Final

CITY OF DUVALL WATERSHED PLAN

Adopted 9/15/15

Resolution 15-16

Prepared for
City of Duvall

August 12, 2015

Exhibit A

OUR COMMITMENT TO SUSTAINABILITY | ESA helps a variety of public and private sector clients plan and prepare for climate change and emerging regulations that limit GHG emissions. ESA is a registered assessor with the California Climate Action Registry, a Climate Leader, and founding reporter for the Climate Registry. ESA is also a corporate member of the U.S. Green Building Council and the Business Council on Climate Change (BC3). Internally, ESA has adopted a Sustainability Vision and Policy Statement and a plan to reduce waste and energy within our operations. This document was produced using recycled paper.

EXECUTIVE SUMMARY

Like many communities on the urban fringe, the City of Duvall is striving to promote economic growth and development without sacrificing its rural character and environmental assets that are at the heart of the community's "small town – real life" identity. This Watershed Plan has been prepared to support the City in achieving this goal, by:

- Informing the 2015 Comprehensive Plan update;
- Focusing future development based on a comprehensive understanding of watershed processes;
- Maintaining and improving forest cover and open space;
- Enhancing stormwater management and salmon recovery; and
- Strengthening sensitive area regulations to provide enhanced protection for important resources.

This Plan is intended to be: (1) a technical document that identifies existing watershed characteristics in and immediately surrounding Duvall; and (2) a policy document that gives the City a roadmap for protecting watershed processes and focusing future development in appropriate areas within the city and its urban growth area.

Public Planning Process

The City convened a Watershed Planning Advisory Group to guide development of this Plan (see Acknowledgements section for a list of members). King County's Snoqualmie Watershed Forum worked closely with the City as a partner, including participating in Advisory Group activities. In addition, the City engaged the public during development of the Plan through several public events and activities, including a booth at Duvall Days and presentations at Planning Commission meetings and an Open House. The City also created a webpage with links to the Plan and collected public input via an online survey.

Subbasin Management Group Framework

To evaluate watershed conditions, the City delineated 17 subbasins that encompass Duvall and the surrounding area. For each subbasin, the City evaluated the importance of watershed processes and the level to which these processes have

been degraded by changes in land cover and other modifications. Based on the results of this evaluation, the City categorized each subbasin into one of five management groups:

- **Group 1 – Protect / Restore**: Subbasins of highest importance; highest priority for protection and restoration.
- **Group 2A – Highest Conservation:** Subbasins of moderate importance that are also highly intact; highest priority for conservation and appropriate for limited development.
- **Group 2B – Moderate Conservation:** Subbasins that may be appropriate for some additional development, but also require protection of remaining important areas.
- **Group 2C – Lowest Conservation:** Subbasins where more intense development is appropriate, with focused protection of remaining important areas.
- **Group 3 – Urban Development:** Subbasins below average importance and highly degraded; areas where more intense development should be focused.

Watershed Plan Implementation

Chapter 3 of the Watershed Plan identifies goals and polices that seek to direct future development in a way that protects and restores Duvall's watershed processes. These goals and policies will be incorporated into the Environment and Sustainability Element, a new chapter of the Comprehensive Plan currently under development as part of the 2015 Comprehensive Plan update.

To implement these watershed goals and policies, the Plan identifies actions the City can take to improve forest cover, water quality, wildlife habitat and soils. These actions are packaged as follows:

> **Package A - Trees and Forest Canopy**: This package identifies actions the City could take to improve protection of existing trees and forest canopy. Recommendations for regulatory code changes include: removing the current allowance to clear-cut all onsite significant trees in Subbasin Management Groups 1 and 2; requiring trees to be retained within a contiguous tract according to established criteria; requiring tree replacement monitoring reports for 5 years after planting; integrating open space requirements with tree protection and sensitive areas standards to encourage protection and restoration of larger forested tracts; providing adequate room for street trees; requiring that 50 percent of open space contain native shrubs and trees; encouraging subdivisions to cluster lots according to new subdivision design guidelines; and encouraging infill

developments consistent with neighborhood character in low density residential zones located in subbasin management Groups 2C and 3 . See the Package A table for more detail.

Package B - Water Quality: This package identifies actions the City could take to improve protection of water qualify. Recommendations for regulatory code changes include: lowering maximum impervious surface limits to 40 percent for common zoning designations in Groups 1 and 2 (with allowances for increased coverage when alternative strategies are implemented); updating parking standards and guidelines as approaches to reduce impervious surface coverage; defining and requiring the use of applicable low impact development (LID) best management practices for new development, and incentivizing higher and/or elective LID approaches; increasing protections for depressional wetlands; and creating a flow control exemption for Group 3 areas with existing pipe/ditch connections to the Snoqualmie River. Non-regulatory recommendations include: creating an educational outreach program to encourage LID approaches and other practices that improve water quality; and developing centralized stormwater facilities within urban growth areas to offset onsite requirements. See the Package B table for more detail.

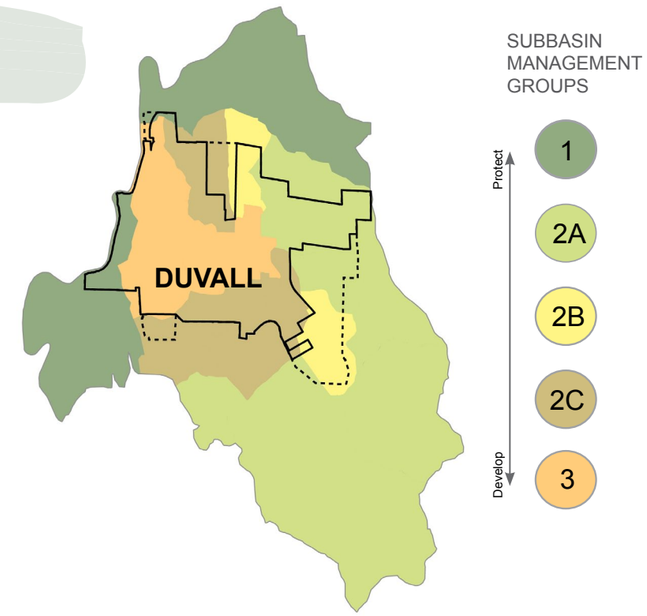
Package C - Wildlife Habitat: This package identifies actions the City could take to improve protection of fish and wildlife habitats. Recommendations for regulatory code changes include: identifying and establishing protections for habitat corridors that extend across and out of the city and urban growth area; improving mechanisms to provide long-term protection of mitigation sites; modifying wetland and stream buffer allowances to be consistent with the relative conservation value of each subbasin management group; and encouraging subdivisions to cluster lots according to new subdivision design guidelines. See the Package C table for more detail.

Package D - Soils and Landscaping: This package identifies actions the City could take to improve protection of native soils, and ensure successful landscaping even when native soils are disturbed. Recommendations for regulatory code changes include: requiring soil reports for development projects (detailing existing conditions, as-built conditions, and compliance with existing and improved City requirements for soil amendments); requiring use of native, drought-tolerant plant species for publically owned properties and open spaces; limiting impacts associated with mass grading by restricting the number of terraced walls or total length of terraced walls; requiring protection of intact forests adjacent to geologically hazardous areas; and removing allowances for landslide hazard area buffer reductions. See the Package D table for more detail.

The following tables summarize each of the four action packages, highlight relationships between actions and additional environmental features that would benefit, and describe how complex the actions would be to implement.

Package A: Improved Outcomes for Trees and Forest Canopy

Action Number	Watershed Plan Action	Implementation Complexity	Additional Environmental Benefits	Applicable Subbasin Management Group
DS-2	Identify opportunities to increase development densities in Management Groups 2C and 3 zoning districts consistent with Comprehensive Plan update.	Moderate		
DS-7	Remove current allowance to clear-cut all on-site significant trees. Require trees to be preserved in contiguous tracts by eliminating double-counting allowance for trees within sensitive areas / buffers (Management Groups 1 and 2); and by establishing clear preferences for where within a site trees should be preserved.	Low		
DS-8	Expand tree mitigation standards to include specifics on tree type (generally requiring native trees); require soil reports to ensure compliance (see Package D for additional details). Ensure that replacement trees are adequately maintained by requiring 1 year, 3 year, and 5 year monitoring reports.	Low		All Groups
DS-9	Establish design guidelines to encourage subdivisions to cluster lots (minimizing mass clearing / grading and maximizing open space).	Low		All Groups
DS-10	Integrate open space requirements with tree protection and sensitive areas standards to encourage tree protection, wider sensitive areas buffers, and/or reforestation as an alternative to pocket parks.	Low		All Groups
SW-7	Widen the minimum landscape strip width for roadways (from 5 feet to 6-8 feet) to provide adequate space for successful tree growth.	Low		All Groups
SA-3	Revise wetland/stream buffer standards to more closely align with tree protection standards.	Moderate		All Groups
SA-6	Require that 50% of open space contain native shrubs and trees; and provide preference for establishing open space adjacent to habitat corridors and sensitive areas.	Moderate		All Groups



LEGEND

1. BALANCING PROTECTIONS WITH DEVELOPMENT OPPORTUNITY

New Protection for Trees and Forest Canopy

Additional Development Opportunities

2. WATERSHED PLAN ACTIONS

DS-# Actions to update **D**evelopment **S**tandards (see Chapter 5)

SW-# Actions to update **S**torm**W**ater management (see Chapter 6)

SA-# Actions to update **S**ensitive **A**reas protections (see Chapter 7)

3. ENVIRONMENTAL BENEFIT TYPE

Trees & Forest Canopy | Water Quality | Wildlife Habitat | Soils & Landscaping

4. IMPLEMENTATION COMPLEXITY

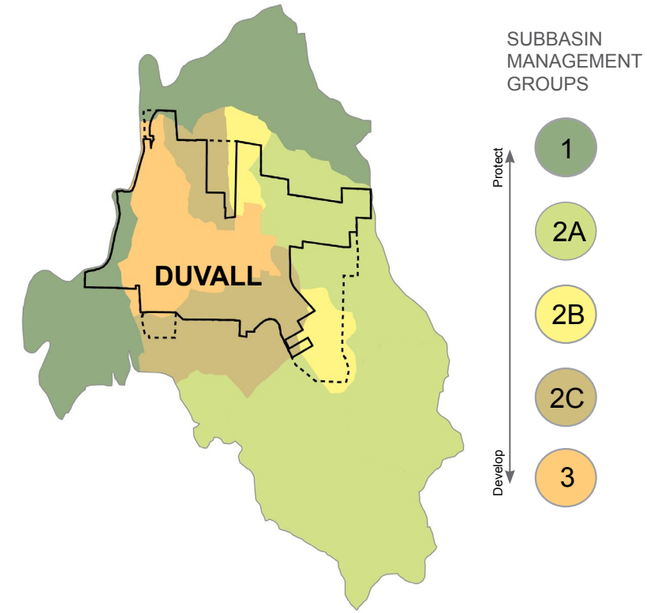
LOW Requires changes to Duvall Municipal Code without additional study or State approval

MODERATE Requires review by State agency before changes can be adopted; no additional technical study necessary

HIGH Requires additional technical study to understand implications before changes could be considered; State review may be necessary

Package B: Improved Outcomes for Water Quality

Action Number	Watershed Plan Action	Implementation Complexity	Additional Environmental Benefits	Applicable Subbasin Management Group
DS-1	Lower maximum impervious surface limit to 40% for R4, R4.5, R6, and PF zones within Management Groups 1 and 2.	Low		1, 2A, 2B, 2C
DS-1	Provide alternatives to new 40% impervious surface limit that allow for additional coverage while still reducing effective impervious surface.	Low		1, 2A, 2B, 2C
DS-3	For commercial uses, revisit the minimum parking standards for each land use and zoning district so that location and intensity of development is considered; apply flexible parking standards for Old Town zoning district; and ensure that maximum standard can only be exceeded when demonstrated need in parking demand study.	Low		3
DS-4	Provide design guidelines to encourage convenient / centralized parking spaces rather than individual garages for multi-family development; provide centralized and individual parking design approaches that reduce impervious surface coverage.	Low		All Groups
SW-1	Define the most useful and applicable LID BMPs and require their use in new development activities.	High		2A, 2B, 3
SW-3	Identify and prioritize stormwater retrofit opportunities, especially actions to reduce effective impervious areas.	High		All Groups
SW-4	Establish flow control exemption for portions of the City that are predominantly built-out and already drain directly to the Snoqualmie River through pipe/ditch infrastructure.	High		3
SW-5	In UGAs, create centralized stormwater facilities to offset onsite requirements.	High		2B, 2C
SW-6	Incentivize stormwater LID approaches (in addition to those required by SW-1) – strategies could include a rain garden reimbursement program, or incentives that provide additional development opportunity when LID approaches are used.	Low High for some LID approaches		All Groups
SW-8	Create educational outreach program (workshops, informational handouts, and website updates), including use of LID Manual developed as part of Watershed Plan.	Moderate		All Groups
SA-2	Increase protections for depressional wetlands by limiting allowances for buffer alteration and/or requiring LID approaches for surrounding development.	Moderate		1, 2A, 2B, 2C



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Wildlife Habitat

Soils & Landscaping

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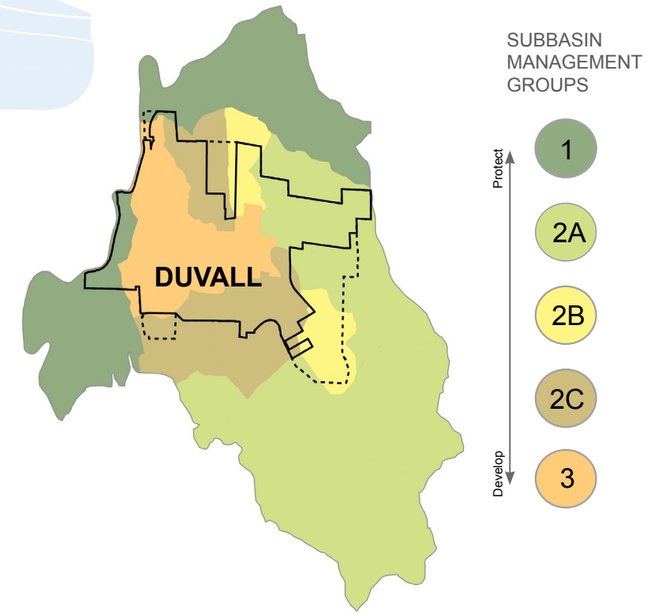
Package C: Improved Outcomes for Fish and Wildlife Habitat

