soil polygon selected will turn blue, and a popup window will provide information about the $SPTH_{200}$ (Figure A5). On a PC, the popup should automatically show (1) the $SPTH_{200}$ in feet, (2) the species of tree it is based on, and (3) the reference study used to derive the height value. On a mobile device, tap the arrow on the right side of the popup to display this information.

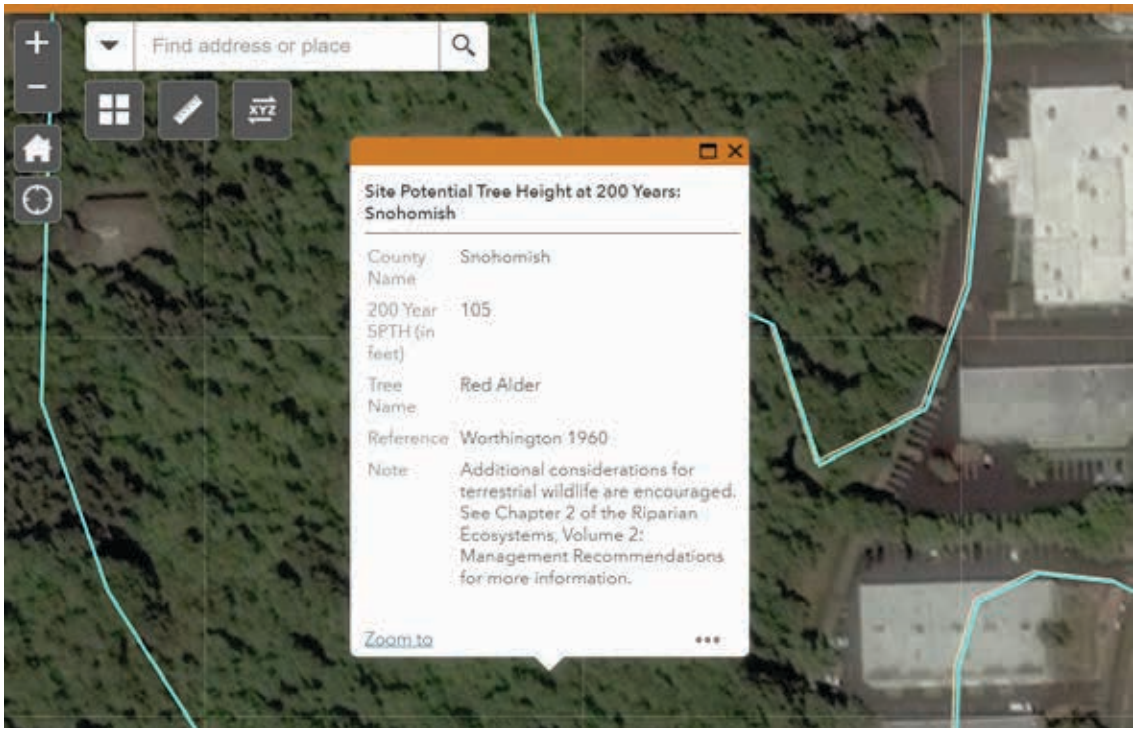


Figure A5. Bringing up the $SPTH_{200}$ information at the project site.

In Example #1, the soil polygon for the project site only showed one tree species: Red Alder. Sometimes soil polygons will list more than one tree species, as shown in Example #2.

Mapping Tool Example #2

Example #2, the project site was at a different location. Steps 1-3 in Example #1 were repeated to zoom to the project site. For this site, the popup window for the selected soil polygon looked different:

- The upper left corner of the popup window says "(1 of 2)"; and
- There is a small arrow near the upper right corner of the popup window.

This means that this soil polygon has two different associated tree species. The first is Douglas-fir (see Figure A6a).

To view the information for the second tree species, click on the small arrow. The second tree species is western hemlock (see Figure A6b).

For project locations with multiple tree species, WDFW recommends using the largest $SPTH_{200}$ value, even if the largest tree species is not the most numerous (or even currently present) onsite.

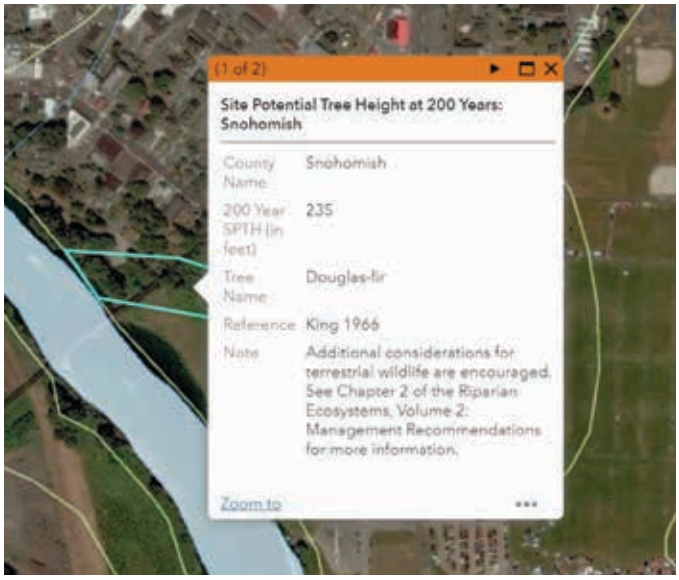


Figure A6a. SPTH information for the first of multiple tree species at a given site.

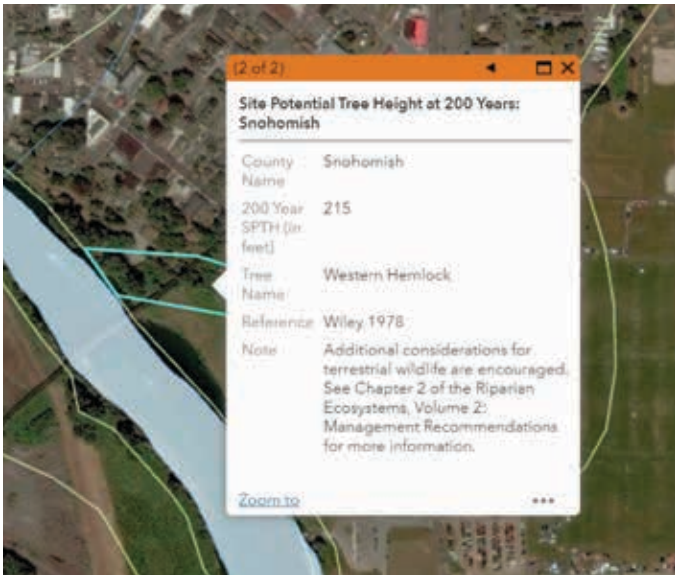


Figure A6b. SPTH$_{200}$ information for the second of multiple tree species at a given site.

Appendix References: Tree Site Index Curves

The following studies were used to determine SPTH$_{200}$ throughout the state:

Alexander, R.R. 1966. Site indexes for lodgepole pine, with corrections for stand density: instructions for field use. Research Paper RM-24. U.S., Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Alexander, R.R. 1967. Site indexes for Engelmann spruce. Research Paper RM-32. U.S., Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Baker, F.S. 1925. Aspen in the Central Rocky Mountain Region. Bulletin 1291. United States Department of Agriculture, \Washington, D.C.

Barnes, G.H. 1962. Yield of even-aged stands of western hemlock. Technical Bulletin 1273. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

British Columbia Forest Service (BCFS). 1977. Site index curves for cottonwood (as adapted by W.J. Sauerwein). pp. 852-853 *in* Pocket Woodland Handbook. U.S. Department of Agriculture, Soil Conservation Service, Portland, Oregon.

Cochran, P.H. 1979a. Gross yields for even-aged stands of white or Douglas-fir and white or grand fir east of the Cascades in Oregon and Washington. Research Paper PNW-263. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Cochran, P.H. 1979b. Site index and height growth curves for managed, even-aged stands of Douglas-fir east of the Cascades in Oregon and Washington. Research Paper PNW-251. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Cochran, P.H. 1985. Site index, height growth, normal yields, and stocking levels for larch in Oregon and Washington. Research Note PNW-424. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Haig, I.T. 1932. Second-growth yield, stand, and volume tables for the western white pine type. Technical Bulletin 323. United States Department of Agriculture, Washington, D.C.

Hegyi, F., J.J. Jelinek, J. Viszlai, and D.B. Carpenter. 1979. Site index equations and curves for the major tree species in British Columbia. Forest Inventory Report No. 1. Ministry of Forestry, Victoria, British Columbia.

Herman, F.R., R.O. Curtis, and D.J. Demars. 1978. Height growth and site index estimates for noble fir in high-elevation forests of the Oregon-Washington Cascades. Research Paper PNW-243. U.S. Forest Service Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Hoyer, G.D., and F.R. Herman. 1989. Height-age and site index curves for Pacific silver fir in the Pacific Northwest. Research Paper RP-418. U.S., Forest Service. Pacific Northwest Research Station, Portland, Oregon.

King, J.E. 1966. Site index curves for Douglas-fir in the Pacific Northwest. Forestry Paper 8. Weyerhaeuser Company, Forestry Research Center, Centralia, Washington.

Kurucz, J.F. 1978. Preliminary, polymorphic site index curves for western red cedar (*Thuja plicata Donn*) in coastal British Columbia. Forest Research Note No. 3. MacMillan Bloedel, Nanaimo, British Columbia.

Meyer, W.H. 1961. Yield of even-aged stands of ponderosa pine. Technical Bulletin 630 (revised 1961). United States Department of Agriculture, Washington, D.C.

Meyer, W.H. 1937. Yield of even-aged stands of Sitka spruce and western hemlock. Technical Bulletin 544. United States Department of Agriculture, Washington, D.C.

Monserud, R.A. 1985. Applying height growth and site index curves for inland Douglas-fir. Research Paper INT-347. U.S. Forest Service. Intermountain Research Station, Ogden, Utah.

Schmidt, W.C., R.C. Shearer, and A.L. Roe. 1976. Ecology and silviculture of western larch forests. Technical Bulletin 1520. U.S. Forest Service, Washington, D.C.

Wiley, K.N. 1978. Site index tables for western hemlock in the Pacific Northwest. Forestry Paper No. 17. Weyerhaeuser Company, Western Forestry Research Center, Centralia, Washington.

Worthington, N.P., F.A. Johnson, G.R. Staebler, and W.J. Lloyd. 1960. Research Paper No. 36. Normal yield tables for red alder. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.













Washington Department of FISH and WILDLIFE

ar-5933 **Pgs. 2633-2652**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: Public Hearing - Revenue Source Regular Property Tax Levy & Setting 2027 Regular Tax Rates

Submitted For: Lizbette Feria, Finance Department

Financial Comments:

Public Hearing on the Revenue Sources supporting the Biennial Budget — Required by State statute before the City Council can adopt the ordinances setting the 2027 property tax levy.

1. 2027 Regular Property Tax 1% and new construction levy amounts. The 1% increase for the 2027 property taxes is $77,482.

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

Public Hearing to present the revenue sources supporting the city's proposed 2027-2028 biennial budget and setting the 2027 property tax levy.

Information

HISTORY:

Per RCW 84.55.120, a taxing district must hold a public hearing on the revenue sources for the General Fund (Current Expense Fund) before passing an ordinance adopting the 2027 ad valorem tax rates. The revenue sources for the general fund will be presented as well. This is one of the three public hearings required for the 2027-2028 biennial budget. The current schedule has an ordinance for the 2027 ad valorem tax rates at the regular City Council meeting on November 4, 2026.

POLICY ISSUES:

According to Washington State RCW 84.55.120, the City Council is required to hold a public hearing on revenue sources for the coming year's budget, including a possible increase in property tax revenue.

PLAN COMPLIANCE:

STRATEGIC PLAN: The four key focus areas are supported by the 2027-2028 proposed budget, which identifies property tax rates as a general fund revenue source.

ALTERNATIVES:

Not adopt the resolution.

STAFF RECOMMENDATION:

Staff recommends that the City Council hold the public hearing on the revenue sources for the general fund and adopt the resolution levying the 1%.

CITY MANAGER COMMENTS:

Concur with the staff recommendation and approved for City Council action.