	Action Number	Watershed Plan Action	Implementation Complexity	Additional Environmental Benefits	Applicable Subbasin Management Group
	SA-1	Identify and establish additional protections for fish and wildlife habitat corridors, limiting habitat fragmentation as future development occurs. This Plan proposes a Habitat Corridors Map, and recommends that any development occurring along a habitat corridor be required to rate habitat value and develop a plan to maintain or improve existing habitat connections.	Moderate		All Groups
	SA-4	Improve mechanisms to ensure long term protection of mitigation sites, by requiring that sites be placed in a conservation easement, and additional performance standards criteria.	Moderate		All Groups
	SA-5	Within Management Groups 1 and 2A, do not allow wetland or stream buffer reductions / averaging and limit other buffer modification allowances.	Moderate		
	SA-5	Within Management Groups 2B and 2C, maintain some allowance for wetland and stream buffer modification (reduction, averaging or other uses) consistent with the decreasing conservation value of the subbasin.	Moderate		
	SA-5	Within Management Group 3, maintain allowances for wetland and stream buffer modification (reduction, averaging or other uses) and consider new allowances that may provide development opportunity when compensation for buffer functions is provided.	Moderate		
	DS-9	Establish design guidelines to encourage subdivisions to cluster lots (minimizing mass clearing / grading and maximizing open space).	Low		All Groups



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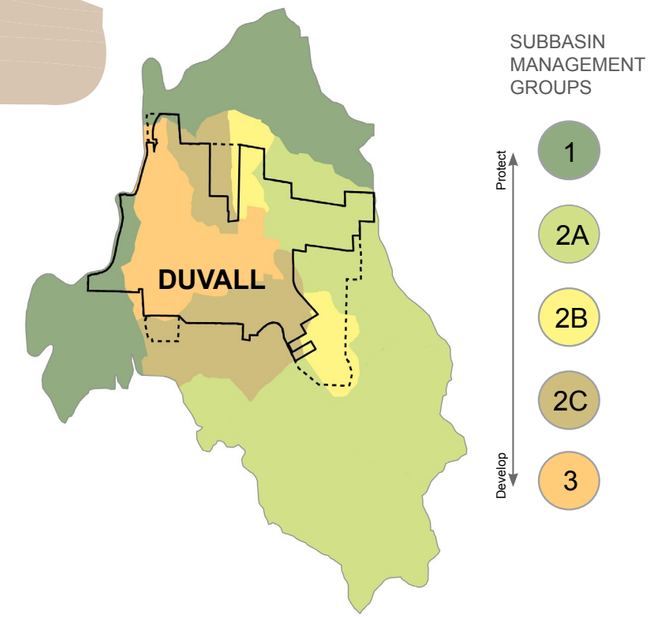
Package D: Improved Outcomes for Soils and Landscaping

Action Number	Watershed Plan Action	Implementation Complexity	Additional Environmental Benefits	Applicable Subbasin Management Group
DS-5	For site planning, require developers to submit a soil report prior to installation of landscaping. Soil report should show that conditions are consistent with existing City requirements. For individual building lots, require developers to complete soil reports for each lot unless a comprehensive soils and planting plan is completed as part of preliminary plat or building permit approval and verified through City staff inspection.	Low		All Groups
DS-4	Require use of native, drought tolerant plant species for publically owned properties and open-space lots, with additional specification for these properties when located within a habitat corridor.	Low		All Groups
DS-9	Establish design guidelines to encourage subdivisions to cluster lots (minimizing mass clearing / grading and maximizing open space).	Low		All Groups
DS-11	In addition to 4-foot wall height limit (existing DMC 10.12 standard), add a limit to the number of terraced walls or total length of terraced walls to avoid mass grading for residential subdivisions.	Low		
SW-2	In addition to requiring soil reports to verify compliance with DMC 14.38, also improve soil amendment requirements and best management practices (BMPs) defined in this section. New BMPs should focus on improving plant performance and reducing stormwater runoff.	Low		All Groups
SA-7	Integrate tree protection and open space standards to preserve intact forest adjacent to geologically hazardous areas (landslide hazard and erosion hazard areas) – see Package A for details. Remove allowance for reduction of landslide hazard area buffers (standard width is 50 feet).	Moderate		All Groups



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ACKNOWLEDGMENTS

The Watershed Planning Advisory Group contributed to the development of the Watershed Plan. Members of the Advisory Group are listed below.

Name	Affiliation
Boyd Benson	Duvall Public Works
Jason Walker	Duvall City Council member
Ben Swanson	Duvall Planning Department
Lara Thomas	Duvall Planning Department
Perry Falcone	King County Snoqualmie Watershed Forum
Beth Ledoux	King County Snoqualmie Watershed Forum
Janne Kaje	King County Snoqualmie Watershed Forum
Jennifer McKeown	Mountains to Sound Greenway
Matthew Baerwalde	Snoqualmie Tribe
Cindy Spiry	Snoqualmie Tribe
Aaron Clark	Stewardship Partners
Chris LaPointe	Stewardship Partners
Doug Peters	Washington State Department of Commerce
Colin F. Hume	Washington State Department of Ecology
Stephen Stanley	Washington State Department of Ecology
Micah Wait	Wild Fish Conservancy

ACRONYMS AND GLOSSARY

Term/Acronym	Description
Aquifer	Any geological formation containing or conducting ground water, especially one that supplies the water for wells, springs, etc.
Basin	The catchment area of a particular river and its tributaries.
BMP	Best Management Practices
Channel Morphology	The shapes of river channels and how they change over time.
Depressional Wetlands	Wetlands which occur in topographic depressions that allow the accumulation of surface water.
DEM	Digital Elevation Model
DMC	Duvall Municipal Code
Effective impervious surface	Impervious area that is directly connected to stream channels (i.e., precipitation falling on that impervious area is effectively transported to the stream).
Evapotranspiration	The process of transferring moisture from the earth to the atmosphere by the evaporation of water and transpiration from plants.
Fish and Wildlife Habitat Conservation Area	Areas important for maintaining species in suitable habitats within their natural geographic distribution so that isolated populations are not created.
Fish and Wildlife Habitat Processes	One of four watershed processes studied in this watershed assessment. Freshwater habitat was evaluated by observing the quantity and quality of habitats for all salmonids present or potentially present in the larger assessment units.
Functions	The processes or attributes provided by areas of the landscape (e.g., wetlands, rivers, streams, and riparian areas) including, but not limited to, habitat diversity, groundwater recharge low flow stream water contribution, erosion control, storm and floodwater attenuation, and water quality enhancement.
Geologically Hazardous Areas	Areas that because of their susceptibility to erosion, sliding, earthquake, or other geological events, pose unacceptable risks to public health and safety and may not be suited to commercial, residential, or industrial development.
Groundwater & Base Flow Management Processes	One of four watershed processes studied in this watershed assessment. Groundwater and Base Flow was evaluated based on delivery and recharge processes. Delivery is the amount of flow generated in the watershed by precipitation. Impervious surfaces generally increase the magnitude and frequency of peak flow events by reducing the amount of precipitation returned to the atmosphere through evapotranspiration and reducing infiltration to deep groundwater. Recharge affects the volume of precipitation reaching the stream as overland flow through infiltration to shallow and deep groundwater. Infiltrating runoff attenuates peak flows that can cause excessive erosion and/or flooding.

Term/Acronym	Description
Importance	Refers to the underlying, pre-development physical conditions (geology, landscape position, etc.).
IP	Intrinsic Potential
KCSWDM	King County Surface Water Design Manual
LID	Low Impact Development
LWD	Large Woody Debris
Mainstem	The main course of a river or stream.
Native Vegetation	Plant species that are indigenous to King County and the local area.
NPDES MS4	National Pollutant Discharge Elimination System municipal separate storm sewer system
NRCS	Natural Resources Conservation Service
PAU	Project Assessment Unit
Sediment export potential	A model of analysis which examines sources and sinks of sediment by looking at three processes: surface erosion, mass wasting, and stream channel erosion based on attributes of the watershed.
Slope Wetlands	Wetlands which occur along sloping land and are caused by the discharge of groundwater to the land surface and precipitation.
SSHIAP	Salmon and Steelhead Habitat Inventory and Assessment Program
Storage	The amount of runoff stored within the watershed as surface water. In natural systems, both wetlands and floodplains can provide surface water storage, which attenuates peak flows.
Stream sinuosity	A stream's tendency to move back and forth across its floodplain, in an S-shaped pattern, over time.
SWCTP	City of Redmond's Stormwater Control Transfer Program
SWMP	Stormwater Management Program
Subbasin	A small unit within the landscape within which the entire area drains water, sediment and dissolved materials to a common receiving body or outlet. As used in this Plan, multiple subbasins form a basin, and multiple basins fit within a watershed. Subbasins are synonymous with the Project Assessment Units (PAUs) detailed in the Plan, and generally correspond to 1st order streams further divided into specific landscape positions.
Surface Storage Processes	One of four watershed processes studied in this watershed assessment. Water from rainfall that is temporarily retained and does not immediately add to a stream's flow. (Rain that "soaks into" the ground, rain that sits in puddles or ponds, rain that is retained or held back by any means is considered to be in "surface storage.")
TESC	Temporary Erosion and Sediment Control
Toe	The lowest part of a slope or cliff; the downslope end of an alluvial fan, landslide, etc.
TMDLs	total maximum daily loads

Term/Acronym	Description
Tributary impoundment	Any location where flow within a tributary stream is dammed, creating a backwater pool or body of water. Tributary impoundments can occur from natural causes (beaver dams) or from human causes (undersized or collapsed culvert); examples of both can be found within the lower reaches of Thayer and Coe-Clemmons Creek, where these tributary streams cross the low gradient floodplain and are impounded by both beaver dams and culverts.
UGA	Urban Growth Area
UGAR	Urban Growth Area Reserve
Water Quality Processes	One of four watershed processes studied in this watershed assessment. Water quality processes of interest included sediment deposition, buffer condition, erosion potential, and pollutants.
Watershed	A geographic region within which water drains into a particular river, stream or body of water.
WDFW	Washington Department of Fish and Wildlife
WDFW intrinsic potential model	Anadromous salmonid distribution model developed by the Washington State Department of Fish and Wildlife; the model identifies the potential for stream reaches to support anadromous salmonid species based on gradient, contributing basin and other underlying landscape conditions (no actual fish presence observations or data, or information on fish passage barriers, is used within the model). Details on the WDFW intrinsic potential model are provided in Volume 2 of Ecology's Puget Sound Watershed Characterization.
Windthrow	Trees uprooted or broken by wind.
WRIA	Water Resource Inventory Area

CHAPTER 1. WATERSHED PLAN OVERVIEW

1.1 Purpose and Background

Like many communities on the urban fringe, the City of Duvall is striving to promote economic growth and development without sacrificing its rural character and environmental assets that are at the heart of the community's "small town – real life" identity. This Watershed Plan has been prepared by the consulting company Environmental Science Associates (ESA) to support the City in achieving this goal. The Plan provides a watershed-based framework to:

- Inform the 2015 Comprehensive Plan update;
- Focus future development based on a comprehensive understanding of watershed processes;
- Maintain and improve forest cover and open space;
- Enhance the City's approach to stormwater management and salmon recovery; and
- Strengthen sensitive area regulations to provide enhanced protection for important resources.

The Plan is based upon a detailed characterization of Duvall's subbasins[1] using methods established by the Washington State Department of Ecology (Ecology) Puget Sound Watershed Characterization (Stanley et al., 2011). This Plan was developed with funding provided by the Environmental Protection Agency (EPA) through a National Estuary Program grant (PC-00J20101) and City matching dollars.

*The term **watershed characterization** refers to the process of evaluating geology, soils, hydrology, precipitation, topography, land cover and other information to describe the condition of the landscape. The characterization considered how natural processes have been altered by current conditions, including the addition of impervious surfaces throughout the city. This analysis will support decisions about future land use and stormwater planning within the city.*

[1] Drainage basins drain into other drainage basins in a hierarchical pattern, with smaller sub-drainage basins (or subbasins) combining into larger drainage basins.

1.2 Public Planning Process

The City convened a Watershed Planning Advisory Group to inform the process (see Acknowledgements section for a list of members). King County's Snoqualmie Watershed Forum worked closely with the City as a partner, including participating in Advisory Group activities. In addition, the City engaged the public in the planning process through a series of public events and activities:

1. **May 8, 2014 - Advisory Group Kick-off Meeting**: This was the first meeting with the Advisory Group and included introduction of ESA, City staff, and Advisory Group team members. ESA provided a project overview, and identified preliminary project basins, key data sources, and methodology.

2. **May 31, 2014 - Duvall Days**: The City set up a project booth for Duvall Days to educate the public about the Watershed Planning project. The booth was staffed by ESA, Sound Salmon Solutions, Mountains to Sound Greenway, and Stewardship Partners. In addition to interactive games, informational handouts, and posters, a survey was available for the public to electronically fill out. The results of the survey are included in Appendix A. The survey results should not be construed as representing a broad range of opinions held by Duvall community members because of the limited number of respondents compared to the total population and the approach used to solicit participation. These results simply provide an overview of a select group of individuals' attitudes toward the Duvall watershed. The City hopes to continue to distribute the survey to solicit more responses that represent a broader range of community members. The survey could be redistributed by the City every 5-10 years to identify any changes regarding the community's attitudes about the health of their watershed and the approaches they think the City should take toward protecting the watershed.

City Booth at Duvall Days

3. **June 17, 2014 - Advisory Group Meeting #2:** ESA described the initial watershed modeling scores and subbasin boundaries (called Project Assessment Units). The Advisory Group provided feedback on the types of watershed processes that should be studied in Duvall and the approach to

creating management categories that would group subbasins based on the quality of their watershed processes.

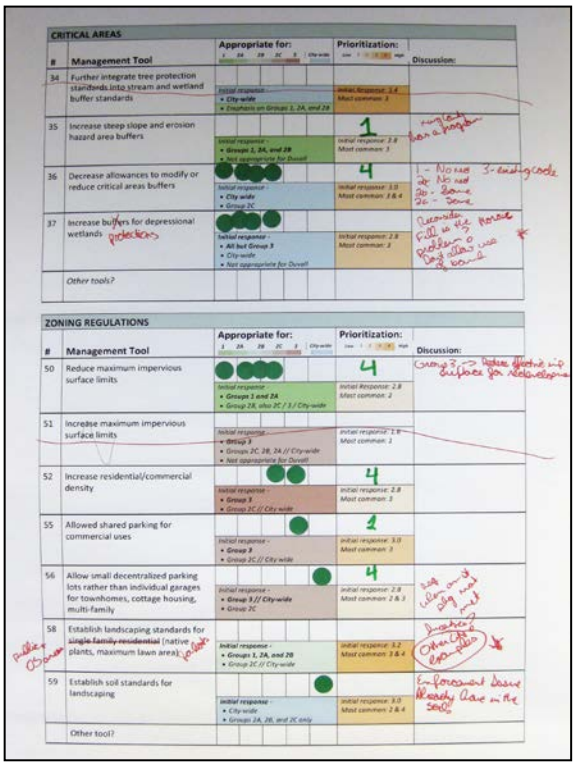
4. **July 29, 2014 - Advisory Group Meeting #3:** ESA described the results of the primary and secondary watershed modeling scores (see Chapter 2 and Appendix B for more detail) and identified subbasin management categories along with a corresponding list of management tools that the City could use to protect or restore watershed processes. The Advisory Group began providing feedback on the management tools, adjusting them to better fit into Duvall's setting. The group provided more extensive feedback on the management tools via an online survey by assigning each tool to a subbasin management category and prioritizing the tool based on its level of importance or relevance to the City. These tools served as the basis for the recommended actions described in Chapters 5, 6, and 7.