Attachments

RESOLUTION NO. 2026-087

A RESOLUTION REGARDING THE REGULAR PROPERTY TAXES OF THE CITY OF WALLA WALLA FOR 2027 PURSUANT TO RCW 84.55.120

WHEREAS, the City of Walla Walla held a public hearing on October 14, 2026 to consider revenue sources for its current expense budget, a/k/a its general fund, for the first half of the 2027-28 fiscal biennium, including possible increases in property taxes; and

WHEREAS, the population of the City of Walla Walla is more than 10,000; and

WHEREAS, the City of Walla Walla's certified levy amount for regular property taxes in 2026 was $7,748,198.10; and

WHEREAS, RCW 84.55.092 protects the levy capacity of the City of Walla Walla, and any difference between the City's lawful levy limit and the actual levy amount from the previous year is reserved levy capacity (also known as banked levy capacity); and

WHEREAS, the City of Walla Walla wishes to increase its regular property tax levy and protect its further levy capacity as permitted under chapter 84.55 RCW; and

WHEREAS, sections 84.55.005 and 84.55.010 of the Revised Code of Washington (RCW) authorize taxing districts to increase their regular property tax levy; and

WHEREAS, section 84.55.005 of the Revised Code of Washington authorizes taxing districts to increase the property tax levy in any year by the lesser of 101% or 100% plus inflation; and

WHEREAS, the inflation rate, a/k/a implicit price deflator (IPD), is 3.876%, and 101% is therefore less than 103.876%; and

WHEREAS, RCW 84.55.120 requires that any increase in regular property tax revenue must be authorized by a separate ordinance or resolution which specifically authorizes the increase in terms of both dollars and percentage; and

WHEREAS, the Walla Walla City Council has considered this matter during a regularly and duly called public meeting of said Council, has given careful review and consideration to the matter, and further finds that the common benefit of the citizens of Walla Walla and the best interests of the City of Walla Walla and good government of the City of Walla Walla will be served by passage of this resolution;

NOW THEREFORE, the City Council of the City of Walla Walla resolves as follows:

Section 1: The Walla Walla City Council hereby authorizes increases in the regular property tax levy for the levy to be collected in the 2027 tax year resulting from new construction, improvements to property, construction of wind turbine, solar, biomass, and geothermal facilities, increases in the value of state assessed property, and any annexations that have occurred.

Section 2: In addition to the increases authorized by section 1, the Walla Walla City Council authorizes an increase for the 2027 levy in the amount of $77,481.98 which is a percentage increase of 1 percent over the previous year.

Section 3: The Walla Walla City Council hereby authorizes a one percent (1%) increase to the levy capacity of the City of Walla Walla (a/k/a the highest regular tax which could have been lawfully levied beginning with the 1985 levy) in accordance with RCW 84.55.005 and RCW 84.55.010.

Section 4: Increases authorized herein for regular property taxes shall be in addition to amounts levied to meet debt service obligations on voter approved bonds.

Section 5: Increases authorized herein shall be in addition to other increases authorized by law.

Section 6: Nothing herein shall be construed to impair the future levy capacity of the City of Walla Walla.

Section 7: If any part of this resolution is declared invalid for any reason by any court of competent jurisdiction, or is otherwise unenforceable, such part shall be deemed a separate, distinct, and independent provision, and such invalidity shall not affect the validity of the remaining parts of this resolution.

Section 8: The City Clerk is authorized and directed to provide a summary of this resolution to the Walla Walla County Assessor in the form preferred by the Assessor together with the levy certification form for the City of Walla Walla.

PASSED on October 14, 2026 by the Walla Walla City Council.

_____
Mayor

Attest:

_____
City Clerk

Approved as to form:

_____
City Attorney

City of Walla Walla

A WONDERFUL PLACE TO **LIVE WORK PLAY**



CITY OF WALLA WALLA REVENUE SOURCES

Public Hearing
October 14, 2026

City of Walla Walla

Adopted Strategic Plan Key Focus Areas



LIVABILITY

Livability: what the City of Walla Walla focuses on to execute the organization's mission of enhancing the quality of life in Walla Walla.



SAFE COMMUNITY

Organizational readiness around emergency management, infrastructure stability (maintenance/ repair/multimodal), and overall community safety.



ECONOMIC HEALTH

The City's financial stability through sustainable revenue sources, attracting new businesses and shopping opportunities, and support a strong economy through diverse employment sectors.



HIGH PERFORMING ORGANIZATION

The City will develop a culture of continuous improvement, collaboration with organizations and partners within the community, and well trained and supported work force.

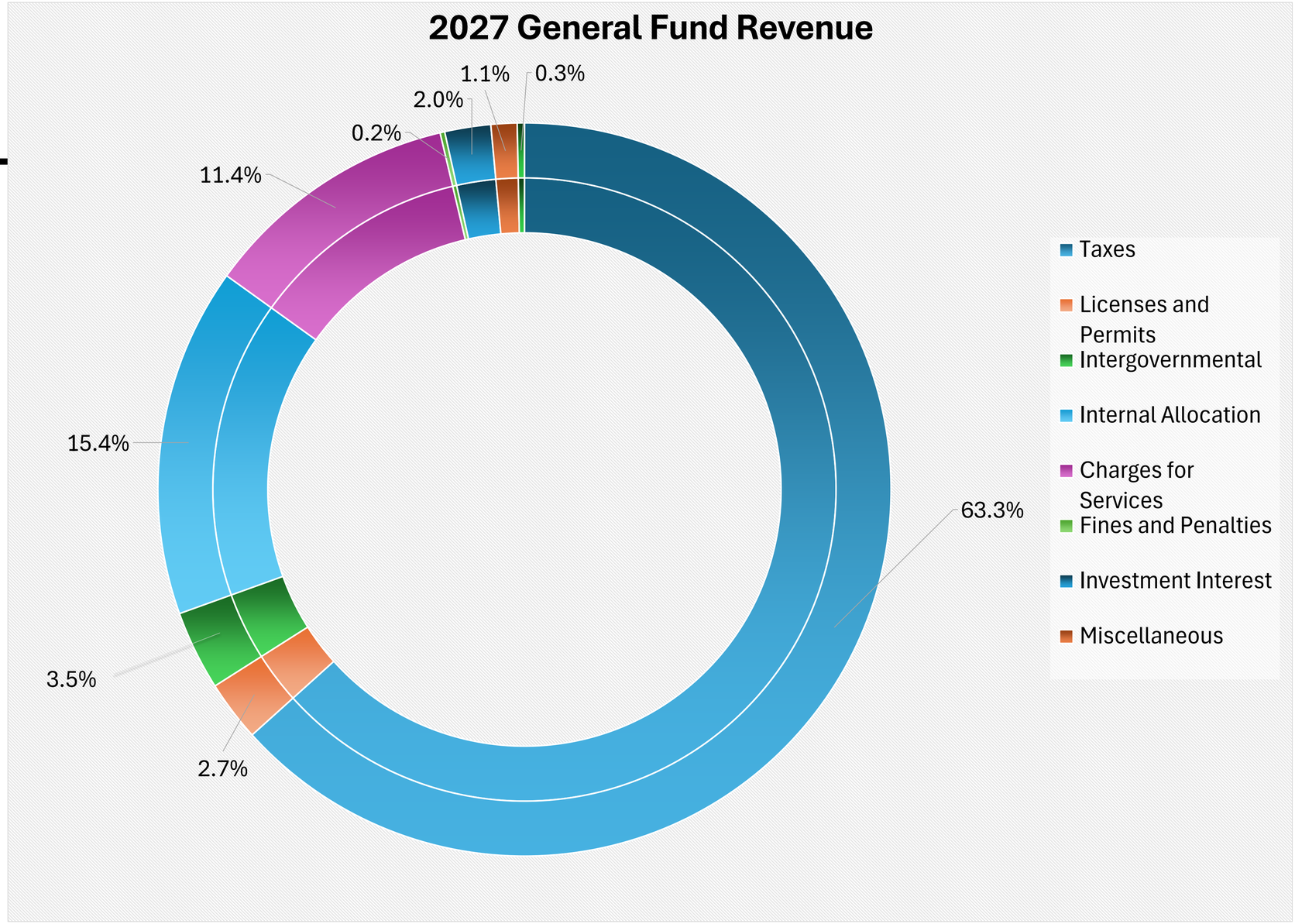
GENERAL FUND REVENUE

- **Property Tax:** A tax the City collects on real property. The maximum allowable annual increase is 1% plus annexations or new construction. The voters can approve a levy lid lift to increase the City's levy.
- **Sales and Use Tax:** Consumers pay the 9.1% sales tax rate when shopping in town, on the Internet, or with materials shipped to Walla Walla. The City collects a portion of this tax.
- **Business and Occupation Tax (B&O):** The City charges a tax for cable, electric, gas, and telephone services. The City charges the maximum limit allowed by the State of Washington; increasing the rates would require a public vote.
- **Utility Excise Tax:** The City charges this internal tax on its utilities. Established by ordinance with councilmanic approval, it has no external limit restrictions.
- **Intergovernmental Revenue:** – Revenue received from other governmental agencies, most likely direct/indirect federal or state grant awards.
- **Licenses and Permits:** – Fees charged to customers for the purchase of permits or licenses. Examples include building permits, business licenses, park permits, and plumbing permits.

GF REVENUE CONTINUED

- **Charges for Services:** Cost recovery method to charge customers for services and program participation.
  - **Internal Charges for Services**: General fund divisions perform services for other departments and divisions within the city. Examples include engineering services for projects. The Enterprise and internal service funds pay a portion of the administrative functions of the General Fund; they do not have to hire their own HR, Finance, Legal, etc.
  - **External Charges for Services**: Examples include parks and recreation program fees, memorial pool programs, building plan review, and cemetery services.
- **Fines and Penalties:** These are financial penalties imposed on individuals for law violations and other rules. Examples include criminal and non-criminal infractions, parking tickets, and library fines.
- **Miscellaneous Revenue**: This category includes investment earnings, private contributions, and other revenue that does not fit into any other category.
- **Transfers:** The General Fund transfers monies to other funds supporting operations and capital projects.

2027 GENERAL FUND REVENUE BY SOURCE



2027 GENERAL FUND REVENUE BY SOURCE

Revenue Type	2027
Taxes	$32,512,640
Licenses and Permits	$1,350,950
Intergovernmental	$1,771,950
Internal Allocation	$7,786,850
Charges for Services	$5,758,390
Fines and Penalties	$103,600
Investment Interest	$1,025,000
Miscellaneous	$580,550
Transfers and Other	159,710
Total Revenue	**$51,049,640**

TAX REVENUE DETAILS

Taxes Type	2027
Property	$7,908,500
Sales and Use	$8,600,000
Business & Occupation	$4,185,000
Utility Excise	$9,301,690
Other	$2,517,450
Total Taxes	**$32,512,640**

PROPERTY TAX GENERAL INFORMATION

The maximum Washington State Constitutional limit is 1% or the implicit price deflator, whichever is less.

- The 2026 IPD is 3.876%, and the city can levy the full 1% increase.
- If the city does not increase the levy by 1%, it can bank the amount.
- What is banked levy capacity? This means the city retains the right to use the 1% banked amount later.
- What happens if we do not levy the 1%?
  A. The increase will not be available until 2027.
  B. The amount does not compound each year.
  C. The 1% earns no interest.
  D. May change over time based on the highest property tax lawful limit.
  - If the City Council does not take action on the property tax ordinance before the November 30th deadline, the City can only levy the 2026 amount.
  - City Staff recommends we levy the 1%.



PROPERTY TAX

- 2027 Property Tax: 1% increase, plus new construction.

2027 Regular Property Tax Levy Calculation		
2026 Levy		$7,748,198
1% Increase		$77,482
New Construction at the 2026 Levy Rate	**$51,406,340**	$82,818
Annexation at the 2027 Levy Rate		$0
Total Regular Levy Increase		$160,300
2027 Property Tax Levy		$7,908,498
2027 Regular Levy Rate/$1,000 AV		**$1.6464**
2026 Regular Levy Rate		**$1.6819**
2026 City of Walla Walla Assessed Valuation for 2027	**$4,803,402,575**	

SALES AND USE TAX

Sales tax revenue 2027 is budgeted at $8,600,000, a 3.0% increase over the 2026 revised budget. The following table explains the breakdown of the City of Walla Walla's 9.1% sales tax rate.

Agency	Percentage
State of Washington	6.500%
Valley Transit	0.600%
Walla Walla County	0.575%
City of Walla Walla	1.425%
Sales Tax Rate	9.100%

City Fund	Percentage
Transportation Benefit District	0.200%
E911 Communications	0.200%
General	1.025%
City of Walla Walla	1.425%

INTERNAL UTILITY TAX

The 2027 proposed Internal Utility Tax rate is 17.6%
The approved rate is 15.6%.

	2027
Fund	**Amount**
Ambulance	$261,360
Sanitation	$1,677,660
Water	$2,921,650
Stormwater	$575,060
Wastewater	$2,427,670
Landfill	$1,438,290
Internal Utility Tax Total	**$9,301,690**

CHARGES FOR SERVICE

The 2027 service rates will be set using a cost-recovery method. Not to earn a profit but to recover expenses.

- Internal allocations are charged to the Enterprise and Internal Service Funds, which cover finance, human resources, technology, and other services.
- Internal charges include cost recovery for engineering support for enterprise funds and capital projects.
- External charges for services are memorial pool fees, park programs, cemetery service, and planning and building fees.

Type		2027
Internal Allocations	$	7,786,850
Internal Customers	$	3,108,870
External Customers	$	2,649,520
Total Charges for Services	**$**	**13,545,240**

INTERGOVERNMENTAL REVENUE

The $1,771,950 of 2027 intergovernmental revenue includes:

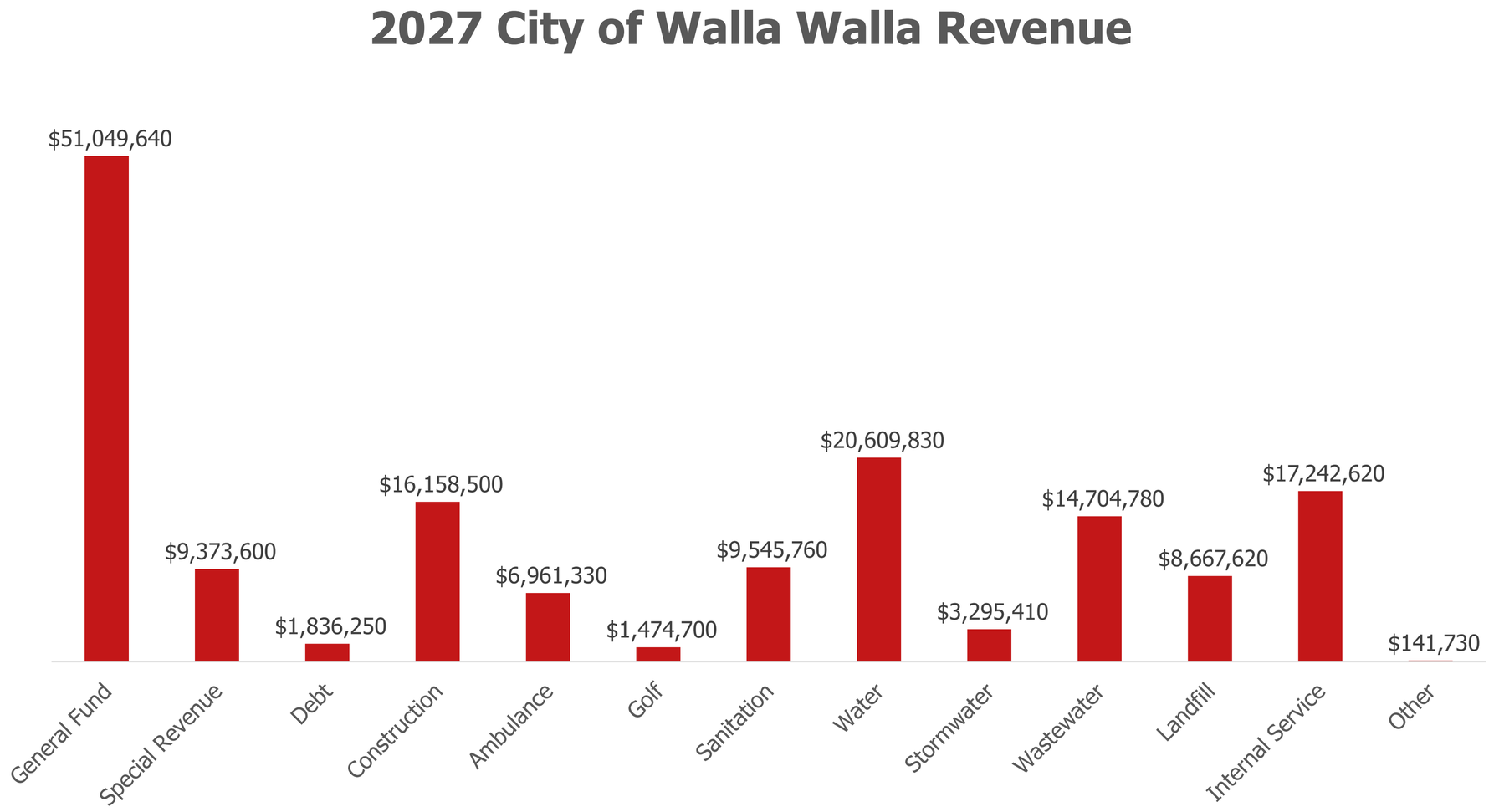
- State Shared Revenue – Criminal Justice, Financial Assistance, Liquor, and Marijuana
- Federal Community Development Block Grant
- State Department of Commerce Police Grant for Crime Victim Services
- State Architecture and Historic Preservation Grant for Cemetery

MISCELLANEOUS AND OTHER

The $1,605,550 revenue included in the miscellaneous and other are:

- Investment Earnings: $1,025,000. This estimate is based on 2026 anticipate revenue and Federal Reserve increasing interest rates by .25% at their September 2026 meeting. We monitor quarterly and will adjust with the future budget amendments, if needed.
- Park Facility Rentals
- Parking Lot Rentals
- Cell Tower Leases
- Private Contributions

The projected 2027 revenue for all funds is $157,960,620.





QUESTIONS???

ar-5888 **Pgs. 2653-2669**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: Approve the September Accounts Payable Register

Submitted For: Lizbette Feria, Finance Department

Financial Comments:

Printed Transactions: 38439-38459, 38468-38524, 38556-38558, 38602-38675, 38696-38744, 38766-38795 = $3,077,372.12
ACH Transactions: 38460-38467, 38525-38532, 38534-38555, 38559-38570, 38572-38601, 38676-38695, 38745-38765 = $1,990,333.55
Wire Transactions: 1454-1457, 1459-1477, 1479-1485, 1487, 1489-1496 = $1,121,960.34
Total Check Register: $6,189,666.01

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

Approve the September 2026 Accounts Payable Register

Information

HISTORY:

Ordinance 2016-05 appointed the Finance Director as the auditing officer for the City of Walla Walla.

POLICY ISSUES:

The City's internal controls include having the appropriate department certify the validity of all hours before payment submission. City Departments and Divisions review all claim payments, and a Finance Department staff member performs a final review before issuing payments.

- RCW42.24.080 requires that all claims presented against the City by a person furnishing materials, rendering services, or performing labor must be certified by the appropriate official to ensure that the materials have been furnished, the services rendered, or the labor performed as described and that the claims are just, due, and unpaid obligations against the City, before payments can be made.
- RCW 42.24.180 allows expedited processing of the payment of claims when certain conditions have been met. The statute allows the issuance of warrants or checks in payment of claims before the legislative body has acted to approve the claims when: 1 the appropriate officers have furnish official bonds, 2 the legislative body has adopted policies that implement effective internal controls; 3 the legislative body has provided for review of the documentation supporting the claims within a month of issuance; and 4 that if claims are disapproved, they shall be recognized as receivables and diligently pursued.
- WWMC 2.17.025 grants the Finance Director's duties, including keeping a full and accurate account of all money disbursed on behalf of the City.

PLAN COMPLIANCE:

STRATEGIC PLAN: This agenda item complies with all areas of the City's Strategic Plan

ALTERNATIVES:

Not to approve the September 2026 Accounts Payable register and direct staff to pursue repayment to the City diligently.

STAFF RECOMMENDATION:

The Council approves the September 2026 Accounts Payable register.

CITY MANAGER COMMENTS:

Concur with the staff recommendation and approved for City Council action.

Attachments

Council Check Register September 2026

City of Walla Walla

Monthly Check Register

09/01/2026 thru 09/31/2026

Check #	Date	Vendor	Description	Amount	Clear
1454	9/2/2026	City of Walla Walla	8/2026 Postage for PLN2-26-0011	89.60	Y
1455	9/2/2026	PNC Bank National Association	7/31 Golf Cart Lease 8.1-8.31	1,980.00	Y
1456	9/3/2026	The Odom Corporation	Pro Shop Merchandise - Alcohol	584.67	Y
1457	9/1/2026	Washington Dental Services Inc	Dental Premiums for All Employees – September 2026	43,756.04	Y
1459	9/9/2026	AWC Employee Benefits Trust	AWC Medical/Vision Premiums for September 2026	427,495.31	Y
1460	9/4/2026	Aramsco, Inc	Glass Beads for Painting for Traffic	7,331.52	Y
1461	9/8/2026	City of Walla Walla	Mill Creek Sportsplex Permit Fees	1,104.38	Y
1462	9/10/2026	The Odom Corporation	Pro Shop Merchandise - Alcohol	797.02	Y
1463	9/3/2026	Cardconnect	08/26 Merchant card services Landfill	3,427.36	Y
1464	9/3/2026	Cardconnect	08/26 Merchant Card Service Golf Course	3,186.03	Y
1465	9/3/2026	Cardconnect	8/26 Merchant card services Pool	410.26	Y
1466	9/3/2026	Cardconnect	08/26 Merchant card services Landfill	157.69	Y
1467	9/2/2026	Chase Paymentech	08/26 Merchant card services DS	401.66	Y
1468	9/2/2026	Chase Paymentech	08/26 Merchant card service CH GB	107.47	Y
1469	9/2/2026	Chase Paymentech	08/26 Merchant card services CH Utility	1,031.29	Y
1470	9/2/2026	Chase Paymentech	08/26 Merchant Process. Fees IVR FN	1,292.53	Y
1471	9/2/2026	Chase Paymentech	08/26 IVR GB Phone	21.00	Y
1472	9/2/2026	Chase Paymentech	08/26 Merchant Card Service GB online	276.90	Y
1473	9/2/2026	Chase Paymentech	08/26 Merchant Card Services CH Utilities Online	13,497.38	Y
1474	9/1/2026	ISVPAY INC	09/26 ISV Pay Gateway Fees	413.20	Y
1475	9/1/2026	Pitney Bowes Global Financial Services LLC	09/26 Postage Account Finance	3,000.00	Y
1476	9/15/2026	The Odom Corporation	Pro Shop Merchandise - Alcohol	142.75	Y
1477	9/18/2026	Wilbur-Ellis Inc	Fairway Seed	280.96	N
1479	9/18/2026	Wilbur-Ellis Inc	Grass Seed for Fire St. 2 Landscape	357.19	N
1480	9/21/2026	Western States Equipment Inc	08/2026 SSFS Emergency Repair, Landfill Dozer	94,179.71	N
1481	9/21/2026	Western States Equipment Inc	09/2026 SSFS Parts, Landfill CAT Dozer	622.17	N
1482	9/21/2026	Western States Equipment Inc	09/2026 SSFS Parts, Landfill CAT Loader	61.77	N
1483	9/21/2026	Western States Equipment Inc	09/2026 SSFS Parts & Service ,Water CAT excavator	853.63	N
1484	9/2/2026	Chase Paymentech	08/26 Merchant card services DS	2,236.21	N
1485	9/22/2026	Western States Equipment Inc	09/2026 SSFS Outside parts & service, LF Loader	2,221.05	N
1487	9/22/2026	The Odom Corporation	Pro Shop Merchandise - Alcohol	320.18	N
1489	9/24/2026	Ed Staub & Sons Petroleum, Inc	Propane, WTP	701.25	N
1490	9/24/2026	Ferguson Enterprises , LLC	Meter Boxes pt2, WAD	1,057.68	N
1491	9/24/2026	Kenworth Sales	09/2026 SSFS Parts, Sanitation Collection	628.09	N
1492	9/25/2026	Ferguson Enterprises , LLC	Meter Boxes, WAD	41,126.84	Y