5. **September 2, 2014 - Advisory Group Meeting #4:** ESA presented the final results of the primary and secondary analysis of the watershed models, the approach to incorporating aquatic habitat data into the models, and the final five subbasin management categories. ESA also provided a Project Assessment Unit two-page "folio sheet" template (see Chapter 4) for review and feedback.

6. **October 14, 2014 - Advisory Group Meeting #5:** The group walked through the survey results of the management tools to obtain consensus on priority and appropriate management categories.

7. **November 18, 2014 - Advisory Group Meeting #6:** The group continued to work through the survey results of the management tools, focusing on the stormwater-related tools. Final feedback on the Project Assessment Unit folio sheet template was provided.

8. **February 18, 2015 - Advisory Group Meeting #7:** Chapters 1-4 of this Watershed Plan were presented to the Advisory Group for their feedback.



Advisory Group Management Tool Poster

9. **March 18, 2015 - Advisory Group Meeting #8:** Chapters 5-8 and Appendices of this Watershed Plan were presented to the Advisory Group for their feedback.

10. **March 18, 2015 – Draft Watershed Plan Open House:** The draft Plan was presented to the Duvall community, including an opportunity for review and comment, a presentation providing an overview of the Plan, and a question and answer period.

11. **Planning Commission and City Council Review of Draft Plan:** The draft of the Plan was presented to the Planning Commission on February 18 and March 18, 2015. The draft of the Plan was distributed to the City Council for review, and was presented at a joint work session between the City Council and the Planning Commission on April 14, 2015. Following this initial meeting, City staff presented Plan policy recommendations on April 28, May 12, and May 26, 2015. At these meetings, City staff presentations focused on revisions to the draft Plan based on Planning Commission and City Council input.

12. **Planning Commission and City Council Review of Final Plan:** The updated, final Plan was presented to City Council and Planning Commission during a joint work session on June 17, 2015. The final Plan was additionally reviewed by the City Council on July 7, 2015.

13. **Planning Commission Public Hearing and Recommendation:** The Planning Commission is scheduled to hold a public hearing on the final Plan on August 19, 2015. On September 2, 2015, the Planning Commission will provide recommendation for Plan approval to the City Council.

14. **City Council Public Hearing and Consideration for Adoption:** The City Council is scheduled to hold a public hearing on the final Plan on September 1, 2015. On September 15, 2015, the City Council will consider the Plan for adoption.

1.3 Plan Purpose and Organization

This Plan is intended to be a technical document that identifies existing watershed characteristics in and immediately surrounding Duvall. The goals, policies, and actions identified in Chapter 3 are based on the findings of this watershed characterization and provide the City with a roadmap to improving watershed protections and focusing future development in appropriate areas within the city and its urban growth area.

The Watershed Plan is organized as follows:

1. **Chapter 1 - Watershed Plan Overview:** Describes the purpose of this Plan, the planning process that led to the adoption of this Plan, and the Duvall landscape setting.

2. **Chapter 2 - Key Watershed Analysis Results:** Summarizes existing watershed and subbasin conditions, as well as the watershed analysis results and subbasin management approach that informs the remainder of the Plan.

3. **Chapter 3 - Watershed Goals, Policies, and Objectives**: Identifies goals and polices that address the findings of the watershed characterization and seek to direct future development. Chapter 3 also introduces the strategies and actions that the City can take to meet this Plan's objectives.

4. **Chapter 4 - Subbasin Folio:** Provides a folio sheet that identifies watershed analysis results for each Project Assessment Unit in the city and urban growth area, with corresponding management priorities to ensure ongoing protection and improvement of important watershed processes.

5. **Chapters 5 - Watershed Strategies for Development Standards:** Identifies objectives and actions consistent with goals and policies provided in Chapter 3 to improve watershed protections in the City's zoning and subdivision code.

6. **Chapter 6 - Watershed Strategies for Stormwater Management:** Similar to Chapter 5, except actions are targeted toward stormwater management.

7. **Chapter 7 - Watershed Strategies for Sensitive Areas Management:** Similar to Chapter 5, except actions are targeted toward the City's sensitive areas ordinance.

8. **Chapter 8 - Land Use Strategies for Urban Growth Areas:** Because most foreseeable future development is likely to occur in urban growth areas located to the north, east, and south of the City's current city limits, this chapter presents information on environmental constraints for these areas, as well as recommendations on where future development is appropriate based on watershed analysis results.

9. **Chapter 9 – References:** Includes references cited in this Plan.

1.4 Duvall Landscape Setting

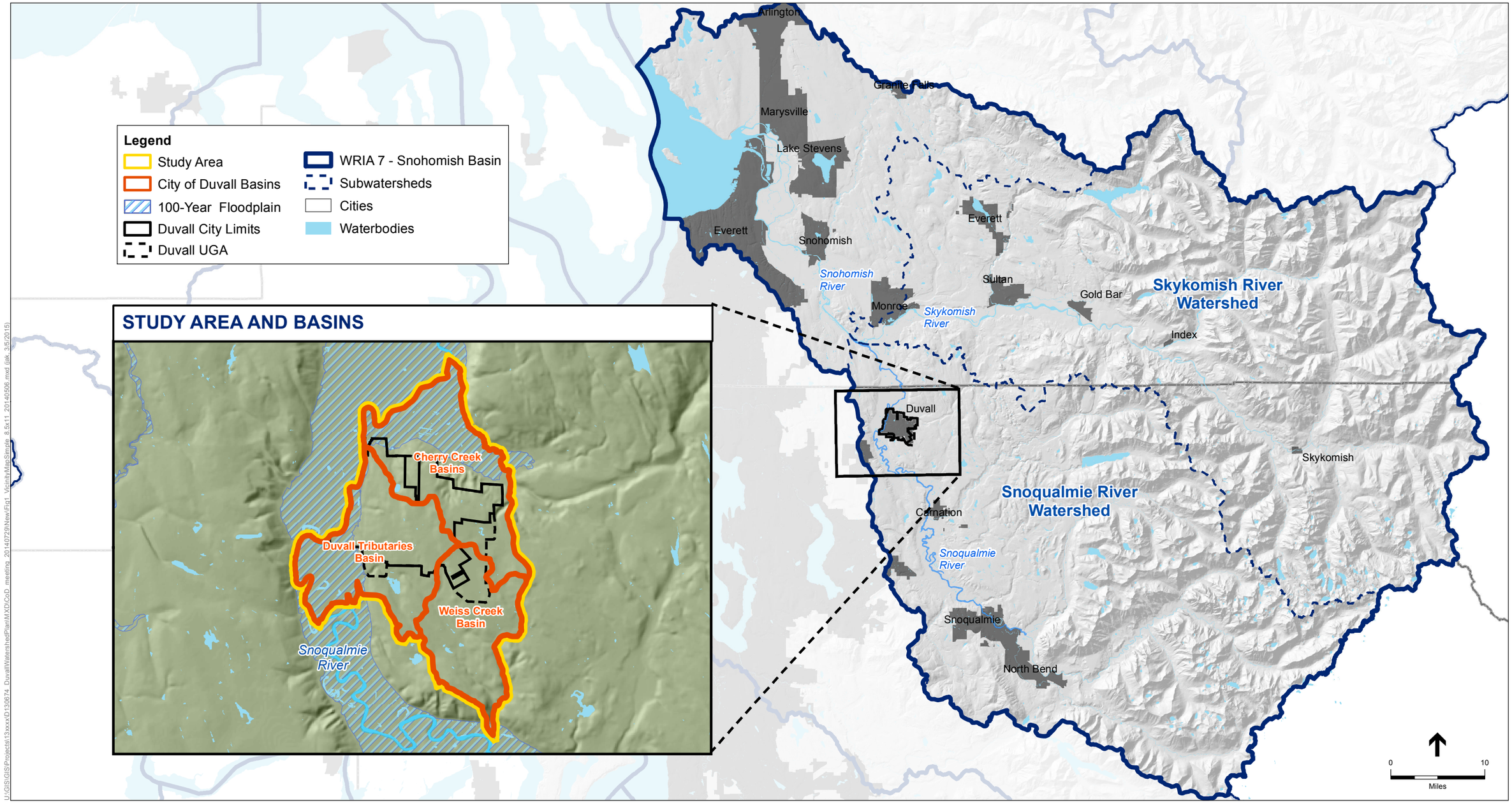
The City of Duvall is located on west- and north-facing hillsides in the lower Snoqualmie River valley. The mainstem Snoqualmie River forms in the headwaters

of the North, Middle, and South Forks of the Snoqualmie River. The mainstem Snoqualmie River extends south and east from the city through unincorporated King County, the City of Carnation, the community of Fall City, and (above Snoqualmie Falls) the Cities of Snoqualmie and North Bend (see Figure 1-1).

The north-facing hillsides along the northern edge of the city slope down to the Cherry Creek valley, which converges with the Snoqualmie River just downstream of Duvall (to the northeast of the city). Cherry Creek is the lowest significant tributary of the Snoqualmie River, and the only significant tributary that drains areas in the city. The mainstem of Cherry Creek does not pass through the city or urban growth area; tributaries to Cherry Creek drain the northeastern portion of the city.

The Snoqualmie River continues north from Duvall for approximately 9 miles before joining the Skykomish River to form the Snohomish River. The Snohomish River drains to Puget Sound in the City of Everett. These three rivers—Snohomish, Skykomish, and Snoqualmie—and their tributaries together drain a watershed (Water Resource Inventory Area 7) of 1,856 square miles located in both Snohomish and King Counties (City of Duvall, 2010; Pentec and NW GIS, 1999; Snoqualmie Watershed Forum, 2013).

The geology of western King County, including the lowland areas of the Snoqualmie River, consists of bedrock underneath layers of sediments deposited by glaciers, as well as sand and gravel (alluvium) deposited recently by modern rivers (Vaccaro et al., 1998). The region has a temperate, maritime climate. Winters are cool and wet, while there is typically a drought period in the summer and early fall. The climate is influenced by Puget Sound to the west and the Cascade Mountains to the east. Average annual precipitation ranges from approximately 30 inches near Puget Sound to 90 inches in the Cascade foothills, with the area surrounding Duvall averaging nearly 50 inches.



SOURCE: Ecology, 2012, King County, 2014.

City of Duvall Watershed Planning . 130674

Figure 1-1: Project Study Area and Watershed Position

Duvall, King County, Washington

Over 80 percent of the population of King County lives in cities and urban growth areas, with less than 20 percent in rural areas (King County, 2012). This trend continues throughout the Snoqualmie watershed, with the majority of the population focused in designated urban growth areas and incorporated cities. Moderate population densities in the Snoqualmie River watershed are focused within and around Duvall, Carnation, Fall City, Snoqualmie, and North Bend. Outside of these urban areas, the Snoqualmie River valley consists primarily of agricultural production districts, rural residential areas, forest production districts, and open spaces (preserved lands) (King County DDES, 2009).

The Snoqualmie River watershed contains a wide range of vegetation types from wetland scrub/shrub and emergent areas in the valley floodplain to forests in the Cascade foothills. In general, the high elevations are largely undeveloped, while lower areas tend to be the most urbanized.

Prior to European settlement, the Snoqualmie River valley was used by several Coast Salish Indian tribes, including the Tulalip, Pilchuck, Snohomish, and Snoqualmie. Large, permanent winter villages were located along the Snoqualmie and Snohomish Rivers where people thrived by fishing for salmon, hunting mammals over land, and gathering native fruits, vegetables, and berries (City of Duvall, 2006).

Early Euro-American settlers were first drawn to the Duvall vicinity of the Snoqualmie River valley in the 1870s by vast timber resources, both in areas of the valley and the surrounding hills. Homesteading occurred in the region, primarily by Civil War veterans with homestead rights. The Duvall area was homesteaded and named after two brothers, Francis and James Duvall. The original town site, named Cherry Valley, was located to the north of the existing town center, near the convergence of Cherry Creek with the Snoqualmie River. The Snoqualmie and Snohomish Rivers were used to transport logs to major downstream population centers, including Everett.

The Snoqualmie River watershed and the entire Water Resource Inventory Area 7 support a variety of fish and wildlife species. Common types of wildlife habitat include freshwater aquatic areas and associated riverine habitats; wetlands and associated riparian areas; lowland conifer-hardwoods; and agricultural and pasture areas. The Snoqualmie River watershed supports Chinook, chum, coho, and pink salmon; bull trout and Dolly Varden; and cutthroat, steelhead, rainbow, and brook trout. All of these species use the mainstem Snoqualmie River at the city's western edge at some point in their life histories, and salmonid use is also abundant in the mainstem and tributaries of Cherry Creek. Coho and steelhead use the lower reaches of tributary streams extending into Duvall, including Cherry Creek Tributary A, Coe-Clemons Creek, Thayer Creek, and reaches of Weiss Creek and other Cherry Creek tributaries downstream of the city.

The river remained the primary means of transportation until the 1890s, when the construction of railroad lines to the town of Snohomish allowed a more intensive timber industry to become established in the immediate area. In the following decades, bridges over the Snoqualmie River and roads linking Duvall to Lake Sammamish and Lake Washington were constructed. Bridges and roadways were also built on fill berms in the floodplain, in most instances stretching east to west across the valley. The developed transportation infrastructure led to rapid population growth in Duvall, as well as other valley communities. The growth of the timber industry and the expanded population brought about rapid changes in vegetative cover (forest cleared for agricultural fields and rural residential uses) and vegetative character (harvest of old-growth forest and establishment of second-growth forest). Population growth continued throughout the 1920s, after which the decline of the timber industry in the area minimized the need for laborers.

In the last 50 years, modern roadways and expanding suburban growth from the Seattle metropolitan area have led to additional growth in the city and the valley, with the majority of the this growth occurring in the last 20 years. Agricultural activities remain a significant regional economy, with cattle and dairy operations, produce and crop farms, and greenhouse operations extending up and down the valley. However, residential housing and associated service businesses have come to characterize Duvall and other urbanized areas of the watershed.

CHAPTER 2. KEY WATERSHED ANALYSIS RESULTS

2.1 Watershed and Basin Conditions

The City of Duvall (1,594 acres) is situated in the Snoqualmie River watershed (442,880 acres), located on the east side of the lower Snoqualmie River valley, and bordered on the west by the mainstem river (see Chapter 1, Figure 1-1). Unincorporated areas of King County extend through the floodplain to the south, east, and north. There are four smaller basins that are tributaries to the Snoqualmie River that are located in or partially within the city and urban growth area boundary: Thayer Creek, Coe-Clemons Creek, Cherry Creek, and Weiss Creek (Table 2-1). All portions of these basins that drain from or through the city or urban growth areas to the Snoqualmie River are included as part of the study area for this watershed analysis (see Figure 1-1 inset).