1493	9/29/2026	Washington State Department of Revenue	8/26 August Excise Tax Return	221,327.67	N
1494	9/3/2026	Cardconnect	08/26 Merchant card services Parks	1,069.86	N
1495	9/30/2026	US Bank National Association	September 2026 US Bank Charges	244,278.22	N
1496	9/30/2026	The Odom Corporation	Pro Shop Merchandise - Alcohol	133.80	N
38439	9/3/2026	Auto Magic, LLC	08.2026 fleet car wash service	150.00	Y
38440	9/3/2026	BNB Mechanical, LLC	Services thru 4/22/26 WWTP Admin Bldg. Plumbing Pro	35,528.40	Y
38441	9/3/2026	CenturyLink	August 2026 alarm line for the landfill	46.87	Y
	9/3/2026	CenturyLink	09.2026 phone and fax service	116.71	Y
38442	9/3/2026	City of Walla Walla	8/28/26 Transfer Insp fees Equinox	28,305.00	Y
38443	9/3/2026	CXtec, Inc	RapidCare Support Renewal - FOC25123U43 and JAD243	621.87	Y
38444	9/3/2026	Granicus LLC	Granicus Maintenance Renewal	17,953.57	Y
38445	9/3/2026	Joshua Griffin	08.28.26 CJTC Officer Wellness Project	437.50	Y
38446	9/3/2026	Honex Site Services LLC	Code Enforcement - Budget Inn Safety Fence	548.16	Y
38447	9/3/2026	ImageTrend, Inc	New World/Tyler Technologies Annual Fee	3,593.79	Y
38448	9/3/2026	Ingram Industries Inc	Children's books	17.88	Y
	9/3/2026	Ingram Industries Inc	Children's books	16.35	Y
	9/3/2026	Ingram Industries Inc	Adult/YA/Children's books	199.02	Y
38449	9/3/2026	Ironwood	7/20-7/24/2026-Watershed Intake Debris Removal	63,177.92	Y
38450	9/3/2026	Kanopy Inc.	Kanopy streaming AUG26	493.00	Y
38451	9/3/2026	McDonald Zaring Insurance Inc	2024-2026 Workers Comp Audit	16,783.00	Y
38452	9/3/2026	WINDERMERE PROPERTY MGMT	Misapplied Payment Refund 231 Sumach	1,163.94	Y
38453	9/3/2026	Pikes Peak Towers LLC	10/1/26-9/30/27 Pike's Peak remote radio site rent	4,200.00	Y
38454	9/3/2026	Port of Walla Walla	9.26 Federal Representation	2,000.00	Y
38455	9/3/2026	Solid Waste Systems Inc	08/2026 SSFS Parts, Sanitation Roll-off truck	3,626.23	Y
	9/3/2026	Solid Waste Systems Inc	08/2026 SSFS Parts, Water Vac Hydro excavator	1,943.01	Y
38456	9/3/2026	Sunshine Landscaping LLC	Code Enforcement Abatement CEC-25-0153	1,636.50	Y
38457	9/3/2026	Tarpomatic, Inc	08/2026 SSFS Landfill Tarping machine	90,365.99	Y
38458	9/3/2026	Walla Walla Electric Inc	08/2026- Replace camera on gate	1,739.00	Y
	9/3/2026	Walla Walla Electric Inc	09.2026 fire alarm monitoring	26.02	Y
38459	9/3/2026	Walla Walla Saw LLC	07/2026 SSFS Outside Repair, Golf Course saw	38.19	Y
38460	9/3/2026	Allied Plumbing and Pumps LLC	8/2026 Trunk Main CIPP Project	498,717.92	Y
38461	9/3/2026	Byrnes Oil Company Inc	08.31.2026 fuel for police admin/operations	6,122.30	Y
38462	9/3/2026	Byrnes Oil Company Inc	08/2026 SSFS Fuel, Golf Course	1,484.97	Y
38463	9/3/2026	Financial Consulting Solutions Group Inc	7.26 Long Term Financial Plan Update	1,727.50	Y
38464	9/3/2026	RH2 Engineering, Inc	ProSer 3/30-4/23/202On-Call Professional Consulting	2,342.13	Y
38465	9/3/2026	Valence Inc	9.26 Phone/Radio monthly maintenance services	3,000.25	Y
	9/3/2026	Valence Inc	8.26 Incidentals, per diem & field labor rate	4,767.67	Y
38466	9/3/2026	W3 Entertainment	08.2026 Lodging Tax Grant Reimbursement	6,214.00	Y
38467	9/3/2026	WATECH	08.2026 VPN service	285.00	Y
38468	9/10/2026	Arcadio Moreno	EQ14287 - tint windows/remove decals	760.90	Y
38469	9/10/2026	Atlas Sand & Rock, Inc.	Top Dressing Sand	2,023.11	Y

38470	9/10/2026	Best Pest Control	09.2026 pest control service	141.83	Y
38471	9/10/2026	Blue Mountain Humane Society	08.2026 Animal care services	5,620.83	Y
38472	9/10/2026	C.I. Support LLC	8.26 Dispatch on site records destruction	11.25	Y
	9/10/2026	C.I. Support LLC	8/26 Finance on site Shred Service	11.25	Y
38473	9/10/2026	Car Wash Partners, Inc.	08/2026 SSFS Service, Monthly Car washes	351.44	Y
38474	9/10/2026	Cascade Natural Gas Inc	08/26 Natural Gas - 201 E Rees Ave	47.81	Y
	9/10/2026	Cascade Natural Gas Inc	08/26 Natural Gas - 55 E Moore St	50.40	Y
	9/10/2026	Cascade Natural Gas Inc	08/26 Natural Gas - 155 E Rees Ave	29.60	Y
	9/10/2026	Cascade Natural Gas Inc	08/26 Natural Gas - 505 E Rees Ave	9,787.47	Y
	9/10/2026	Cascade Natural Gas Inc	08/26 Natural Gas - 2120 S 2nd Ave	37.41	Y
38475	9/10/2026	CenturyLink	08/26 Long Distance	2,490.69	Y
38476	9/10/2026	Copiers Northwest, Inc	Aug. Copies on Printer at Fire St. 1	89.40	Y
	9/10/2026	Copiers Northwest, Inc	Aug. Copies on Printer at Fire St. 2	46.25	Y
	9/10/2026	Copiers Northwest, Inc	8.26 Copy/Scan overage - HR	349.33	Y
	9/10/2026	Copiers Northwest, Inc	8.26 Copy/Scan overage - CM/DCM/Fin	357.06	Y
	9/10/2026	Copiers Northwest, Inc	8.26 Copy/Scan overage - CA	235.47	Y
38477	9/10/2026	Devries Business Management Inc	8.31.26 On site shred service	18.50	Y
38478	9/10/2026	DirectTV LLC	9/5-10/4 Dispatch weather/news monitoring	69.99	Y
38479	9/10/2026	Ed Staub & Sons Petroleum, Inc	Propane, WTP	175.18	Y
38480	9/10/2026	Eurofins Environment Testing Northwest	Fire watershed sample testing, WTP	455.00	Y
38481	9/10/2026	Federal Express Inc	Shipping fees for compost testing	86.81	Y
38482	9/10/2026	Franklin County Fire Protection District 3	Portable Radios	24,200.00	Y
38483	9/10/2026	Insight Public Sector	Additional Adobe Acrobat Pro licenses - Finance	131.48	Y
38484	9/10/2026	King Beverage, Inc	Pro Shop Merchandise - Alcohol	36.00	Y
	9/10/2026	King Beverage, Inc	Pro Shop Merchandise - Alcohol	296.25	Y
38485	9/10/2026	L N Curtis & Sons Inc	Turnout Extractor for Fire St. 1	8,039.99	Y
38486	9/10/2026	LexisNexis Coplogic Solutions Inc	08.2026 DeskOfficer Online Reporting	1,047.36	Y
38487	9/10/2026	Mia Vargas	Spanish Language Translation Services	840.00	Y
38488	9/10/2026	Midwest Tape LLC	Audiovisual, DVD	10.73	Y
38489	9/10/2026	ADRIENNE FEEHAN	Close 1375 Pat Ave	324.87	Y
38490	9/10/2026	CHRISTIE MCANNALLY	Close 1704/1708 Walla Walla Ave	211.81	Y
38491	9/10/2026	HODGEN FAMILY LIVING TRUST	Close 224 Austin St	116.90	Y
38492	9/10/2026	JENNIFER GARZA	Close 1350 University St	256.94	Y
38493	9/10/2026	JESSEY CEREGHINO	Close 1725 Twin Creek Ln	88.64	Y
38494	9/10/2026	JESSEY CEREGHINO	Close 1725 Twin Creek Pl	89.26	Y
38495	9/10/2026	JOHN LACOMBE	Close 1441 Portland Ave	111.76	N
38496	9/10/2026	KERNEY FAMILY TRUST	Close 19 W Morton St	117.73	Y
38497	9/10/2026	KIMBERLY GUISNESS	Close 420 E Pine St	170.39	Y
38498	9/10/2026	LINDA ROBISON	Close 303 E Oak St	248.68	Y
38499	9/10/2026	PAUL MCCASKILL	Close 2441 Country Club Rd	201.48	N
38500	9/10/2026	SARAH BEAVER	Close 58 Talon Loop	116.80	Y

38501	9/10/2026	SUSAN ELIZABETH JAMES	Close 1131 Ava St	388.53	Y
38502	9/10/2026	THE BREITENSTEIN FAMILY TRUST	Close 175 N 4th Ave	285.40	Y
38503	9/10/2026	OXARC Inc	2026 Annual Chlorine Order, WTP	10,108.24	Y
38504	9/10/2026	Pacific Power Inc	08/26 Power - Golf Course	2,179.52	Y
	9/10/2026	Pacific Power Inc	08/26 Power - Service Center	4,969.19	Y
38505	9/10/2026	Pacific Security	8.2026 Sleep Center Guard Services	10,975.36	Y
38506	9/10/2026	Paradigm Software LLC	09/26-08/27 Credit card service fees for the LF	6,897.64	Y
	9/10/2026	Paradigm Software LLC	09/2026 - Paradigm User Conference (4 employees)	1,363.75	Y
38507	9/10/2026	Parametrix, Inc	ProSer thru 7/31/26 Pioneer Park Pedestrian Improv	851.35	Y
	9/10/2026	Parametrix, Inc	ProSer Thru 7/31/26Hobosn-Division-Madison IRRP	4,569.48	Y
38508	9/10/2026	Pepsi Cola Bottling of Walla Walla Inc	09/2026 - Water for the LF	177.65	Y
38509	9/10/2026	Polaris Industries Inc.	FD Polaris Crew XP 1000	44,242.30	Y
38510	9/10/2026	Protect Youth Sports	08/2026 Background Checks for Golf, Parks, Rec	1,002.75	Y
38511	9/10/2026	Miguel Ruiz	Tint windows of task force vehicle	872.80	Y
38512	9/10/2026	Ronald Mailloux	Medicare 9/2026	202.90	Y
38513	9/10/2026	Simplot AB Retail Inc	Turf Supplies - Herbicide	2,382.47	Y
38514	9/10/2026	Sterling Jennings	WA Fire Mechanics Conference Wenatchee, WA 2026	112.20	Y
38515	9/10/2026	Taylor Made Golf Company Inc	Golf Balls for Resale	1,963.80	Y
38516	9/10/2026	Umpqua Research Company	Mill Creek Glen water samples, WTP	135.00	Y
38517	9/10/2026	Unifirst Corporation	Ambassador Towels 08/28/26	45.03	Y
	9/10/2026	Unifirst Corporation	08/2026 SSFS Uniform & Facility Services	180.55	Y
	9/10/2026	Unifirst Corporation	9.4.26 Dispatch rug rental	35.25	Y
38518	9/10/2026	Visit Walla Walla	8.2026 Lodging Tax Allocation	51,708.34	Y
38519	9/10/2026	Walla Walla Country Club	Range Balls	1,571.04	Y
38520	9/10/2026	Walt's Septic Tank Service LLC	September 2026 Portable Toilet Service for the LF	185.49	Y
38521	9/10/2026	Wastequip Inc	(300) 96-gallon containers - PO #260114	30,154.86	Y
38522	9/10/2026	Western States Equipment Inc	08/2026 SSFS Service & Repair, Landfill CAT loader	5,396.61	Y
38523	9/10/2026	Walla Walla Alliance for the Homeless	8.26 Sleep Center Management Services	3,047.92	Y
38524	9/10/2026	Walla Walla County	9/26 208 W Rose REETA Fee	10.00	Y
38525	9/10/2026	Anatek Labs Inc	TOC for labs, WTP	1,846.00	Y
38526	9/10/2026	Ashely C Kulberg	9.2026 Monthly Indigent Defense	11,270.84	Y
38527	9/10/2026	Byrnes Oil Company Inc	Confidential - 08.31.2026 fuel for task force	632.37	Y
38528	9/10/2026	Cobalt Community Research LLC	2026 Visitor Reports	895.00	Y
38529	9/10/2026	Consor North America, Inc	ProSer July 2026 Myra Rd South Ext-SR125 Taumarson	11,220.00	Y
38530	9/10/2026	Coran Chavez	Backflow Test Yakima, WA 2026	79.51	Y
38531	9/10/2026	Danielle Dolphin	HUD/CDBG Beaverton, OR 2026	216.00	Y
38532	9/10/2026	David Evans and Associates	ProSer 7/19-8/15/26 Bridge Inspections & On Call	6,116.54	Y
38534	9/10/2026	DKS Associates	ProSer6/1-6/30/26 3rd & Chestnut Safety Study	2,985.00	Y
38535	9/10/2026	Financial Consulting Solutions Group Inc	ProSer thru 8/31/26 Utility Financial Planning	2,666.00	Y
38536	9/10/2026	Geosyntec Consultants International, Inc	ProSer thru 8/16/26-2025 Methane Emissions Grant	1,566.12	Y
38537	9/10/2026	Jeffrey A Linn	WA Fire Mechanics Conference Wenatchee, WA 2026	74.80	Y

38538	9/10/2026	Justin Laib	09/02/2026 - J. Laib CDL License Renewal	136.00	Y
38539	9/10/2026	Kennewick Industrial and Electrical Supply Inc	Sprinkler Parts/Landscape Fabric St. 2	153.49	Y
38540	9/10/2026	Kennewick Industrial and Electrical Supply Inc	Irrigation Repair - Martin Field	16.47	Y
38541	9/10/2026	Kennewick Industrial and Electrical Supply Inc	Replacement Valve Box Cover - Pioneer	49.39	Y
38542	9/10/2026	Kennewick Industrial and Electrical Supply Inc	Irrigation Repair - Cemetery	603.17	Y
38543	9/10/2026	Kennewick Industrial and Electrical Supply Inc	Replacement Valve Box Lid	148.16	Y
38544	9/10/2026	Kennewick Industrial and Electrical Supply Inc	Irrigation Repairs	21.09	Y
38545	9/10/2026	Leah Fisk	Pacific NW Annual Conference Spokane, WA 2026	206.40	Y
38546	9/10/2026	Leoff Health & Welfare Trust	LEOFF Trust Invoice for September 2026 - Fire	128,934.98	Y
38547	9/10/2026	Leoff Health & Welfare Trust	LEOFF Trust Invoice for September 2026 - Police	118,370.11	Y
38548	9/10/2026	Lizbette Feria	WFOA Annual Conference Kennewick, WA 2026	47.30	Y
38549	9/10/2026	Morrison-Maierle, Inc.	ProSer thru 8/28/26-Design Dam Sediment Gate	307.50	Y
38550	9/10/2026	Operations Management International Inc	ProSer thru 8/31/26 Management and Operations of	248,311.59	Y
38551	9/10/2026	Smarsh Inc	08.2026 archive service	12.33	Y
38552	9/10/2026	Stephanie Young	WFOA Annual Conference Kennewick, WA 2026	68.80	Y
38553	9/10/2026	Tristar Claims Management Services, Inc.	08/26 Worker's Compensation Disbursements	63,645.88	Y
38554	9/10/2026	Tyler Technologies Inc	08/26 Munis time and attendance implementation	981.90	Y
38555	9/10/2026	Valence Inc	9.26 Spare network clock & shipping	7,879.23	Y
38556	9/11/2026	Walt's Septic Tank Service LLC	Portable toilet rental for the landfill	185.49	Y
38557	9/11/2026	Walla Walla County	9/26-208 W Rose Temporary Easement	306.50	Y
38558	9/11/2026	Walla Walla County	407 N 4th Ave Code Enforcement Legal Filing	309.50	Y
38559	9/17/2026	Amy Harris	WACE Training Leavenworth, WA 2026	74.80	Y
38560	9/17/2026	Barry Jaquins	Medicare 9/2026	195.90	Y
	9/17/2026	Barry Jaquins	Leoff 1 Prescription Reimbursement 9/9/26	34.25	Y
38561	9/17/2026	Basin Disposal of Washington	August 2026 Residential Recycling Services	9,418.91	Y
	9/17/2026	Basin Disposal of Washington	8.26 Dispatch recycling service	8.58	Y
	9/17/2026	Basin Disposal of Washington	08/26 Aviary Recycling	8.58	Y
	9/17/2026	Basin Disposal of Washington	August 2026 BDI Contract Payment	73,718.50	Y
38562	9/17/2026	BuildingWork	8/26 Contract Design Fees & reimbursable expenses	50,719.50	Y
38563	9/17/2026	Burwood Brewing Company LLC	2026 Lodging Tax Grant Final Pmt	1,279.37	Y
38564	9/17/2026	Byrnes Oil Company Inc	09/2026 SSFS Fuel, Cemetery Unleaded	597.66	Y
	9/17/2026	Byrnes Oil Company Inc	09/2026 SSFS Fuel, Cemetery Diesel	1,385.56	Y
	9/17/2026	Byrnes Oil Company Inc	08/2026 SSFS Fuel, City Fleet	25,140.22	Y
	9/17/2026	Byrnes Oil Company Inc	08/2026 SSFS Fuel, City Fleet	30,548.12	Y
	9/17/2026	Byrnes Oil Company Inc	08/2026 SSFS Fuel, City Fire & Ambulance	4,164.21	Y
	9/17/2026	Byrnes Oil Company Inc	08/2026 SSFS Fuel, City Fire & Ambulance	4,072.77	Y
38565	9/17/2026	Charles Hawman	Medicare 9/2026	183.90	Y
38566	9/17/2026	Dan Aycock	Medicare 9/2026	202.90	Y
38567	9/17/2026	David Evans and Associates	ProSer 6/14-8/15/202 Poplar Street 5th to 14th Des	83,344.79	Y
	9/17/2026	David Evans and Associates	ProSer 7/19-8/15-26-4th & 6th Ave Bridge Replace	62,104.49	Y
38568	9/17/2026	Dennis Kralman	Medicare 9/2026	202.90	Y

38569	9/17/2026	Washington State Department of Corrections	August work crew for the Sudbury Landfill	282.38	Y
38570	9/17/2026	Washington State Department of Corrections	08/26 Offender Work Crew - Cemetery	1,146.74	Y
38572	9/17/2026	Floyd E Bloom	Medicare 9/2026	202.90	Y
38573	9/17/2026	Fred Moore	Medicare 9/2026	202.90	Y
38574	9/17/2026	Gallup Inc	Annual Employee Engagement Survey	9,344.19	Y
38575	9/17/2026	Government Portfolio Advisors	8/26 Monthly Investment Advisory Services	2,716.35	Y
38576	9/17/2026	Greg Van Donge	Medicare 9/2026	202.90	Y
	9/17/2026	Greg Van Donge	Leoff 1 Prescription Reimbursement 9/8/26	55.00	Y
38577	9/17/2026	Hillis Clark Martin & Peterson PS	08/2026 - Legal Consult for Sudbury Road Landfill	225.00	Y
	9/17/2026	Hillis Clark Martin & Peterson PS	08/2026 - Legal Consult for Sudbury Road Landfill	30.00	Y
	9/17/2026	Hillis Clark Martin & Peterson PS	Marcus Whitman Stillwater Chevron Legal Consulting	432.00	Y
38578	9/17/2026	Humbert Asphalt Inc	Hot Mix Asphalt	20,072.14	Y
38579	9/17/2026	Jack Pinza	Medicare 9/2026	202.90	Y
38580	9/17/2026	John Martin	Medicare 9/2026	202.90	Y
38581	9/17/2026	Joseph Herbst	Basic Field Officer Training Renton, WA 2026	326.60	Y
38582	9/17/2026	Julie Carlson Straube	9.26 Monthly Indigent Defense	13,525.00	Y
38583	9/17/2026	Kellermyer Bergensons Services, LLC	Aug '26 Janitorial services, WTP	261.00	Y
	9/17/2026	Kellermyer Bergensons Services, LLC	08/26 Janitorial Services	6,831.00	Y
38584	9/17/2026	Kelley Create Co	Sept '26, 581 Mill Creek Copier srv. WTP	42.78	Y
	9/17/2026	Kelley Create Co	08.2026 administrative copier use	84.73	Y
	9/17/2026	Kelley Create Co	08.2026 Special Teams copier use	46.88	Y
	9/17/2026	Kelley Create Co	09.2026 Records copier use	214.32	Y
	9/17/2026	Kelley Create Co	08.2026 Administrative copier use KyoMA4000	24.20	Y
	9/17/2026	Kelley Create Co	09/2026 SSFS Lease, Copier Contract	59.76	Y
38585	9/17/2026	Kelley Create Co	08/1-08/31/26, KC31735 Copier srv. PW	99.78	Y
38586	9/17/2026	Kenneth Butherus	Medicare 9/2026	202.90	Y
38587	9/17/2026	Lemons Law Office, PLLC	9.26 Monthly Fee - Indigent Defense	13,525.00	Y
38588	9/17/2026	Mason Knowles	Basic Field Officer Training Renton, WA 2026	326.60	Y
38589	9/17/2026	Mike Kyle	Medicare 9/2026	202.90	Y
38590	9/17/2026	Mike Stroe	Medicare 9/2026	202.90	Y
38591	9/17/2026	Paul Lommasson	Medicare 9/2026	202.90	Y
38592	9/17/2026	Renea Parker	Procurement Fundamentals Training Lace, WA 2026	108.00	Y
38593	9/17/2026	Robert Wheeler	Medicare 9/2026	202.90	Y
38594	9/17/2026	Steven Slawson	Medicare 9/2026	158.90	Y
38595	9/17/2026	Tim Gehlhausen	Medicare 9/2026	171.90	Y
38596	9/17/2026	Tim Martindale	ICAC Conference Bellevue, WA 2026	437.00	Y
38597	9/17/2026	Travis Chester	Recertify CPSI Kirkland, WA 2026	216.20	Y
38598	9/17/2026	Tyler Technologies Inc	9/26 Munis time and attendance implementation	981.90	Y
38599	9/17/2026	Valence Inc	9.26 Wallula Microwave Parts	1,459.10	Y
38600	9/17/2026	Wallace Fisher	Medicare 9/2026	202.90	Y
38601	9/17/2026	Wesley Carney	Medicare 9/2026	202.90	Y

38602	9/17/2026	Anderson Perry & Associates Inc	ProSer thru 7/31/26 Rose Street Preservation Design	5,887.49	Y
38603	9/17/2026	Arcadio Moreno	CVA grant detailing vehicle	381.50	Y
38604	9/17/2026	Sunnyside Community Hospital Association	05.07.26 inmate dental service John Allen	97.54	Y
38605	9/17/2026	AW Rehn & Associates Inc	08/2026 COBRA Letters	112.00	Y
38606	9/17/2026	Best Pest Control	Pest Treatment - Golf Course	272.75	Y
	9/17/2026	Best Pest Control	09/26 Pest Control - Cemetery	87.28	Y
	9/17/2026	Best Pest Control	09/26 Pest Control - City Hall	114.56	Y
	9/17/2026	Best Pest Control	09/26 Pest Control - Fort WW Rotary Shelter	120.01	Y
	9/17/2026	Best Pest Control	09/26 Pest Control - Garden Center	120.01	Y
	9/17/2026	Best Pest Control	09/26 Pest Control - City Shop & Maint. Yard	163.65	Y
38607	9/17/2026	Blue Mountain Action Council	8/26 Utility Discount	180.00	Y
38608	9/17/2026	Broad Sky Networks LLC	09/26 Phone Services	98.90	Y
38609	9/17/2026	Cascade Natural Gas Inc	July '26 Gas for 1505 Strum Ave, WTP	29.60	Y
	9/17/2026	Cascade Natural Gas Inc	07/26 Natural Gas - 925 W Whitman Dr	27.03	Y
	9/17/2026	Cascade Natural Gas Inc	07/26 Natural Gas - 65 E Moore St	54.29	Y
	9/17/2026	Cascade Natural Gas Inc	07/26 Natural Gas - 75 E Moore St	27.03	Y
	9/17/2026	Cascade Natural Gas Inc	07/26 Natural Gas - 15 N 3rd Ave	27.03	Y
	9/17/2026	Cascade Natural Gas Inc	Aug 2026 Utility Bill for Fire St. 2	126.99	Y
38610	9/17/2026	CenturyLink	55 E Moore St Alarm Line 06/26	48.53	Y
	9/17/2026	CenturyLink	55 E Moore St Alarm Line 07/26	48.53	Y
	9/17/2026	CenturyLink	Sept 2026 - Fire St. 1 Fax Line	50.85	Y
	9/17/2026	CenturyLink	Sept 2026 Fire St. 1 Alarm Line	48.53	Y
	9/17/2026	CenturyLink	Sept 2026 - Fire St. 1 Router	48.53	Y
	9/17/2026	CenturyLink	9/1-9/30 Dispatch non-emergency line services	674.43	Y
	9/17/2026	CenturyLink	9/1-9/30 Alt dispatch center phone service	206.28	Y
	9/17/2026	CenturyLink	08/26 City Hall Elevator	57.01	Y
38611	9/17/2026	City of Walla Walla	Drop Box #85, Tree Debris, Yard Debris	296.28	Y
38612	9/17/2026	City of Walla Walla	September 2026 Petty Cash	70.50	Y
38613	9/17/2026	Columbia County Public Hospital District	Medications for Ambulances	322.17	Y
38614	9/17/2026	Correct Equipment	Hydro instruments, WTP	2,122.00	Y
38615	9/17/2026	Corwin Ford	08/2026 SSFS Parts, Police Interceptor	21.82	Y
	9/17/2026	Corwin Ford	08/2026 SSFS Parts, Police Interceptor	470.44	Y
	9/17/2026	Corwin Ford	09/2026 SSFS Parts	90.88	Y
38616	9/17/2026	CW Nielsen Manufacturing Inc	12 replacement badges-officer, sgt, detective	2,147.09	Y
38617	9/17/2026	Blue Mountain Tools, Corp	09/2026 SSFS Annual Equipment Software renewal	1,940.89	N
38618	9/17/2026	Matrix Imaging Solutions, LLC	08/26 Utility BIlling Service	10,234.11	Y
38619	9/17/2026	De Nora Holdings US, Inc	UV Sensor Recalibration, WTP	1,806.31	N
38620	9/17/2026	Elmenhurst Chiropractic	Leoff 1 Medical Pinza, Jack 8/24/26	58.81	Y
38621	9/17/2026	Facet NW, Inc	Critical Areas Ordinance (CAO) July 2026	3,906.00	Y
38622	9/17/2026	Fred Mitchell	Medicare 9/2026	202.90	Y
38623	9/17/2026	Ingram Industries Inc	Children's books	81.75	Y