Cherry Creek is the lowest significant tributary of the Snoqualmie River and the only significant tributary that drains areas of the city. The mainstem of Cherry Creek never passes into the city or urban growth area; tributaries to Cherry Creek drain the northeastern portion of the city.

Table 2-1. Drainage Basins of Duvall

Stream Name	Total Basin Area (acres)	Area within Study Area (acres)	% Total Watershed Area
Thayer Creek	235	235	100%
Coe-Clemons Creek	371	371	100%
Cherry Creek	32,000	2,185	6.8%
Weiss Creek	2,169	2,067	95%

Historic Changes to Land Cover

The hydrology and ecology of the study area have been shaped by the historical uses of the landscape. Starting in the 1870s, European settlers were drawn to the area by timber resources, using the Snoqualmie River to transport logs downstream. In the 1890s, the railroad was constructed along the east side of the river, adjacent to Duvall's Main Street, on a 12- to 15-foot-tall fill berm that stretches along the river valley. In the following decades, bridges over the Snoqualmie River and roads linking through to Lake Sammamish and Lake Washington were constructed, also built on fill berms in the floodplain. The growth of the timber industry and the

expanded population brought about rapid changes in vegetative cover (clearing of forest to create agricultural fields) and vegetative character (harvesting of old-growth forest and establishment of second-growth forest). Population growth continued through the 1920s, after which the decline of the timber industry in the area minimized the need for laborers.

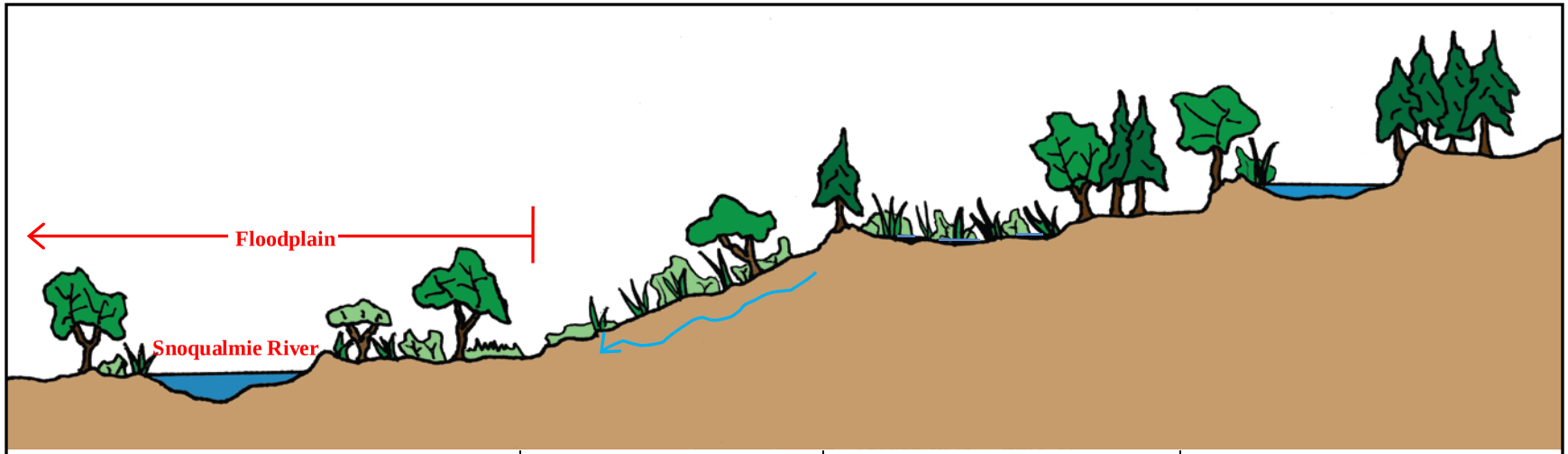
After the 1920s the pattern of alterations to the valley landscape was characterized by clearing of native shrub and riparian vegetation, ditching of streams and land to create pasture, and bank hardening along the Snoqualmie River. In the last 50 years, modern roadways and expanding suburban growth from Seattle have led to additional growth in Duvall and throughout the valley. Significant population growth in Duvall has primarily occurred in the last 20 years. Agricultural activities are an important component of the economy and land use, with cattle and dairy operations, produce and crop farms, and greenhouse operations extending up and down the valley. However, residential housing and associated service businesses have come to characterize Duvall and other urbanized areas of the watershed.

A number of recent studies describe the current conditions in Duvall's watersheds. A Landscape Analysis was developed for Duvall to support the City's last sensitive area ordinance update, completed in 2006 (Parametrix, 2005). Other watershed studies and plans with background information useful in understanding watershed processes, published in the last 10 years, include the Snoqualmie Watershed Water Quality Synthesis Report (Kaje, 2009); the Snohomish Basin Ecological Analysis for Salmonid Conservation (SBSRTC, 2005), developed as part of the Snohomish River Basin Salmon Conservation Plan (SBSRTC, 2005); and the City of Duvall Shoreline Master Program Update (ESA, 2011). King County included both Cherry Creek and Weiss Creek watersheds as example watersheds in their analysis of Hydrologic Control Index (HCI) (Luchetti, 2014).

Watershed Processes

Watershed processes control the physical form of the landscape and the types of habitats that occur throughout the ecosystem. Watershed processes are characterized in this study based on Ecology's Puget Sound Watershed Characterization (Stanley et al., 2011) and are generally related to water flow. Water flow processes, such as surface water storage and groundwater movement, vary based on landscape position (Figure 2-1, Table 2-2) and play a substantial role in shaping wetland and stream functions. Important areas in Duvall and the surrounding vicinity for water flow processes and habitat processes were summarized in the City of Duvall Shoreline Master Program Inventory and Characterization Report (ESA, 2011) and are provided in Table 2-2.

Figure 2-1. Landscape Processes that Maintain Key Aquatic Resources in the Puget Sound Lowlands (adapted from Stanley et al., 2005 and ESA, 2011)



Rivers / Floodplains / Riverine Wetlands	Slope Wetlands	Depressional Wetlands	Lakes / Lacustrine Wetlands
KEY LANDSCAPE PROCESSES[1]			
• Hydrology o **Surface water runoff (peak flow)** o **Groundwater movement** • **Sediment supply**	• Hydrology: **Groundwater movement**	• Hydrology o Surface water runoff o **Groundwater movement** • **Sediment supply**	• Hydrology o Surface water runoff o **Surface water storage** o Groundwater movement • Sediment supply
VALUE OF THE PROCESSES			
• Floodplains - flood storage and habitat • Vegetation – nutrients and shade	• Vegetation and soil – filters/cleans water • Water stays cool	• Vegetation and soil – filters/cleans water • Water – storage and slow release, stays cool	• Water – storage and slow release

[1]Processes in bold are most important for maintaining the integrity of aquatic resources such as wetlands and streams.

Table 2-2. Summary of Landscape Processes – Controls, Mechanisms, and Important Areas (adapted from ESA, 2011)

Process	Natural Controls	Mechanisms	Types of Important Areas[1]	Description of Important Areas in Duvall and Vicinity
Hydrology (surface and ground water)	• Climate and precipitation patterns • Timing of snowmelt • Soils and geology • Vegetation	Infiltration/ recharge	Permeable soils, ***riparian areas***, ***floodplains***	• Moderate levels of infiltration and recharge occur primarily within the Cherry Valley floodplain, as well as within the Snoqualmie River floodplain at lower levels. • Areas of significant infiltration and recharge are located in the vicinity of Fall City and above the Snoqualmie Falls.
		Surface water storage	***Depressional wetlands***, ***lakes***, ***floodplains***	• As Thayer, Coe-Clemons, and Cherry Creek tributaries reach the floodplain, surface flows spread across the valley and surface water is stored in several large depressional wetlands. • Entire Duvall floodplain area serves as storage during overbank flood events. • One small lake is located within the Cherry Creek basin of Duvall; other moderately sized wetlands are also mapped in Duvall.
		Peak flows	***Impervious surfaces***, rain-on-snow (ROS) zone, ***forest cover***	• Impervious surfaces are minimal within Snoqualmie River floodplain; however, rapid development throughout Duvall over the last two decades has converted agricultural and forest land to commercial and residential development which has increased the amount/extent of impervious surface. • Heightened levels of impervious surface correspond with reduced forest cover – a mechanism change that primarily occurred through logging and agricultural conversion between 1880 and 1950.
		Groundwater movement (baseflow)	**Permeable deposits**, fissured bedrock	• Groundwater moves through the hillside near the surface, expressing as seeps and slope wetlands near the break between the hillside and the Snoqualmie River floodplain. • Detailed assessment of bedrock conditions has not occurred in Duvall.
Sediment Supply	• Topography • Soil erodibility • Vegetation cover	Erosion	***Erodible soils (especially on steep slopes)***, ***Channel Migration Zones (CMZs)***	• Potential erosion areas along the Snoqualmie River west of the Snoqualmie Valley Trail. Review of historical mapping and aerial photography suggest that mainstem channel migration occurs relatively slowly within the lower Snoqualmie River valley. • Erodible soils along steep slopes occur along the reach of Coe-Clemons Creek immediately east of Main Street. Active bank failure is noted within this reach, causing downstream sedimentation.
		Mass wasting	***Slopes prone to landslides***	• Steep slopes susceptible to landslides occur along the reach of Coe-Clemons Creek immediately east of Main Street. • Steep slope areas occur along the northern boundary of the city, where tributary streams to Cherry Creek cut through the hillside to the valley to the north.
Habitat	• Water energy • Riparian vegetation • Soil erodibility • Topography • Climate • Biotic interactions	Riparian vegetation	***Riparian zones***, forested CMZs	• Riparian vegetation generally consists of a narrow band of mixed forest backed by herbaceous and shrub vegetation communities. Existing development along the Snoqualmie River does prohibit or hinder potential future enhancement of riparian habitats. • Riparian cover along tributary streams provides moderate organic input function, including along Coe-Clemons Creek, however these sources of LWD are disconnected from the Snoqualmie River by undersized culverts (Main Street, Snoqualmie Valley Trail, and other transportation and trail infrastructure).
		Large woody debris (LWD) recruitment	***Riparian zones***, forested CMZs, ***landslide hazard areas***	

Source: Summarized from Stanley et al. (2005) and Parametrix (2005)

[1]Important areas in bold are those areas found within the Duvall vicinity. Important areas also in italics are found within the Duvall Snoqualmie River floodplain.

Infiltration and Recharge

Two major geologic formations in the Snoqualmie watershed create conditions for hydrologic infiltration and groundwater recharge: porous soils (outwash) above relatively impermeable subsurface strata; and alluvium along major streams. Deep recharge occurs in areas where bedrock is fissured, including areas within and adjacent to the Snoqualmie River and tributary floodplains (Turney et al., 1995; King County Groundwater Protection Program, 2004). Along major tributaries, including Cherry Creek, areas of high recharge extend out of the river floodplain into contributing basins. The entire area of the city is mapped as having a high or moderate level of recharge (primarily moderate). Areas of high recharge in Duvall are focused within the Snoqualmie River floodplain and the Snoqualmie / Cherry Creek floodplain extending along the north side of the city. Compared to rates in upstream areas (as high as 90 inches annually), recharge rates throughout much of Duvall are low (10 to 20 inches annually).

Recharge *is a mechanism of water flow processes where water moves downward from surface water to groundwater; recharge is dependent on the infiltration rate associated with soils and underlying geology, and throughout most of Duvall recharge is relatively slow.*

Discharge *is also a mechanism of water flow processes, where groundwater seeps out to surface water features, as springs or shallow groundwater seeps; seeps within Duvall frequently occur as slope wetlands.*

Surface storage features*, whether as wetlands within the upper terraces of Duvall's tributary basins or the large storage feature that is the Snoqualmie River floodplain, is another mechanism of water flow processes where surface runoff accumulates during storm events, desynchronizing flows to downstream areas.*

Discharge and Stream Flow Maintenance

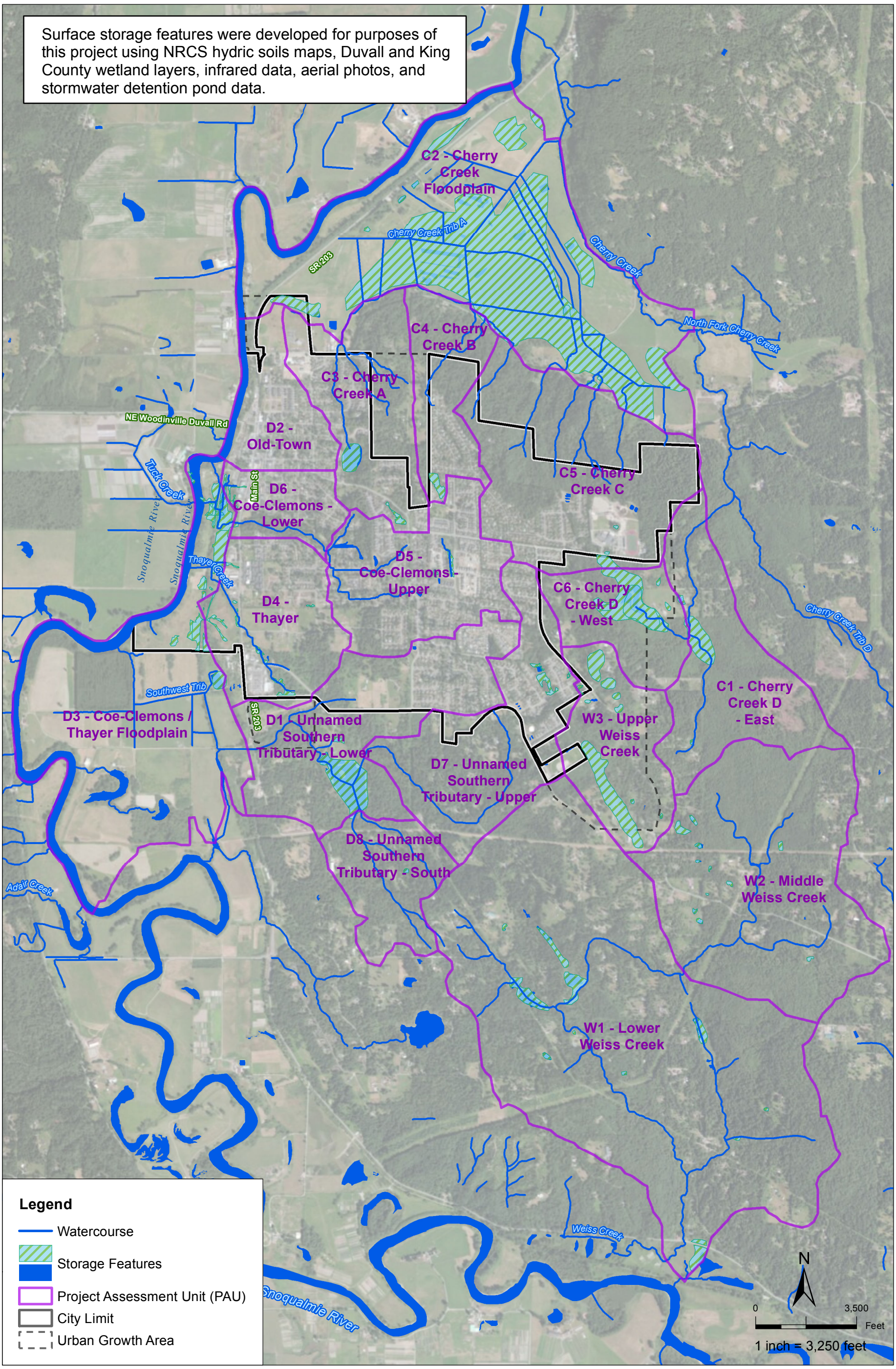
Recharge replenishes deep groundwater (aquifers) with surface water and shallow groundwater. Recharge to groundwater and subsequent discharge to surface water features also maintains flows to streams. Groundwater discharge provides base flows during dry summer months that are important to sustaining salmon and other wildlife populations. Two large aquifers have been mapped in the Snoqualmie River valley, the largest of which (the Snoqualmie Aquifer) lies well upstream of Duvall. Risks of contamination to Snoqualmie watershed aquifers are most severe in areas of high infiltration located to the south and east of Duvall, although the relatively shallow groundwater table (approximately 40 feet above mean sea level within the floodplain) and higher rates of recharge in the city's floodplain areas warrant protection to prevent groundwater contamination (Turney et al., 1995; Parametrix, 2005).

Throughout Duvall, groundwater has been mapped as intermediate to shallow. Relatively impermeable soils through the hillside of the city (above the floodplain) impede infiltration and keep groundwater relatively shallow. Groundwater at intermediate to shallow levels generally follows surface topography. There are a number of hillside seeps in Duvall where shallow groundwater seeps out at

topographical breaks (Turney et al., 1995). These seeps, which frequently occur as slope wetlands, drain to tributary streams within the City, and directly to floodplain areas.

Surface Water Storage

The Snoqualmie River carries large volumes of water compared to quantities contributed by the Duvall area basins. The floodplain provides storage for river waters only during flood events. Wetlands, Lake Rasmussen, ponds, and other depressional features store smaller amounts (approximately 5.3 acres) of water throughout the year, including storage of surface flows from localized storm events (see Figure 2-2).



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

Figure 2-2
Wetlands and Streams

Habitat

Riparian vegetation consists of the plants that grow along the margin of streams, lakes, and wetlands. Out of 107 miles of riparian area surveyed in the Snohomish basin, Pentec (1999) found that nearly two-thirds of the riparian vegetation consisted of grass, brush, or sparse trees. The loss of riparian vegetation within the city has impacted salmonid habitat by reducing the food supply for fry, increasing solar heating of the water, and reducing cover and refuge habitat. Fish habitat features such as complex channels, overhanging cover, and pools have declined in the lower Snoqualmie watershed, including contributing basins. This is due in part to the loss of large wood in the river, which has reduced the amount of wood available to create pools and to collect sediment and gravels.

Terrestrial wildlife is also affected by the loss of riparian vegetation because many species depend on wetlands and riparian zones. For example, riparian forests are used by songbirds for nesting and foraging, by big game for forage and calving areas, and by other forest species as movement corridors between rivers and upland habitats (Pentec, 1999).

Sediment Export

Under natural conditions, sediment reaches aquatic ecosystems through surface erosion, mass wasting, and erosion from within the stream channel. Sediment is generally transported through high gradient (steeply sloping) streams and deposited in lower gradient reaches. Areas where erosion naturally occurs at high rates include transitions from plateaus to terraces and upland ravines formed by streams; natural erosion and sediment movement is important to introducing and maintaining nutrients and habitat structure for fish, wildlife and other organisms within stream systems.

Excess sediment can result from human activities that expose soils and increase runoff without providing adequate erosion control measures. Bank erosion above a natural background level can indicate hydrologic or sediment conditions that are out of balance. Areas of sediment supply and deposition within and in the vicinity of Duvall include the Coe-Clemons Creek riparian corridor and areas of the Cherry Creek basin along the northern edge of the city.

Degradation of Processes

Degradation of processes is linked to changes in land use and increases in impervious surfaces associated with urban development. Alterations to hydrologic processes in the Snoqualmie watershed include decreased infiltration/recharge, channelization, and disconnection of streams from their floodplains; decreased storage capacity due to bank armoring, channelization, and wetland loss; increased peak flows resulting from vegetation clearing, and an increase in impervious surface; and groundwater withdrawals and groundwater contamination

(Parametrix, 2005; Solomon and Boles, 2002; Collins and Sheikh, 2003). Additionally, Herrera Environmental Consultants (2002) assessed stream habitat in Thayer, Coe-Clemons, and two Cherry Creek tributaries within the city limits. They identified reaches for all of these streams with deeply incised channels and bank failures caused by altered runoff patterns. Excessive sedimentation was also seen in reaches of Thayer Creek and the Cherry Creek Tributary B system.

2.2 Watershed Characterization

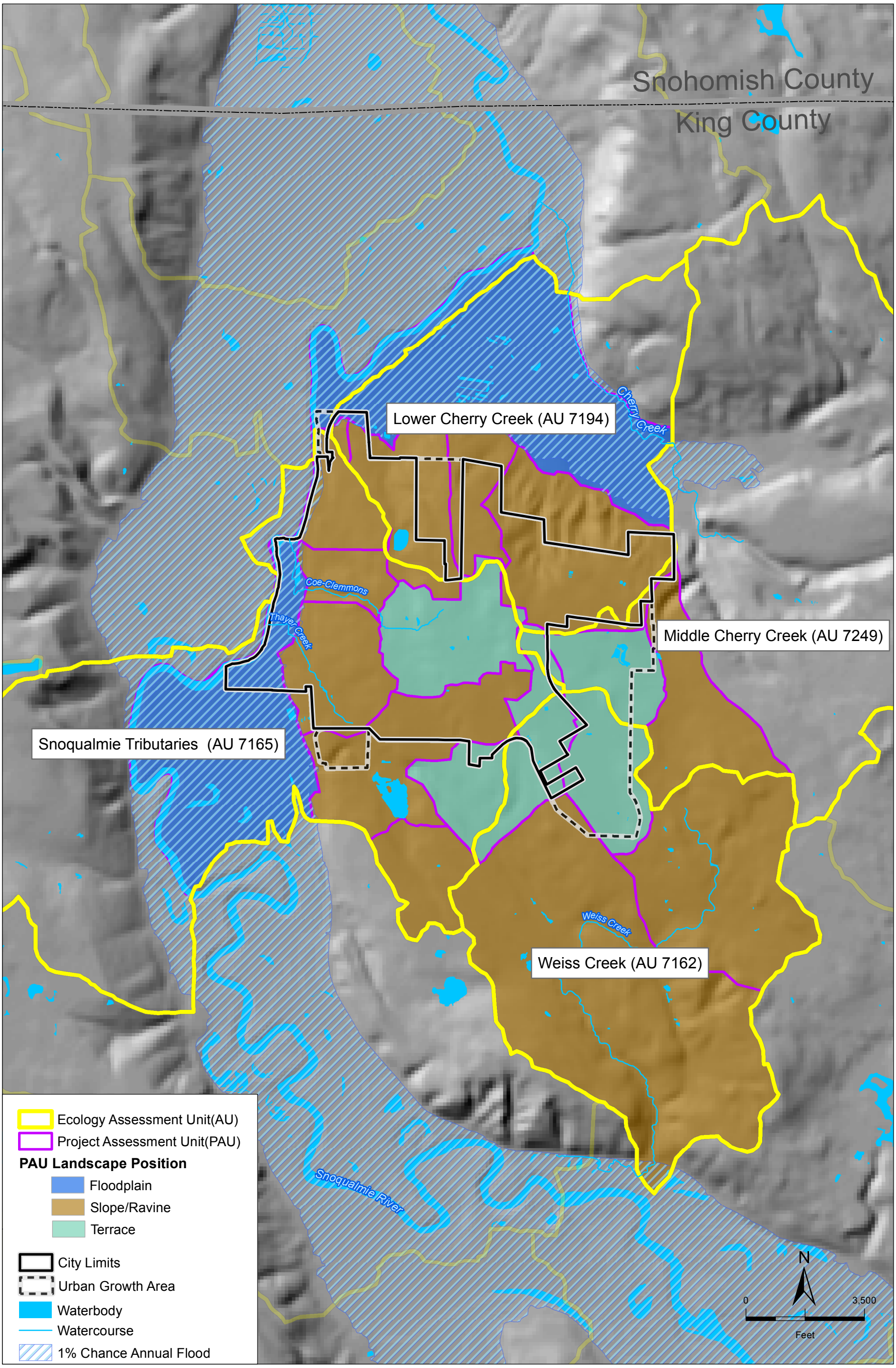
Summary of Duvall Subbasins

Ecology identified three Assessment Units within the study area (Figure 2-3). The Assessment Units include the Cherry Creek basin (extending north of the city), Duvall tributaries draining directly to the Snoqualmie River (making up the majority of the city), and the Weiss Creek basin (extending to the south of the city). These Assessment Units range in size from 1 to 10 square miles and demarcate the basin boundary.

To characterize watershed conditions in Duvall more precisely, the city delineated 17 subbasins or Project Assessment Units (PAUs) (see Appendix B for more detail on methods). PAUs range from 98 to 1,273 acres and generally correspond to first-order streams and specific landscape positions (Table 2-3).

The shape and size of the PAU is related to the morphology of the subbasin and its drainage pattern. Several PAUs extend outside of city or urban growth area boundaries. Areas outside of urban growth area boundaries were included in this watershed analysis to help understand the connection between actions taken either inside or outside the City of Duvall's jurisdiction with watershed processes. The area outside of the city boundary is either a headwater or a receiving water. Headwater areas can provide information on the quality or quantity of water coming in to the city or urban growth area, while receiving water areas are impacted by the actions occurring within the Duvall city and urban growth area boundary.

Landscape position is a descriptive term intended to coarsely group areas with similar geologic characteristics, topographic characteristics, and hydrologic processes. Three distinct landscape positions were identified within the study area: terrace, slope/ravine, and floodplain (Figure 2-3 and Table 2-3). The importance of key watershed processes does vary by landscape position. Therefore, the landscape position of each PAU was used as an indication of which management strategies may be most appropriate (see Chapter 4 for details on management strategies applied to each PAU).



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

Figure 2-3
Ecology Assessment Units,
Project Assessment Units,
and Landscape Position

PAUs in the **terrace subbasin landscape position** are generally sources to downstream PAUs, both in the slope/ravine position and floodplain position. Terrace landscapes tend to include depressional wetlands and low-gradient streams (low-energy systems) that can provide important hydrologic functions related to storage and recharge, as well as water quality filtration functions. Increases in surface flows and reduction in recharge (often associated with development) in these areas can degrade functions and impact downstream PAUs.

PAUs in the **slope/ravine landscape position** generally receive and respond to watershed inputs from upstream basins. They have seeps, high-gradient streams, and unstable slopes that can be significant sources of sediment export. These high-energy systems are important to water flow recharge and discharge processes, which can be vulnerable to landscape alterations that result in higher stream flows. Higher and flashier flows in this landscapes position can result in erosion and sedimentation (impacting resources within this position and in downstream floodplains).

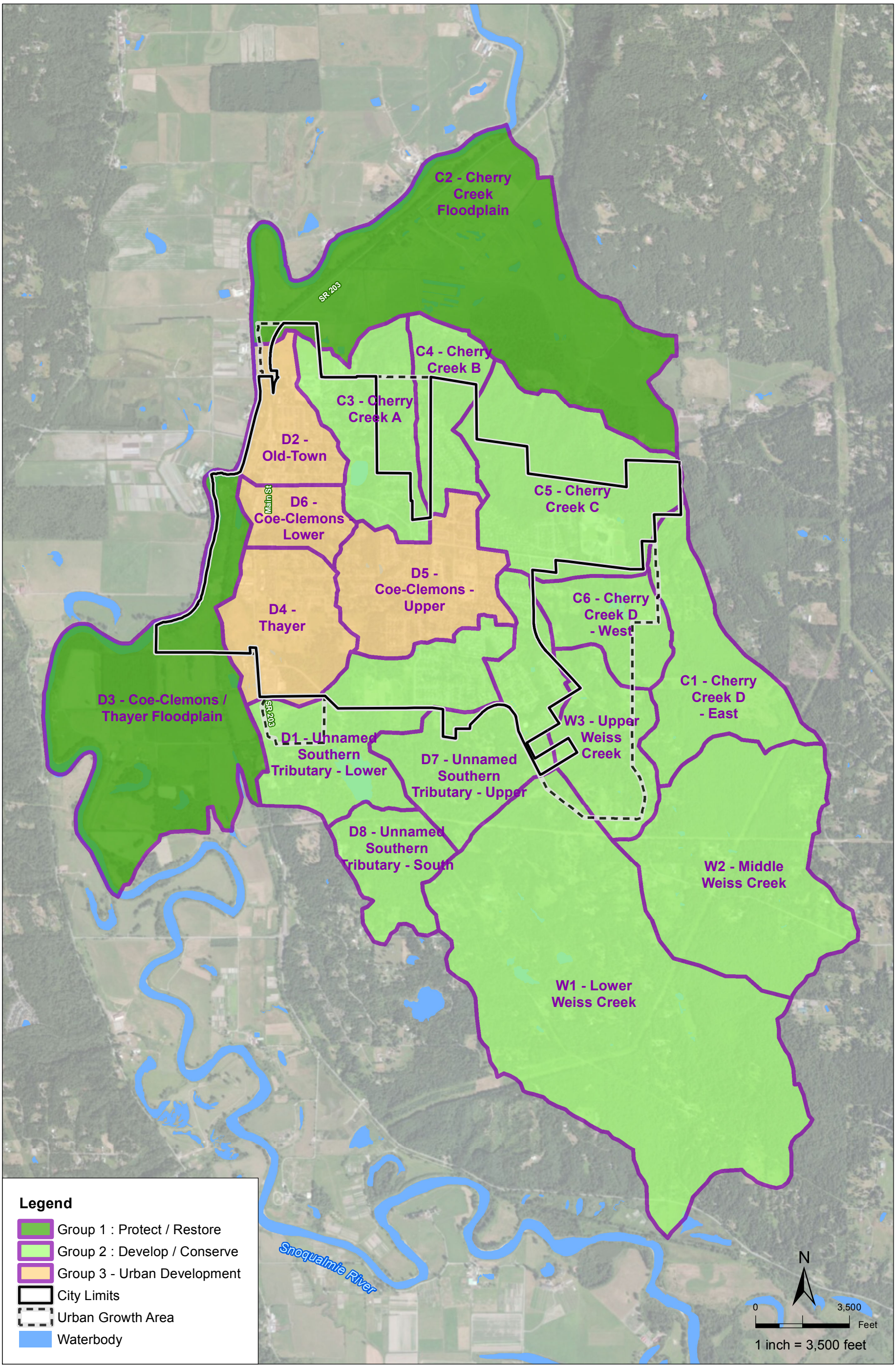
PAUs in the **floodplain landscape position** receive all watershed inputs, and provide significant water flow storage and recharge functions, as well as significant water quality and fish and wildlife habitat functions. The contributing area to the floodplain PAUs in the Duvall study area is far greater than the contributing basins that drain the city. However, the surface and groundwater flows from Duvall that reach the Snoqualmie River and Cherry Creek still influence salmon and wildlife habitat, water quality, and other functions provided by these floodplains.