	9/17/2026	Ingram Industries Inc	Children's books	11.98	Y
	9/17/2026	Ingram Industries Inc	Children's books	19.63	Y
	9/17/2026	Ingram Industries Inc	Adult/YA books	32.58	Y
	9/17/2026	Ingram Industries Inc	Children's books	64.97	Y
	9/17/2026	Ingram Industries Inc	YA/Children's books	111.54	Y
	9/17/2026	Ingram Industries Inc	Adult/YA/Children's books	241.63	Y
	9/17/2026	Ingram Industries Inc	Children's books	32.71	Y
	9/17/2026	Ingram Industries Inc	Adult/YA/Children's books	392.33	Y
	9/17/2026	Ingram Industries Inc	Children's book	14.83	Y
38624	9/17/2026	Irma Sanchez-Ayala	Uniform Alterations for Smithen	18.55	Y
38625	9/17/2026	J-U-B Engineers Inc	ProSer 6/28-8/1/26 wa2007 Hydro Controls Upgrade	834.98	Y
38626	9/17/2026	Jessica A Corona	9/9/26-Right of Entry Permit Expires 7/31/27	500.00	N
38627	9/17/2026	Koncrete Industries Inc	Rock for Fire St. 2 Landscape	455.49	Y
	9/17/2026	Koncrete Industries Inc	Concrete for Water Dept. Patches	763.70	Y
38628	9/17/2026	Larry Warren	Medicare 9/2026	200.90	Y
38629	9/17/2026	Lyrasis	Electronic books	1,188.26	Y
38630	9/17/2026	Mary Catherine Scott	9/2026-7/2028--208 W Rose St Temporary Easement	1,950.00	Y
38631	9/17/2026	MBG Cleaning Services	8.26 Janitorial Services	1,600.00	Y
	9/17/2026	MBG Cleaning Services	MBG Janitorial Service AUG26	1,550.00	Y
38632	9/17/2026	MemberSports Inc	MemberSports Subscription 09/26	500.00	Y
38633	9/17/2026	Michael Everett	Medicare 9/2026	202.90	Y
38634	9/17/2026	Midwest Tape LLC	Audiovisual, DVD	40.63	Y
38635	9/17/2026	Mountain Hi Truck and Equipment LLC	08/2026 SSFS Parts, Landfill water truck	593.38	Y
38636	9/17/2026	Neil Hinton	Medicare 9/2026	202.90	Y
38637	9/17/2026	AIYANA HICKS	Close 314 N Blue St	97.54	N
38638	9/17/2026	ARLEAH PROPERTIES LLC	Close 64 Talon Loop	235.83	N
38639	9/17/2026	DOROTHY L STEDING REV. TRUST	Close 2111 Paramount St	153.19	Y
38640	9/17/2026	HAYDEN HOMES LLC	Close 427 Whistling Duck Rd	43.40	Y
38641	9/17/2026	HAYDEN HOMES LLC	Close 638 Kingbird Ct	136.87	Y
38642	9/17/2026	KATINA HENDERSON	Close 1022 Hobson St	112.88	Y
38643	9/17/2026	KIMBERLY MUELLER	Close 1459 Jackson St	37.33	Y
38644	9/17/2026	MOHAMED F OSMAN	Close 1508 Ironwood Dr	838.86	N
38645	9/17/2026	RICHARD M SIEMSSEN REVOCABLE LIVING TRUS	Close 214 Eagan St	165.72	N
38646	9/17/2026	SUNSHINE LANDSCAPE AND POOLS LLC	Refund of temp hydrant deposit.	299.60	Y
38647	9/17/2026	TERRY L HEISEY	Close 75 Wolf Fork Pl	152.21	Y
38648	9/17/2026	OverDrive Inc	Electronic book	5.00	Y
38649	9/17/2026	OXARC Inc	2026 Annual Chlorine Order	5,054.12	Y
	9/17/2026	OXARC Inc	Sodium Hypochlorite Bulk 08/24/26	1,888.79	Y
	9/17/2026	OXARC Inc	CO2 Bulk 08/26/26	1,421.74	Y
	9/17/2026	OXARC Inc	Cylinder Rental 08/31/26	133.63	Y
	9/17/2026	OXARC Inc	CO2 Tank 08/31/26	151.81	Y

	9/17/2026	OXARC Inc	Sodium Hypochlorite Bulk 08/31/26	1,888.79	Y
	9/17/2026	OXARC Inc	Fort WW Skate Park Repair	36.29	Y
38650	9/17/2026	Pacific Power Inc	07/26 Power - Fire 1, Library, City Hall	3,548.13	Y
	9/17/2026	Pacific Power Inc	Aug 2026 -Pacific Power f/Training Classroom	56.71	Y
	9/17/2026	Pacific Power Inc	8/3-9/1 Dispatch center power services	1,115.40	Y
	9/17/2026	Pacific Power Inc	7/30-8/28 Wallula radio site power service	183.85	Y
	9/17/2026	Pacific Power Inc	Power for Street Lights 8/3/26 - 9/1/26	71.16	Y
	9/17/2026	Pacific Power Inc	Power for Street Lights 8/3/26 - 9/1/26	149.70	Y
	9/17/2026	Pacific Power Inc	Power for Street Lights 8/3/26 - 9/1/26	41.55	Y
	9/17/2026	Pacific Power Inc	08/26 Power - 21 S Division St	61.01	Y
	9/17/2026	Pacific Power Inc	08/26 Power - Martin Field	41.25	Y
	9/17/2026	Pacific Power Inc	08/26 Power - Misc. Parks	310.45	Y
	9/17/2026	Pacific Power Inc	Power for Street Lights 8/4/26 - 9/2/26	312.89	Y
	9/17/2026	Pacific Power Inc	Power for Street Lights 8/4/26 - 9/2/26	28.08	Y
	9/17/2026	Pacific Power Inc	Power for Street Lights 8/4/26 - 9/2/26	21.50	Y
	9/17/2026	Pacific Power Inc	Power for Street Lights 8/7/26 - 9/8/26	185.09	Y
	9/17/2026	Pacific Power Inc	Power for Street Lights 8/7/26 - 9/8/26	25.54	Y
	9/17/2026	Pacific Power Inc	Power for Street Lights 8/7/26 - 9/8/26	474.97	Y
	9/17/2026	Pacific Power Inc	08/2026 SSFS Monthly EV Charges	327.37	Y
38651	9/17/2026	Paradigm Software LLC	09/2026- Remote service support to update WeighPay	477.31	Y
38652	9/17/2026	Pepsi Cola Bottling of Walla Walla Inc	August 2026 Water cooler rent for the LF	43.64	Y
	9/17/2026	Pepsi Cola Bottling of Walla Walla Inc	Pro Shop Merchandise - Soda	270.62	Y
38653	9/17/2026	Power House Theatre	Q3 2026 Lodging Tax Grant	6,387.50	Y
38654	9/17/2026	ProQuest LP	Syndetics, provides catalog images	400.00	Y
38655	9/17/2026	Regency Pacific Management LLC	Leoff 1 Room & Board Stroe, Mihai 8/2026	12,400.00	Y
38656	9/17/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Golf Balls	1,421.50	Y
	9/17/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Golf Balls	1,174.74	Y
	9/17/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Gloves	67.98	Y
	9/17/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Gloves	1,268.96	Y
	9/17/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Golf Balls	109.98	Y
	9/17/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Golf Balls	22.66	Y
	9/17/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Golf Clubs	1,114.90	Y
	9/17/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Clubs	978.03	Y
38657	9/17/2026	Soiltest Farm Consultants Inc	Compost Testing Services - North	429.00	Y
	9/17/2026	Soiltest Farm Consultants Inc	Compost Testing Services - South	429.00	Y
38658	9/17/2026	StoneShare Corp	Copilot Standardization Project	10,000.00	N
38659	9/17/2026	Stop Stick, Ltd	7 aluminum trays (9 ft) for new patrol cars	511.68	Y
38660	9/17/2026	Swire Coca-Cola USA	Pro Shop Merchandise - Soda	584.15	Y
	9/17/2026	Swire Coca-Cola USA	Pro Shop Merchandise - Soda	845.60	Y
38661	9/17/2026	Systems Design West LLC	Aug. Ambulance Billing Service	7,703.18	Y
38662	9/17/2026	Tallmans Inc	Leoff 1 Prescription Charges 8/2026	78.49	Y

38663	9/17/2026	TeamSideLine.com	TeamSideline Annual Subscription 10/26-10/27	1,853.61	Y
38664	9/17/2026	Terry Thompson	Medicare 9/2026	223.20	Y
38665	9/17/2026	TIFCO Industries Inc	Facilities Supplies	109.19	Y
	9/17/2026	TIFCO Industries Inc	Facilities Supplies	176.14	Y
38666	9/17/2026	TimeClock Plus, LLC	9/27-10/26 Dispatch scheduling software	109.10	Y
38667	9/17/2026	Tom Anderson	Medicare 9/2026	202.90	Y
38668	9/17/2026	Towing-In,LLC	Case 2026-23824 evidence towing	125.00	Y
38669	9/17/2026	United States Geological Survey	Water Resources investigations, WTP	716.00	Y
38670	9/17/2026	Valley Vision Clinic PS	Leoff 1 Medical Aycock, Dan 8/25/26	319.00	Y
	9/17/2026	Valley Vision Clinic PS	Leoff 1 Medical Aycock, Dan 8/24/26	60.00	Y
38671	9/17/2026	Washington City/County Management Association	10.26 NW's Leadership Academy Reg Fee - Click	1,250.00	N
38672	9/17/2026	Washington State Department of Health	9/26 DWSRF Loan Payment DM15-952-027/DWL24634	683,827.73	Y
	9/17/2026	Washington State Department of Health	9/26 DWSRF Loan payment DM13-952-183	703,038.11	Y
38673	9/17/2026	Walla Walla County	8.26 MSAG reimbursement for Kendall Corn	3,093.72	Y
38674	9/17/2026	Walla Walla County	06.2026 correction services	21,254.39	Y
38675	9/17/2026	Walla Walla Electric Inc	Sept '26 Mill Creek alarm, WTP	26.02	Y
38676	9/24/2026	1-2-3 Printing Inc	1000 business cards for M. Coleman	72.01	Y
	9/24/2026	1-2-3 Printing Inc	09/26 Finance Customer Service Business Cards	45.82	Y
	9/24/2026	1-2-3 Printing Inc	Business cards for Officer Hendrickson	72.01	Y
38677	9/24/2026	Jennine E Ejde	9.2026 Indigent Defense Monthly	18,034.00	Y
38678	9/24/2026	Byrnes Oil Company Inc	09.15.2026 fuel for administrative/operations use	5,861.57	Y
	9/24/2026	Byrnes Oil Company Inc	Confidential 09.15.2026 fuel for Task Force use	676.90	Y
	9/24/2026	Byrnes Oil Company Inc	09/2026 SSFS Fuel, Golf Course Diesel & Unleaded	2,378.30	Y
38679	9/24/2026	Christopher Buttice	FBINAA NW Training Conf. Airway Heights, WA 2026	68.80	Y
38680	9/24/2026	Cody Maine	First Responders Wellness Summit 2026	101.20	Y
38681	9/24/2026	Corwin Ford	09/2026 SSFS Parts, FD Ambulance	32.73	Y
	9/24/2026	Corwin Ford	09/2026 SSFS parts, Credit upon return	95.19	Y
	9/24/2026	Corwin Ford	09/2026 SSFS parts, Credit upon return	60.01	Y
	9/24/2026	Corwin Ford	09/2026 SSFS parts, Credit upon return	54.99	Y
38682	9/24/2026	Derek Davidson	WA Fire Mechanics Conference Wenatchee, WA 2026	112.20	Y
38683	9/24/2026	Elizabeth Chamberlain	ICSC Conf Airfare Reimbursement	462.39	Y
	9/24/2026	Elizabeth Chamberlain	Economic Dev. Recruitment Conf. San Diego, CA 2026	293.78	Y
38684	9/24/2026	Emily Arteche	WA Planning Directors Conference Chelan, WA 2026	423.52	Y
38685	9/24/2026	Eric Knudson	FBINAA NW Training Conf. Airway Heights, WA 2026	68.80	Y
38686	9/24/2026	Herrera Environmental Consultants Inc	ProSer 8/1-8/28/26 Update Sudbury Landfill Fill Pl	3,078.52	Y
38687	9/24/2026	Hughes Fire Equipment Inc	09/2026 SSFS Parts, Fire Truck	75.81	Y
38688	9/24/2026	Jeffrey A Linn	Miles-WA Fire Mechanics Conference Wenatchee, WA 26	270.56	Y
38689	9/24/2026	Kristy Capps	First Responders Wellness Summit 2026	101.20	Y
38690	9/24/2026	Phillip Millett	Industrial Safety & Health Conf. Tacoma, WA 2026	176.30	Y
38691	9/24/2026	J Preston Frederickson	Economic Dev. Recruitment Conf. San Diego, CA 2026	219.30	Y
38692	9/24/2026	Shawn Doering	Industrial Safety & Health Conf. Tacoma, WA 2026	176.30	Y