Table 2-3. Project Assessment Unit (PAU) Summary

PAU Name	PAU #	Landscape Position	Area (acres)	Percent of Subbasin within City	Percent Forest Cover	Percent Impervious Surface
Cherry Creek Tributary Basin						
Cherry Creek Floodplain	C2	Floodplain	865	1%	5%	3%
Cherry Creek A	C3	Slope / Ravine	264	55%	44%	24%
Cherry Creek B	C4	Slope / Ravine	158	46%	62%	15%
Cherry Creek C	C5	Slope / Ravine	457	59%	71%	11%
Cherry Creek D – East	C1	Slope / Ravine	288	< 1%	56%	4%
Cherry Creek D – West	C6	Terrace	166	< 1%	55%	6%
Coe-Clemons / Thayer / Unnamed Tributary Basin						
Old Town	D2	Slope / Ravine	146	88%	11%	43%
Coe-Clemons – Lower	D6	Slope / Ravine	98	100%	27%	43%
Coe-Clemons – Upper	D5	Terrace	273	100%	26%	43%
Thayer	D4	Slope / Ravine	235	92%	24%	29%
Coe-Clemons / Thayer Floodplain	D3	Floodplain	663	13%	7%	3%
Unnamed Southern Tributary – Lower	D1	Slope / Ravine	373	42%	40%	17%
Unnamed Southern Tributary – South	D8	Slope / Ravine	158	0%	70%	7%
Unnamed Southern Tributary – Upper	D7	Terrace	327	36%	54%	18%
Weiss Creek Basin						
Weiss Creek – Upper	W3	Terrace	207	4%	42%	11%
Weiss Creek – Middle	W2	Slope / Ravine	587	0%	54%	8%
Weiss Creek – Lower	W1	Slope / Ravine	1273	0%	63%	7%

Subbasin Importance and Degradation Scores – Primary and Secondary Analysis

The goal of the Duvall watershed analysis was to evaluate the importance of watershed processes and the level to which these watershed processes are intact within the study area. In this project, results of the Ecology Watershed Characterization water flow assessment, normalized to the Duvall study area, were used to evaluate watershed processes at a local scale (primary analysis – see Appendix B for details). Additional analysis using finer scale data was completed to augment the primary analysis (secondary analysis, also detailed in Appendix B).



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

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Figure 2-4

Primary Results - Watershed Characterization Overall Water Flow

Finally, results from both primary and secondary analyses were used along with local information about land and infrastructure management and City policies and priorities.

Primary Analysis

Water flow processes were assessed and scored using Puget Sound Watershed Characterization data (Stanley et al., 2011). Scores represent the relative importance and degradation of each process (see Appendix B for more information). The score for water flow importance reflects the underlying, pre-development physical conditions (geology, landscape position, etc.). The score for water flow degradation reflects the amount of change to land cover for key indicators that are important to the integrity of water flow processes.

Review of normalized scores for water flow importance and degradation revealed distinct differences among PAUs. By plotting these scores, three distinct groups became apparent for the 17 PAUs (Figure 2-4, see also Figure B-3 in Appendix B).

Secondary Analysis

After completing the primary analysis, 11 out of 17 PAUs were sorted into Group 2. These 11 PAUs include most of the city and urban growth area/urban growth area reserve, covering an area with substantial differences in existing land use and land cover types. To provide a more useful characterization for guiding land use decisions, Group 2 PAUs were further evaluated for finer scale understanding of watershed processes importance and degradation, and further subdivided into more useful management groups.

Four additional indicators of ecological processes were identified for evaluation where finer resolution data were available for completion of secondary analysis of watershed importance: (1) sediment export potential model from Ecology's water quality assessment; (2) modified storage; (3) forest cover; and (4) aquatic habitat. For each of the four additional measures of importance, PAU scores were normalized and weighted equally to determine one value for importance (see Appendix B, section B.5 for details).

Additionally, total impervious area was compared to total forest cover (within each PAU), with the ratio developed as a secondary (and higher resolution) measure of degradation of watershed processes.

The results of each secondary analysis data set were rolled into one value (Secondary Importance Score) and plotted against the secondary measure for level of degradation (Figure 2-5; see also Figure B-9 in Appendix B).

2.3 Subbasin Management Group Framework

Subbasins are ranked based on the relative importance of their watershed processes to the overall watershed, and on the extent of degradation these processes have sustained as a result of past human practices (e.g., converting forested lands to impervious surfaces). The subbasins are ranked according to the following five Subbasin Management Groups (see Figure 2-5):

Management Group 1 – Protect / Restore

- Applies to Snoqualmie River/Cherry Creek floodplains (PAUs C2 and D3).
- Assigned to subbasins that are of highest importance to multiple watershed processes and are a high priority for protection and restoration.

Management Group 2A – Highest Conservation

- Applies to six subbasins along east and south edges of the city (PAUs C5, C6, C1, W2, W1, and D8).
- Assigned to subbasins that are the highest priority for conservation and are likely not appropriate for much additional development. Assessment results show moderate importance to multiple watershed processes that are also highly intact.

Management Group 2B – Moderate Conservation

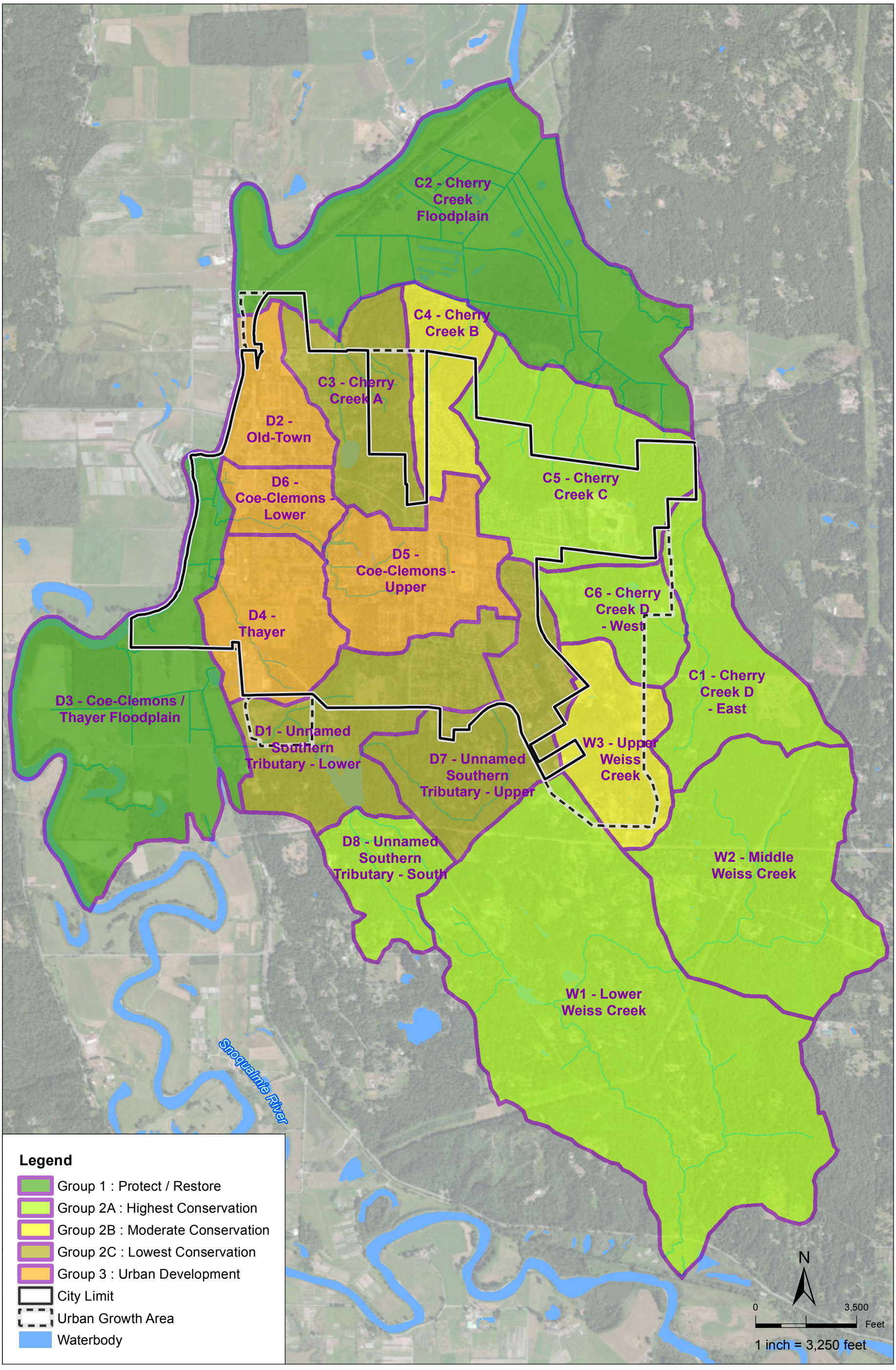
- Applies to Cherry Creek B (PAU C4) and Upper Weis Creek (PAU W3).
- Assigned to subbasins that may be appropriate for some additional development, but also require protection of areas important for remaining watershed processes.

Management Group 2C – Lowest Conservation

- Applies to three subbasins including North urban growth area (PAU C3) and southeast City / South urban growth area (PAUs D1 and D7).
- Assigned to subbasins where more intense development is appropriate. The remaining resources and areas important to watershed processes would benefit from protection.

Management Group 3 – Urban Development

- Applies to four subbasins in historic downtown Duvall (PAUs D2, D4, D5, and D6).
- Assigned to subbasins where more intense development should be focused. Subbasins are below average for water flow importance and have the highest existing degradation.



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

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Figure 2-5

Secondary Results - Subbasin Management Recommendations

CHAPTER 3. WATERSHED GOALS AND POLICIES

3.1 Goals and Policies

This chapter identifies goals and policies based on the findings of the watershed characterization described in Chapter 2 (Key Watershed Analysis Results). The goals and policies provided here can be incorporated into the Sustainability and Environment Element of the 2015 Comprehensive Plan. All policies apply city-wide unless otherwise noted.

WATERSHED GOAL 1
Improve important watershed processes and functions through progressive review and updates of land use designations, development practices, and infrastructure improvements.

Policies:

W1.1 Improve protections of watershed processes by amending zoning and subdivision regulations, sensitive area protections, and storm drainage standards that are appropriate for each Management Group. Standards should afford more protection for subbasins that are important for watershed processes and allow for higher intensity development in subbasins of lower importance.

W1.2 Update zoning, subdivision, sensitive areas, and storm drainage standards and other development standards consistent with the subbasin management group framework established in the Watershed Plan.

W1.3 Work with King County to designate urban growth areas to exclude subbasins in the Management Group 2A and include subbasins in the Management Groups 2B and 2C, where feasible.

W1.4 Consider the findings of the Watershed Plan when designating urban growth areas and urban growth area reserves with Comprehensive Plan designations and zoning districts.

W1.5 Minimize impervious surfaces associated with off-street parking lots, driveways, and subdivision designs.

WATERSHED GOAL 2
Improve watershed processes by investing in stormwater infrastructure, parks, open spaces, and restoration in the City's capital improvement program.

Policies:

W2.1 Use the findings of the Watershed Plan to identify and prioritize park improvements that achieve multiple benefits (e.g., restore wetlands and create a trail network).

W2.2 Partner with King County to leverage their expertise and resources to implement subbasin management priorities and objectives identified in the Watershed Plan for areas outside the city limits.

W2.3 Partner with conservation groups, other government agencies, not-for-profit organizations, businesses, and other partners to restore habitat and watershed processes within the city limits.

W2.4 Identify and prioritize stormwater retrofits to address impaired watershed processes and reduce effective impervious surface areas based on the findings of the Watershed Plan.

W2.5 Explore the feasibility of building and maintaining centralized stormwater facilities in Management Groups 2B and 2C in the urban growth area to offset onsite detention requirements.

W2.6 Identify and target grant monies and other funding sources for restoration that addresses protection and restoration of watershed processes in Management Groups 1, 2A, and 2B. Consult the Duvall Shoreline Master Program Restoration Plan to identify restoration priorities in Management Group 1.

W2.7 Work with private property owners to voluntarily establish conservation easements on lands with intact forest cover or high value natural resources, especially land that is prioritized for protection or restoration by existing City plans (for example, Duvall's Shoreline Master Program Restoration Plan) in Management Groups 1, 2A, and 2B.

WATERSHED GOAL 3
Preserve and enhance Duvall's tree canopy cover through education and outreach, partnerships, and pragmatic implementation strategies.

Policies:

W3.1. Create an urban forestry plan that documents existing conditions, identifies incentives and programs, and recommends revisions to code requirements to protect and increase forest cover.

W3.2. Partner with nonprofit organizations to promote a voluntary tree planting program that provides Duvall's residents and businesses with opportunities to plant trees in the street right-of-way planter strip and on private property. Outreach and education should be a component of this program.

W3.3. Information about King County's Public Benefit Rating System, a tax reduction program, should be shared with Duvall property owners located in Management Groups 2A, 2B, and 2C to encourage conservation of forested properties.

W3.4. Promote conservation of healthy, native forests in large tracts as part of new subdivision development in Management Groups 2A, 2B, and 2C.

W3.5. Amend the significant tree requirements to increase the percentage of trees preserved at the time properties develop and to require preservation of stands of trees. Trees to be saved should be in locations and of a species type to allow maximum opportunity for retention.

W3.6. Expand tree mitigation standards in Chapter 14.40 of the Duvall Municipal Code to include standards on tree type, location, and monitoring.

W3.7. Create a landmark heritage tree program that establishes criteria for nominating and recognizing trees of exceptional value.

WATERSHED GOAL 4
Improve city-wide stormwater systems to maintain and enhance water flow and water quality processes through implementation of low impact development techniques.

Policies:

W4.1. Improve stormwater management based on the findings of the Watershed Plan by expanding low impact development requirements, creating incentives, and establishing green infrastructure standards for public roadways in the Duvall Municipal Code.

W4.2. Encourage property owners to use low impact development best management practices for improved stormwater systems by establishing voluntary programs, and partnering with not-for-profit organizations and governmental agencies.

W4.3. Create an educational outreach program that includes workshops, informational handouts, and links to additional resources on amended soils, rain gardens, native landscaping and rainwater harvesting, landscaping management best practices, and environmental stewardship for property owners.

WATERSHED GOAL 5
Improve long-term management of sensitive areas by updating standards that address watershed processes into the City's Sensitive Areas Ordinance.

Policies:

W5.1. Identify, designate, and protect habitat corridors between streams, wetlands, and geologic hazard areas within city limits, including linkages to areas outside of city limits.

W5.2. Restrict wetland and stream buffer reduction allowances in the Duvall Municipal Code for Management Groups 1 and 2.

W5.3. Increase regulatory protections for depressional wetlands in Management Groups 1 and 2.

W5.4. Incorporate standards in the Sensitive Areas Ordinance that limit modifications to wetland and stream buffers that would result in tree loss.

WATERSHED GOAL 6
Avoid mass clearing and grading associated with new developments that result in large amounts of tree loss and changes in topography.

Policies:

W6.1. Strengthen the limitations on clearing mature or native vegetation in Management Groups 1 and 2 as new development occurs by more closely integrating open space subdivision standards with sensitive area standards.

W6.2. Limit extensive grading and retaining walls for large subdivisions in Management Groups 1 and 2.

3.2 Implementation

Table 3-1 identifies actions that the City of Duvall can take to implement the goals and policies identified in Section 3.1. The table identifies the watershed processes that would benefit from each action, the subbasin management group in which the action would be implemented, the action priority, the chapter in the Watershed Plan that provides more detail on the action, and the policies that each action would address.

Table 3-1. Watershed Actions

Action Number	Action	Watershed Processes that would Benefit				Applicable Subbasin Management Group	Prioritization	More Detail Provided in:				Watershed Policies Addressed
		Surface Storage	Groundwater / Base Flow Maintenance	Fish & Wildlife Habitat	Water Quality			Chapter 5 – Watershed Strategies for Development Standards	Chapter 6 – Watershed Strategies for Stormwater Management	Chapter 7 – Watershed Strategies for Sensitive Areas Management	Chapter 8 - Urban Growth Area Land Use Strategies Overview	
DS-1	Revisit zoning limits for impervious surfaces and identify appropriate reductions in Management Groups 1 and 2.	X	X		X	Groups 1 and 2	High	X				W1.1
DS-2	Revisit density standards for zoning districts located in Management Groups 2C and 3 and identify opportunities to increase densities consistent with the Comprehensive Plan update process.			X	X	Group 3	High	X				W1.1
DS-3	Improve shared parking allowances for commercial uses.		X			All groups located within Duvall	Low	X				W1.5
DS-4	Allow small decentralized parking lots rather than individual garages for townhomes, cottage housing, and multi-family developments.		X			All groups located within Duvall	High	X				W1.5
DS-5	Improve implementation and compliance with existing soil standards for landscaping	X	X	X	X	All groups located within Duvall	High	X				W1.1
DS-6	Establish landscaping standards for publicly-owned properties and open space lots.		X	X	X	All groups located within Duvall	Medium	X				W1.1
DS-7	Limit clearing of mature or native vegetation as new development occurs. Integrate open space requirements for residential zones with sensitive areas protections to preserve contiguous tracts.	X	X	X	X	All groups located within Duvall, special provisions applicable to Management Groups 1 and 2	High	X				W6.1
DS-8	Expand tree mitigation standards to include specifics on tree type, soil, location, and monitoring, including allowance for fruit and nut trees, native species, and smaller caliper plantings. Where clear cuts occur adjacent to preserved riparian forest, require planting near edges to prevent windthrow.		X	X		All groups located within Duvall	Medium	X				W3.4

Action Number	Action	Watershed Processes that would Benefit				Applicable Subbasin Management Group	Prioritization	More Detail Provided in:				Watershed Policies Addressed
		Surface Storage	Groundwater / Base Flow Maintenance	Fish & Wildlife Habitat	Water Quality			Chapter 5 – Watershed Strategies for Development Standards	Chapter 6 – Watershed Strategies for Stormwater Management	Chapter 7 – Watershed Strategies for Sensitive Areas Management	Chapter 8 - Urban Growth Area Land Use Strategies Overview	
DS-9	Encourage subdivisions to cluster lots to minimize mass clearing and grading by establishing design guidelines that encourage open space.	X	X	X	X	All groups located within Duvall, most appropriate to Group 2	High	X				W1.1 and W1.5
DS-10	Revise regulations that require open space as a percentage of the subdivision so that reforestation, protection of existing trees, and critical area buffer enhancements are options in addition to providing open space for recreation.	X	X	X	X	All groups located within Duvall, with differing criteria depending on the management group	Medium	X				W6.1
DS-11	Limit wall height and mass grading.		X		X	Groups 1 and 2	High	X				W6.2
SW-1	Define the most useful and applicable LID BMPs and require their use in new development activities.	X	X	X	X	Groups 2B, 2C and 3	High		X			W4.1
SW-2	Improve soil amendment BMP for clarity, ease of understanding, and enforcement (Ecology 2012).	X	X		X	All groups located within Duvall	High		X			W4.1
SW-3	Define the most useful and applicable LID BMPs and stormwater enhancement approaches for small sites; require their use in new development and redevelopment activities on small sites..	X	X	X	X	All groups located within Duvall, most appropriate for Groups 2B, 2C, and 3	High		X			W2.4 and W4.1
SW-4	Create a flow control exemption for portions of the City that are predominantly built-out and already drain directly to the Snoqualmie River through pipe or ditch infrastructure.	X			X	Group 3	Medium		X			W4.1
SW-5	In UGAs, create centralized stormwater facilities to off-set onsite detention requirements.	X		X	X	Groups 2B and 2C	Low		X			W2.5
SW-6	Create and incentivize stormwater LID standards.	X	X	X	X	All groups located within Duvall	High		X			W4.1
SW-7	Incorporate new standards for landscape strips in roadways.		X	X	X	All groups located within Duvall	High		X			W4.1

Action Number	Action	Watershed Processes that would Benefit				Applicable Subbasin Management Group	Prioritization	More Detail Provided in:				Watershed Policies Addressed
		Surface Storage	Groundwater / Base Flow Maintenance	Fish & Wildlife Habitat	Water Quality			Chapter 5 – Watershed Strategies for Development Standards	Chapter 6 – Watershed Strategies for Stormwater Management	Chapter 7 – Watershed Strategies for Sensitive Areas Management	Chapter 8 - Urban Growth Area Land Use Strategies Overview	
SW-8	Create an educational outreach program that includes workshops, informational handouts, and website updates on: amended soils, rain gardens, native landscaping and rainwater harvesting, landscaping management best practices, and environmental stewardship.	X	X	X	X	All groups located within Duvall	Medium		X			W4.3
SA-1	Identify and establish methods to create and protect fish and wildlife habitat corridors within all subbasin management groups.			X		All groups located within Duvall	Medium			X		W5.1
SA-2	Identify additional regulatory mechanisms to increase protection of depressional wetlands.	X	X	X	X	Groups 1 and 2	Medium			X		W5.3
SA-3	Revise wetland and stream buffer standards to more closely align with tree protection standards in order to conserve functions provided by wetland and stream buffers.	X		X	X	All groups located in Duvall	High			X		W5.4
SA-4	Establish a regulatory mechanism for long-term protection and management of mitigation sites for sensitive areas buffers.			X	X	All groups located in Duvall	High			X		W5.4
SA-5	In order to avoid impacts to sensitive areas and preserve their buffers, prohibit buffer modifications to wetland and fish and wildlife habitat conservation area buffers in Management Groups 1 and 2A. Allow limited buffer modifications for Management Groups 2B and 2C.	X	X	X	X	Groups 1 and 2, with differing criteria depending on the subbasin management group	High			X		W5.4

Action Number	Action	Watershed Processes that would Benefit				Applicable Subbasin Management Group	Prioritization	More Detail Provided in:				Watershed Policies Addressed
		Surface Storage	Groundwater / Base Flow Maintenance	Fish & Wildlife Habitat	Water Quality			Chapter 5 – Watershed Strategies for Development Standards	Chapter 6 – Watershed Strategies for Stormwater Management	Chapter 7 – Watershed Strategies for Sensitive Areas Management	Chapter 8 - Urban Growth Area Land Use Strategies Overview	
SA-6	Encourage open space within subdivisions beyond the 10 percent requirement by also requiring reforestation, protection of existing trees, and enhancement of sensitive areas buffers in addition to providing open space for recreation. Other measures could include conservation of mature forests and limiting vegetation clearing.		X	X	X	All groups located in Duvall	Medium			X		W6.1
SA-7	Increase protection of geologic hazards through implementation of tree protection standards.			X	X	All groups located in Duvall	Medium			X		W5.1

CHAPTER 4. SUBBASIN FOLIO

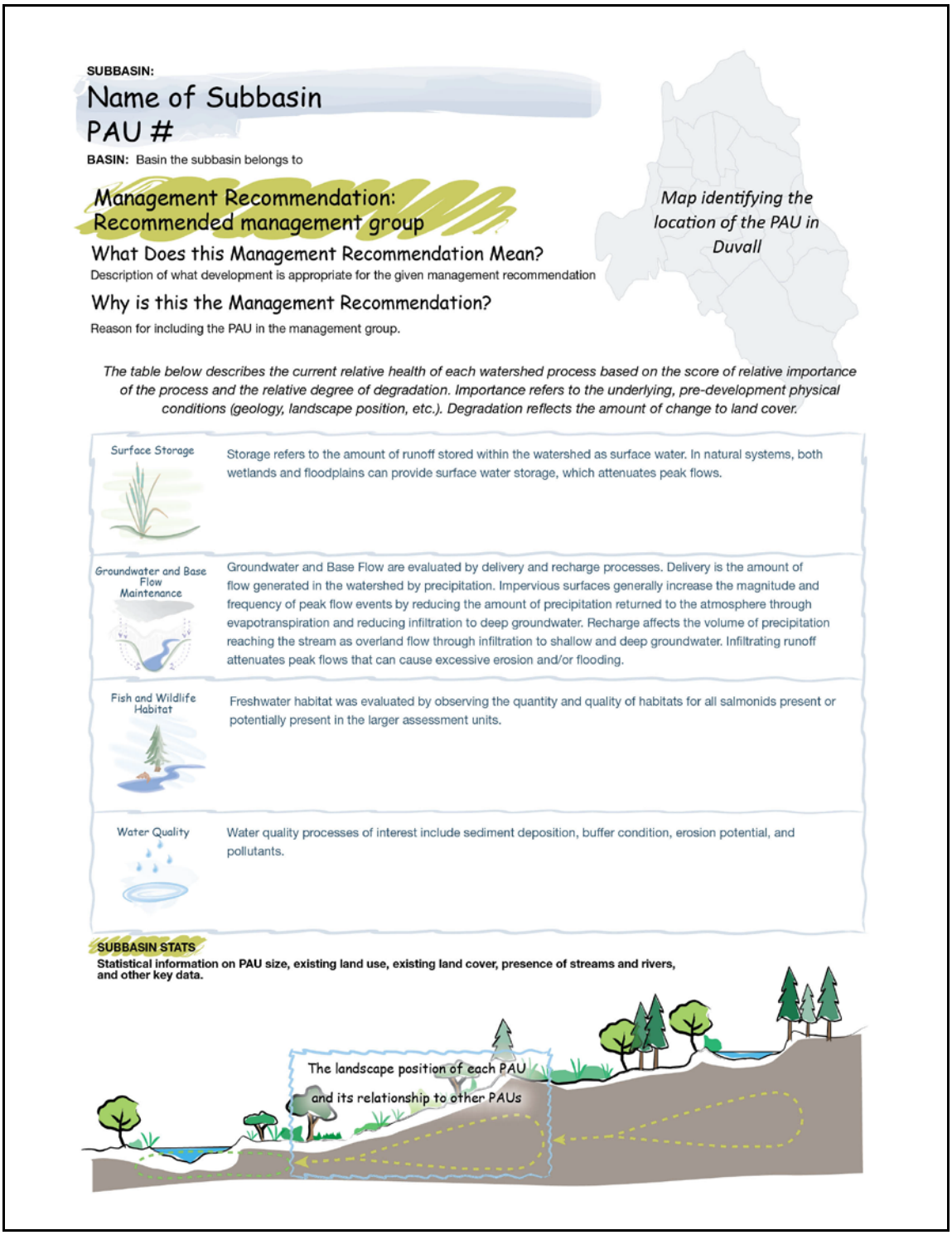
4.1 Understanding the Folio

To develop an understanding of watershed conditions in and around the City of Duvall, each subbasin or project assessment unit (PAU) was evaluated in terms of four key processes: (1) surface storage, (2) groundwater and base flow maintenance, (3) fish and wildlife habitat, and (4) water quality. Each PAU was scored according to the relative importance of the processes and the relative degree of degradation. *Importance* refers to the underlying, pre-development physical conditions (geology, landscape position, etc.). *Degradation* reflects the amount of change to land cover. Each PAU was then placed in a Subbasin Management Group based on its score. Additional information on these steps is provided in Chapter 2 and Appendix B.

A description of each PAU is provided in a two-page "folio sheet." Figure 4-1 is an example folio sheet that identifies the key information included. A brief explanation of watershed processes is provided on the example sheet. For a more detailed description of processes and the values of those processes, see Chapter 2. Landscape position is also shown on the folio sheets to provide context for how the given PAU affects the watershed processes of the PAUs downstream and what PAUs upstream are affecting the watershed processes of the given PAU.

The folio sheets are grouped according to the tributaries the PAU drains to, and include Cherry Creek, Duvall Tributaries, and Weiss Creek basins (see Figure 4-2 for location of these basins). PAUs W1, C1, C2, W2, and D8 are not included in this chapter because they are located almost entirely outside of Duvall city and urban growth area limits, and therefore would not be under the jurisdiction of the City of Duvall at any future time. See Figure 2-5 in Chapter 2 for location of PAUs.

Figure 4-1 Example Folio Sheets



SUBBASIN:

Name of Subbasin
PAU #

BASIN: Basin the subbasin belongs to

Management Recommendation:
Recommended management group

What Does this Management Recommendation Mean?

Description of what development is appropriate for the given management recommendation

Why is this the Management Recommendation?

Reason for including the PAU in the management group.

Map identifying the location of the PAU in Duvall

The table below describes the current relative health of each watershed process based on the score of relative importance of the process and the relative degree of degradation. Importance refers to the underlying, pre-development physical conditions (geology, landscape position, etc.). Degradation reflects the amount of change to land cover.