38693	9/24/2026	Stephanie Young	Miles/WFOA Annual Conference Kennewick, WA	85.73	Y
38694	9/24/2026	Tyler Technologies Inc	07.10.2026 T. LaMonte travel expense GoLive	2,581.09	Y
38695	9/24/2026	Valence Inc	Radio encryption hardware for replacement radio	448.29	Y
38696	9/24/2026	Best Pest Control	9.26 4 yr pest prevention plan	147.29	Y
38697	9/24/2026	Cascade Natural Gas Inc	Aug '26 Natural gas Millcreek Rd, WTP	27.03	N
	9/24/2026	Cascade Natural Gas Inc	Sept. 2026 Utility Bill for Fire St. 1	795.81	N
	9/24/2026	Cascade Natural Gas Inc	09.2026 natural gas service	182.73	N
38698	9/24/2026	CenturyLink	Aug '26 Service line 509-525-9489, WTP	71.04	Y
	9/24/2026	CenturyLink	09/26 Cemetery Router	48.53	Y
	9/24/2026	CenturyLink	09/26 City Hall	63.57	Y
	9/24/2026	CenturyLink	9.26 Sleep Center landline	115.10	Y
	9/24/2026	CenturyLink	Sept. 2026 Fire St. 2 Alarm Line	97.06	Y
38699	9/24/2026	Charter Communications Inc	9/13-10/12 VPN services for jail radio room	114.99	N
38700	9/24/2026	CTC Media Group	Wireless Code Consultant - June 2026	4,170.00	N
	9/24/2026	CTC Media Group	Wireless Code Consultant - July 2026	100.00	N
	9/24/2026	CTC Media Group	Wireless Code Consultant - August 2026	2,302.50	N
38701	9/24/2026	Grapeland Supply LLC	Office Copier Paper	111.28	N
	9/24/2026	Grapeland Supply LLC	Copier Paper	333.85	N
38702	9/24/2026	Ingram Industries Inc	Adult/YA books	213.41	Y
	9/24/2026	Ingram Industries Inc	Children's books	95.93	Y
	9/24/2026	Ingram Industries Inc	Adult/Children's books	95.65	Y
	9/24/2026	Ingram Industries Inc	Adult/YA/Children's books	324.54	Y
	9/24/2026	Ingram Industries Inc	Children's books	24.33	Y
	9/24/2026	Ingram Industries Inc	Children's book	11.34	Y
	9/24/2026	Ingram Industries Inc	Children's book	16.35	Y
	9/24/2026	Ingram Industries Inc	Adult fiction	69.06	Y
38703	9/24/2026	Irma Sanchez-Ayala	Hem uniform pants for A. Kjeldgaard	18.55	N
38704	9/24/2026	Kottkamp, Yedinak and Esworthy P.L.L.C.	Hearing Examiner PLN3-26-0006 Barber Variance	925.00	N
	9/24/2026	Kottkamp, Yedinak and Esworthy P.L.L.C.	Hearing Examiner for Code Enforcement CEC-26-0104	800.00	N
38705	9/24/2026	Marshall Keymer	Tower Space at 1473 W. Rose for Radio Antennas Sep	250.00	Y
38706	9/24/2026	MBG Cleaning Services	09-2026 Janitorial Services for Police	3,100.00	N
38707	9/24/2026	Midwest Tape LLC	Audiovisual, DVD	24.52	N
	9/24/2026	Midwest Tape LLC	Audiovisual, DVDs	33.26	N
38708	9/24/2026	Oil Re-Refining Company Inc	09/2026 - Ethylene Glycol Recycling	464.00	Y
38709	9/24/2026	Allison Handal	Book found, patron reimbursement	25.00	N
38710	9/24/2026	A-1 PLUMBING & EMERGENCY ROOTER	50% permit refund 105 Fishtrap Ln	27.50	N
38711	9/24/2026	A-1 PLUMBING & EMERGENCY ROOTER	Permit refund 105 Fishtrap Ln	10.00	N
38712	9/24/2026	Julie Rathbun	Project cancelled - 827 Hobson St	115.00	N
38713	9/24/2026	Pina’s Roofing LLC	Refund - incorrect fee calculation 310 S 10th Ave	142.68	Y
38714	9/24/2026	Pyro Spectacular	Fireworks Display Permit Refund 919 E Sumach St	100.00	N
38715	9/24/2026	TerraFirma	Permit Fee Refund 121 Thorne St	10.00	N

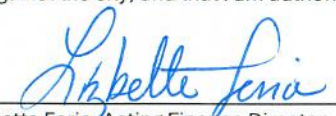
38716	9/24/2026	Total Comfort Solutions Heating, Cooling & Plumbing	Permit Fee Refund 1044 N Clinton St	40.00	N
38717	9/24/2026	Walla Walla Community College	Refund - 611 Water Center Dr fence prmitt overpment	165.28	N
38718	9/24/2026	West Coast Construction & Equipment	1651 W Rose St - Duplicate Permit	126.00	N
38719	9/24/2026	AARON THONNEY	Close 2159 Solara Ln	126.99	Y
38720	9/24/2026	CHM DEVELOPMENT COMPANY	Close 001548 - CHM - Drop Box	391.19	N
38721	9/24/2026	CHRISTOPHER PARSONS	Close 1518 Portland Ave	396.50	Y
38722	9/24/2026	EASY FOAM INC	Final bill for temp hydrant- Dell and Myra	372.32	N
38723	9/24/2026	JEANINE L FLORANCE, TTEE	Close 216 N Madison St	75.48	N
38724	9/24/2026	JORDAN MALONE	Close 143 Union St	107.93	N
38725	9/24/2026	MARY CATHERINE SCOTT, TTEE	Close 208 W Rose St	381.07	N
38726	9/24/2026	MELINDA PREWITT	Close 130 Dice Pl	98.52	N
38727	9/24/2026	RICKY PUMMEL	Close 821 E Chestnut St	142.76	N
38728	9/24/2026	ROBERT SARGEANT	Close 412 Coyote Ridge Dr	377.88	N
38729	9/24/2026	TARRAGON NORTHWEST LLC	Refund for overpaid invoice.	173.76	N
38730	9/24/2026	Wasser Agency	Refund for overpaid invoice.	149.44	N
38731	9/24/2026	OverDrive Inc	Electronic books	717.77	N
38732	9/24/2026	Pacific Power Inc	Aug '26 Electricity, multiple meters, WTP	635.22	N
	9/24/2026	Pacific Power Inc	July '26 Electricity for multiple meters, WTP	37,137.98	N
	9/24/2026	Pacific Power Inc	08/2026 SSFS Monthly EV Charges	22.47	N
	9/24/2026	Pacific Power Inc	Aug 2026 - Pacific Power f/Fire St. 2	1,722.70	N
	9/24/2026	Pacific Power Inc	9.26 Power to Sleep Center	1,614.23	N
	9/24/2026	Pacific Power Inc	09.2026 power for PD building	5,013.56	N
	9/24/2026	Pacific Power Inc	09/2026 SSFS Monthly EV Charges	293.97	N
38733	9/24/2026	Paradigm Software LLC	2026-2027 annual support for LF weigh station.	15,819.81	Y
	9/24/2026	Paradigm Software LLC	Remaining Sales Tax for invoice 17456.	12.67	Y
38734	9/24/2026	Pepsi Cola Bottling of Walla Walla Inc	Pro Shop Merchandise - Soda	37.92	N
38735	9/24/2026	Pioneer City Oil Inc	08/2026 SSFS Fuel, Water Intake	979.36	N
38736	9/24/2026	Platt Electric Supply Inc	Electric Supplies	282.55	N
38737	9/24/2026	Police Training Solutions	Sergeant's investigation of force training	4,254.90	N
38738	9/24/2026	Quality Petroleum Products Inc	08/2026 SSFS Fuel, WTP Diesel	1,075.06	N
	9/24/2026	Quality Petroleum Products Inc	09/2026 SSFS Fuel, WTP Diesel	968.96	N
38739	9/24/2026	Turner & Townsend Heery, LLC	Professional services: library reno project 09/18	5,855.20	N
38740	9/24/2026	Utilities Underground Location Center (UULC)	Excavation Notifications August	101.47	N
	9/24/2026	Utilities Underground Location Center (UULC)	Aug '26 Excavation notifications: 146, WAD	101.47	N
38741	9/24/2026	Verizon Wireless	Confidential 08.2026 phone for investigative use	39.25	N
38742	9/24/2026	Washington State Patrol	3rd qtr. 2026 WSP ACCESS Fees	3,000.00	N
38743	9/24/2026	Walla Walla Summer Theater Group	2026 Lodging Tax Grant	7,000.00	N
	9/24/2026	Walla Walla Summer Theater Group	2026 Lodging Tax Grant Final Balance	470.00	N
38744	9/28/2026	Bryan Rakestraw	Travel reimbursement replacement Spokane/Yakima 25	318.90	Y
38745	9/30/2026	Advanced Traffic Products Inc	12" Red Light Balls for Stock for Signals	3,976.70	Y
38746	9/30/2026	David Evans and Associates	ProSer thru 8/29/26 Alder-Tausick-Airport Pavement	5,598.65	Y

	9/30/2026	David Evans and Associates	ProSer 8/16-9/12/26 Preventative Bridge Maintenance	35,320.37	Y
38747	9/30/2026	DKS Associates	ProSer thru 8/31/26 Downtown WW Signal Timing Update	16,490.00	Y
	9/30/2026	DKS Associates	ProSer thru 8/31/2026 Safety Planning Studies	20,798.00	Y
38748	9/30/2026	Elizabeth Hernandez	AWC Member Expo Chelan, WA 2026	105.40	Y
38749	9/30/2026	Esther Click	NWWLA Program Redmond, WA 2026	188.60	Y
38750	9/30/2026	Geosyntec Consultants International, Inc	August 2026 Landfill Environmental Consult	37,979.85	Y
38751	9/30/2026	Herrera Environmental Consultants Inc	ProSer 8/1-8/28/26 Stormwater Guidelines Update	2,966.02	Y
38752	9/30/2026	Humana Health Care Plans	Leoff 1 Medical Insurance Premiums 10/2026	14,510.34	Y
38753	9/30/2026	Humbert Asphalt Inc	Hot Mix Asphalt	6,612.57	Y
38754	9/30/2026	Jared Jones	APWA Fall Conference Spokane, WA 2026	47.30	Y
38755	9/30/2026	Jarrod G Palmer	APWA Fall Conference Spokane, WA 2026	47.30	Y
38756	9/30/2026	Julissa Virrey Soto	AWC Member Expo Chelan, WA 2026	105.40	Y
38757	9/30/2026	Kelley Create Co	Oct '26, 581 Mill Creek Copier srv. WTP	8.56	Y
	9/30/2026	Kelley Create Co	09.2026 copier use in Report Writing Room	94.23	Y
38758	9/30/2026	Kelli Shane	APWA Fall Conference Spokane, WA 2026	68.80	Y
38759	9/30/2026	Kelly Brown	APWA Fall Conference Spokane, WA 2026	64.50	Y
38760	9/30/2026	Operations Management International Inc	Sept 2026 Management and Operations of WWTP	248,311.59	Y
38761	9/30/2026	OXARC Inc	2026 Annual Chlorine Order	359.52	Y
38762	9/30/2026	Tammy Smith	9.26 Reimbursement - wellness/health activities	46.15	Y
38763	9/30/2026	Travis Rakestraw	APWA Fall Conference Spokane, WA 2026	47.30	Y
38764	9/30/2026	Tyler Technologies Inc	9/26 Tyler Payroll Module, Retro Pay Setup	981.90	Y
38765	9/30/2026	W3 Entertainment	2026 Concert Infrastructure Rebate	2,308.31	Y
38766	9/30/2026	Banlin Construction	Library renovation and expansion AUG26	464,065.25	N
38767	9/30/2026	Best Pest Control	09/26 Pest Control - Memorial Pool	174.56	N
38768	9/30/2026	Brown and Caldwell	Services 6/26-7/15/26 Wastewater Pretreatment Prog	2,106.05	N
38769	9/30/2026	Cascade Natural Gas Inc	Aug '26 Mill Creed UV Building, WTP	27.03	N
	9/30/2026	Cascade Natural Gas Inc	Aug '26 Mill Creek RF Bldg., WTP	27.03	N
	9/30/2026	Cascade Natural Gas Inc	Aug '26 Mill Creek Admin Bldg., WTP	27.03	N
	9/30/2026	Cascade Natural Gas Inc	8/14-9/15 Dispatch generator fuel usage	28.33	N
	9/30/2026	Cascade Natural Gas Inc	08/26 Natural Gas - 940 E Alder St	27.03	N
38770	9/30/2026	City of Walla Walla	September 2026 Petty Cash	276.50	N
38771	9/30/2026	Ingram Industries Inc	Children's books	32.71	N
	9/30/2026	Ingram Industries Inc	Adult/children's book	44.54	N
	9/30/2026	Ingram Industries Inc	Adult/Children's books	119.95	N
	9/30/2026	Ingram Industries Inc	Adult/YA/Children's books	281.38	N
	9/30/2026	Ingram Industries Inc	Adult/Children's books	345.30	N
38772	9/30/2026	Irma Sanchez-Ayala	Uniform Alteration f/Zitterkopf	37.09	N
	9/30/2026	Irma Sanchez-Ayala	Hem uniform pants for A. Kjeldgaard	37.09	N
38773	9/30/2026	King Beverage, Inc	Pro Shop Merchandise - Alcohol	328.50	N
38774	9/30/2026	Koncrete Industries Inc	Railroad Ballast for Alley Repair	268.94	N
38775	9/30/2026	Mackay Sposito, Inc	WA DNR Urban Forestry Consultation	743.50	N

38776	9/30/2026	WorldWide Health Alliance Inc.	Paramedic Program Transfer Fee/Ebding	3,000.00	N
38777	9/30/2026	Northwest Pavement Management Association	10/26-10/30/26 NWPMA 2026 Conference Fee	435.60	N
38778	9/30/2026	Phillip A Brown	Services thru 8/31/26 ASR On-Call Consulting	4,700.00	N
	9/30/2026	Phillip A Brown	Ser thru 8/31/26 WTP2301 Well 5 Rehab & ASR Fea	13,261.44	N
38779	9/30/2026	SIMPLOT GROWER SOLUTIONS	Temp Hydrant Deposit Refund	500.00	N
38780	9/30/2026	OverDrive Inc	Electronic books	310.96	N
	9/30/2026	OverDrive Inc	Electronic books	27.50	N
38781	9/30/2026	Pacific Power Inc	Power for Street Lights 8/3/26 - 9/1/26	422.42	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/13/26 - 9/14/26	305.66	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/3/26 - 9/1/26	1,927.67	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/11/26 - 9/10/26	1,662.46	N
	9/30/2026	Pacific Power Inc	Howard & Park Sprinkler Stormwater August	18.01	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/7/26 - 9/8/26	445.33	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/13/26 - 9/14/26	126.96	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/11/26 - 9/10/26	72.81	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/3/26 - 9/1/26	143.19	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/13/26 - 9/14/26	41.49	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/13/26 - 9/14/26	291.03	N
	9/30/2026	Pacific Power Inc	Aug '26 Electricity for multiple meters, WTP	24,809.23	N
	9/30/2026	Pacific Power Inc	08/26 Power - Cemetery	207.14	N
	9/30/2026	Pacific Power Inc	08/26 Power - Ruth & McKinley St	18.01	N
	9/30/2026	Pacific Power Inc	08/26 Power - Fort WW Restrooms	79.12	N
	9/30/2026	Pacific Power Inc	08/26 Power - Garden Center	139.33	N
	9/30/2026	Pacific Power Inc	08/26 Power - Misc. Parks	3,040.74	N
	9/30/2026	Pacific Power Inc	08/26 Power - Fire 1, Library, City Hall	3,816.41	N
	9/30/2026	Pacific Power Inc	08/26 Power - 755 NE Myra Rd	26.41	N
	9/30/2026	Pacific Power Inc	08/26 Power - 1530 Dalles Military Rd	27.47	N
	9/30/2026	Pacific Power Inc	08/26 Power - Ft Walla Walla Amphitheater	349.13	N
	9/30/2026	Pacific Power Inc	08/26 Power - Fort Walla Walla	421.69	N
	9/30/2026	Pacific Power Inc	Power for Street Light 8/11/26 - 9/10/26	15,289.75	N
	9/30/2026	Pacific Power Inc	Power for Street Lights 8/4/26 - 9/2/26	5,421.28	N
	9/30/2026	Pacific Power Inc	8/24-9/23 Pike's Peak radio site power svc	243.79	N
38782	9/30/2026	Pacific Power Inc	9/18/2026 Pine St Lighting Agreement	20,373.00	N
38783	9/30/2026	Traxium LLC	Library cards	670.00	N
38784	9/30/2026	Providence Health & Service - Washington	08/2026 Hep B Vaccine: Renea Parker	96.75	N
38785	9/30/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Hats	253.08	N
	9/30/2026	Roger Cleveland Gold Company	Pro Shop Merchandise - Hats	556.20	N
38786	9/30/2026	Slice of Life	Concessions Pizza - August 2026	726.32	N
38787	9/30/2026	Uline Inc	Streets Shop Supplies	4,077.98	N
38788	9/30/2026	United Tactical System, LLC	1 set of PepperBall less lethal	1,116.00	N
38789	9/30/2026	Valley Vision Clinic PS	Leoff 1 Medical Bainter, Gary 9/10/26	60.00	N

38790	9/30/2026	Visit Walla Walla	July 2026 TPA Tax Distribution	56,338.82	N
38791	9/30/2026	Walla Walla County	Q1 2026 District Court - City Share	142,830.76	N
	9/30/2026	Walla Walla County	Q2 2026 District Court - City Share	142,370.54	N
38792	9/30/2026	Walla Walla County	ROW Minimum #2026-0036	75.00	N
38793	9/30/2026	Walla Walla Electric Inc	8.26 Re-check wiring - generator to HVAC - Eureka	426.70	N
38794	9/30/2026	Walla Walla Recycling Inc	August 2026 Landfill dropbox recycling services	1,723.50	N
38795	9/30/2026	Z Pest Control LLC	September 2026 rodent control services for Landfill	153.84	N
Total				**6,189,666.01**	

I, Lizbette Feria, Acting Finance Director, do hereby certify under penalty of perjury that the materials have been furnished, the services rendered or the labor performed as described, or that any advance payment is due and payable pursuant to a contract or is available as an option for full or partial fulfillment of a contractual obligation, and that the claim is a just, due and unpaid obligation against the city, and that I am authorized to authenticate and certify said claim.



Lizbette Feria, Acting Finance Director

The payments on this claims roster are comprised of the following:

PRINTED (Numbers 38439-38459 38468-38524 38556-38558 38602-38675 38696-38744 38766-38795)	$3,077,372.12
TRANSFER (Numbers 38460-38467 38525-38532 38534-38555 38559-38570 38572-38601 38676-38695 38745-38765	$1,990,333.55
Wire (1454-1457 1459-1477 1479-1485 1487 1489-1496)	$1,121,960.34
TOTAL	**$6,189,666.01**

ar-5900 **Pgs. 2670-2672**

City Council - Regular Meeting

Meeting Date: 10/14/2026

Item Title: Approve the September 2026 Payroll and Benefits Transactions

Submitted For: Lizbette Feria, Finance Department

Financial Comments:

Payroll and benefit direct deposit transactions of $2,004,421.14
Payroll and benefit electronic and wire transfers of $1,215,949.58
Payroll and benefit check transactions of $29,000.69
Total September 2026 payroll and benefits: $3,249,371.41

These payments were budgeted, and sufficient funds are available in the 2026 budget to cover these payments.

All Contracts:
Not Applicable

Federally funded contracts only:
Not Applicable

Construction contracts only:
Not Applicable

Brief Summary of Requested Action:

Approve the September 2026 Payroll and Benefits Transactions.

Information

HISTORY:

Ordinance 2016-05 appointed the Finance Director as the auditing officer for the City of Walla Walla. All payments made during this period were valid claims against the City. The Finance Department has details. The City's internal controls include having the appropriate department certify the validity of all hours before payment submission. Finance Department staff review all claim payments, and Payroll performs system validation and exception reviews to validate payroll records. The Finance Director, Accounting Supervisor, Accountant, and Payroll Accountant review the batch report in detail to ensure that the hours employees reported are correct, and the payment amounts are accurate.

POLICY ISSUES:

RCW 42.24.080 requires that all claims presented against the City by persons furnishing materials, rendering services, or performing labor must be certified by the appropriate official to ensure that the materials have been furnished, the services rendered, or the labor performed as described and that the claims are just, due, and unpaid obligations against the City, before payments can be made.
RCW 42.24.180 allows expedited processing of claim payments when certain conditions are met. The statute allows the issuance of warrants or checks in payment of claims before the legislative body has acted to approve the claims when:

1. The appropriate officers have furnished official bonds,
2. The legislative body has adopted policies that implement effective internal controls;
3. The legislative body has provided for review of the documentation supporting the claims within a month of issuance; and 4 that if claims are disapproved, they shall be recognized as receivables and diligently pursued.

WWMC 2.17.025 grants the Finance Director the authority to pay city employees upon presentation of property-certified payroll.

PLAN COMPLIANCE:

STRATEGIC PLAN: This action complies with all areas of the City's Strategic Plan.

ALTERNATIVES:

Not approve the September 2026 Payroll and Benefit Transactions

STAFF RECOMMENDATION:

Approving the September 2026 Payroll and Benefit Transactions

CITY MANAGER COMMENTS:

Concur with the staff recommendation and approved for City Council action.

Attachments

September 2026 Payroll Certification

City of Walla Walla

Payroll Check Approval Register
Pay Period: September
Check Date: 10/05/2026

Check Total:	$ 29,000.69
Direct Deposit Total:	2,004,421.14
Wires & Electronic Funds Transfers:	1,215,949.58
Grand Total:	3,249,371.41

I, the **Acting Finance Director**, do hereby certify to the City Council that the checks and direct deposits presented are true and correct to the best of my knowledge.

All checks numbered	**849740**	through	**849765**	, and
Direct deposit numbers	**806599**	through	**806992**	, and
Electronic Fund transfer	**806993**	through	**807007**	

are approved for payment in the amount of **$ 3,249,371.41**
on this 5th day of October, 2026

Lizbette Feria, Acting Finance Director, City of Walla Walla

Walla Walla, Washington

City of Walla Walla

Payroll Final Check List
Pay Period: September
Check Date: 10/05/2026

Total Checks and Direct Deposit	$ 2,033,421.83
Total Wires & Electronic Funds Transfers	1,215,949.58
Grand Total:	3,249,371.41