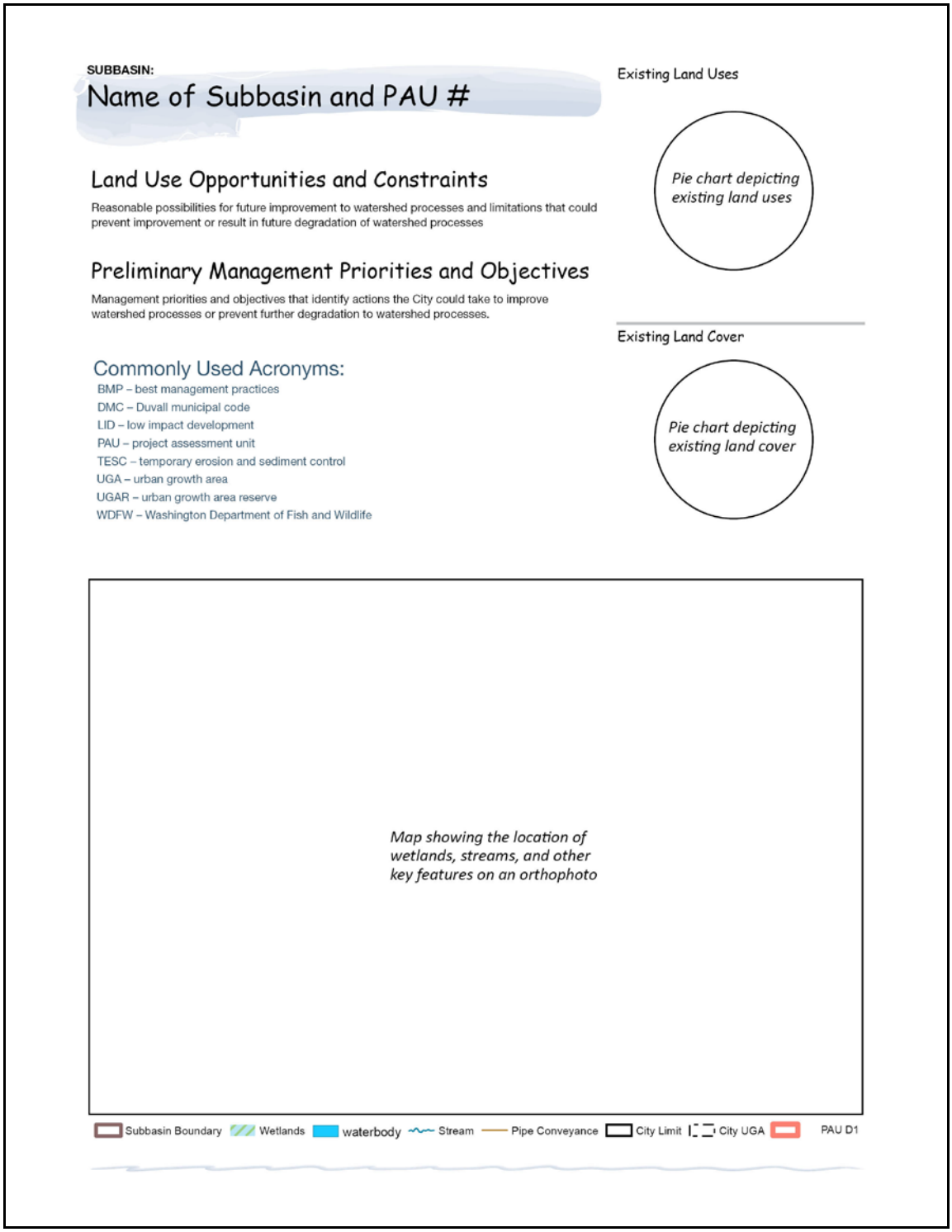
Surface Storage	Storage refers to the amount of runoff stored within the watershed as surface water. In natural systems, both wetlands and floodplains can provide surface water storage, which attenuates peak flows.
Groundwater and Base Flow Maintenance	Groundwater and Base Flow are evaluated by delivery and recharge processes. Delivery is the amount of flow generated in the watershed by precipitation. Impervious surfaces generally increase the magnitude and frequency of peak flow events by reducing the amount of precipitation returned to the atmosphere through evapotranspiration and reducing infiltration to deep groundwater. Recharge affects the volume of precipitation reaching the stream as overland flow through infiltration to shallow and deep groundwater. Infiltrating runoff attenuates peak flows that can cause excessive erosion and/or flooding.
Fish and Wildlife Habitat	Freshwater habitat was evaluated by observing the quantity and quality of habitats for all salmonids present or potentially present in the larger assessment units.
Water Quality	Water quality processes of interest include sediment deposition, buffer condition, erosion potential, and pollutants.

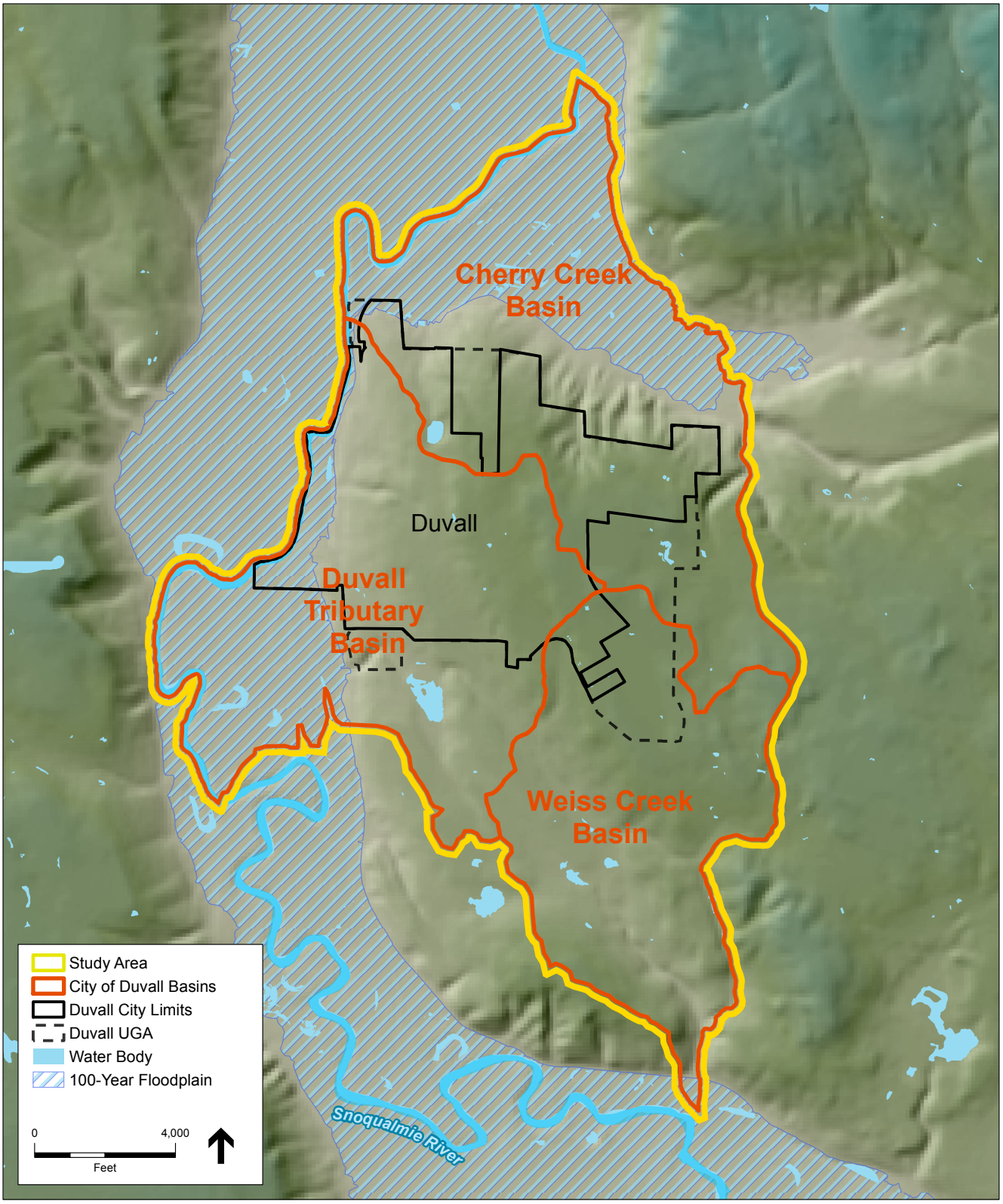
SUBBASIN STATS

Statistical information on PAU size, existing land use, existing land cover, presence of streams and rivers, and other key data.

The landscape position of each PAU
and its relationship to other PAUs

(Figure 4-1 Continued)





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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

City of Duvall Watershed Planning . 130674

Figure 4-2
Duvall Basins

4.2 Cherry Creek Basin

The Cherry Creek watershed covers approximately 32,000 acres, but less than 7 percent of the total watershed is within the study area[1] (see Chapter 2, Figure 2-3). Only tributaries to Cherry Creek (not the Cherry Creek mainstem) lie within the city. However, alterations to the tributaries can impact the mainstem and alter the floodplain downstream which has high conservation value. High to moderate degradation is observed in tributaries A and B, where development is more extensive. Tributaries C and D still have low levels of development and many watershed processes are still intact. Table 4-1 identifies the PAU folio sheets associated with Cherry Creek subbasins.

Table 4-1. PAU Folio Sheets in Cherry Creek Subbasins

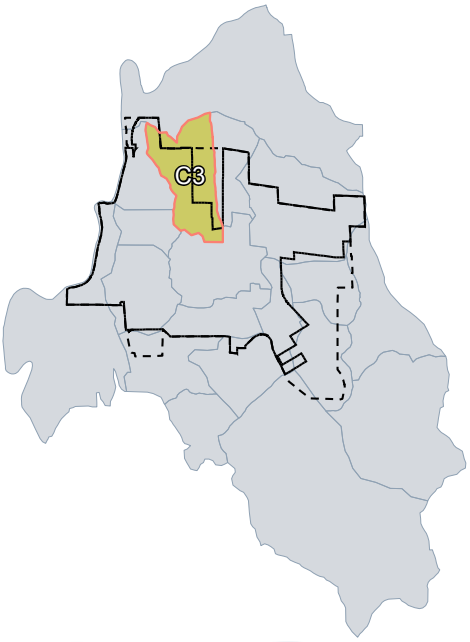
PAU #	Subbasin Name
C3	Cherry Creek A
C4	Cherry Creek B
C5	Cherry Creek C
C6	Cherry Creek D - West

[1] All portions of Cherry Creek tributary subbasins, Duvall tributary subbasins, and Weiss Creek subasins that drain from or through the city or urban growth areas to the Snoqualmie River are included as part of the study area for this watershed analysis.

SUBBASIN:

Cherry Creek A (PAU C3)

BASIN: Cherry Creek Tributaries



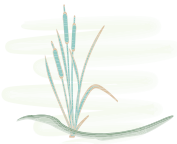
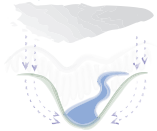
Management Recommendation: Group 2C Lowest Conservation

What Does this Management Recommendation Mean?

This subbasin is appropriate for more intense development but as development occurs the resources and areas most important for watershed processes should be conserved.

Why is this the Management Recommendation?

The subbasin scored relatively low for importance and high for degradation. New development, including in the North UGA would have less impact on processes compared to other subbasins and may create opportunities to improve important areas (Cherry Creek Tributary A riparian corridor, Lake Rasmussen). Analysis results are detailed below:

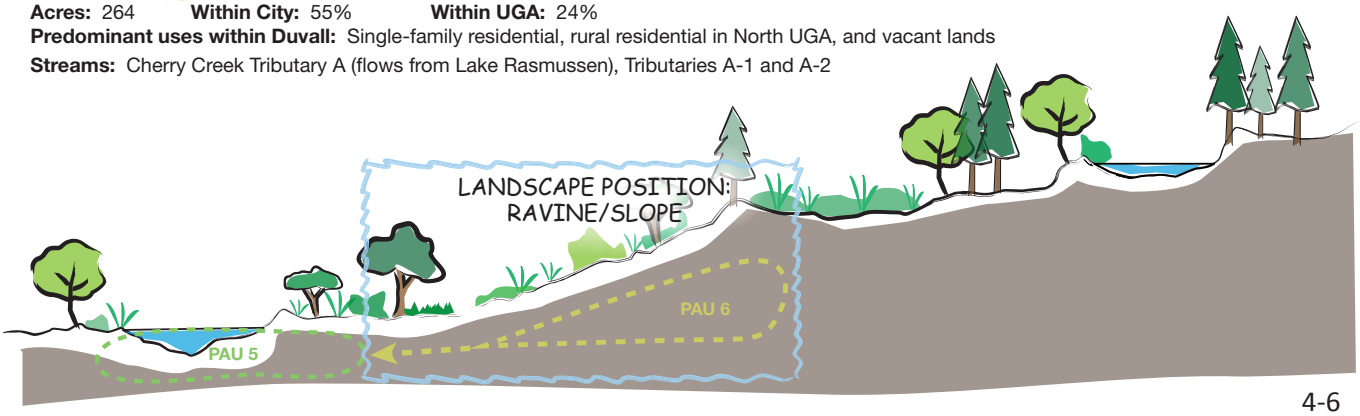
Surface Storage 	**Lake Rasmussen and other depressional wetlands in upper basin provide moderate levels of surface storage during storm events, reducing downstream erosion:** • 3% wetlands and other surface storage features • Lake Rasmussen (5.5 acres) within the upper portion of subbasin Storage processes minimally degraded despite existing intensity of development due to retention of existing wetlands and Lake Rasmussen.	**Broad management priorities:** • Limit sediment discharge to Lake Rasmussen • Conserve depressional wetlands • Restore wetlands to increase storage capacity
Groundwater and Base Flow Maintenance 	**Subbasin features are moderately important for groundwater recharge processes; however, are less important for maintaining stream base flows:** • 1% permeable soils (supports recharge) • Few slope wetlands Infiltration to groundwater degraded due to high impervious surface cover (less so within North UGA area). Base flow maintenance processes are more intact, especially around Cherry Creek Tributaries A-1 and A-2.	**Broad management priorities:** • Establish impervious surface limits and other strategies to maintain infiltration • Maintain wetland and riparian areas around subbasin streams
Fish and Wildlife Habitat	**The subbasin is moderately to highly important for fish and wildlife habitat:** • Documented coho presence in Cherry Creek Tributaries A extending above NE Cherry Valley Rd; reach extending towards Lake Rasmussen also has potential to support steelhead • Forested areas are generally contiguous within subbasin (and to larger forested tracts to the east) Salmon habitat impaired by riparian encroachment and stream crossings. Roadway interruption between subbasin and floodplain habitats in north.	**Broad management priorities:** • Improve Tributary A channel conditions • Conserve riparian area and associated wetlands around subbasin streams • Limit tree loss within contiguous forested area
Water Quality	**This subbasin has moderate to high sediment export potential:** • Lake Rasmussen and depressional wetlands within subbasin provide filtration and sediment deposition for runoff • Steep slope areas in northern subbasin have high export potential for phosphorus and sediment Runoff from developed areas has likely increased pollutant inputs to subbasin and downstream areas, as well as channel erosion.	**Broad management priorities:** • Identify stormwater retrofit actions • Address Lake Rasmussen pollutant input • Maintain depressional wetlands • Encourage stormwater management for North UGA (implications for steep slopes)

SUBBASIN STATS

Acres: 264 **Within City:** 55% **Within UGA:** 24%

Predominant uses within Duvall: Single-family residential, rural residential in North UGA, and vacant lands

Streams: Cherry Creek Tributary A (flows from Lake Rasmussen), Tributaries A-1 and A-2



SUBBASIN:

Cherry Creek A (PAU C3)

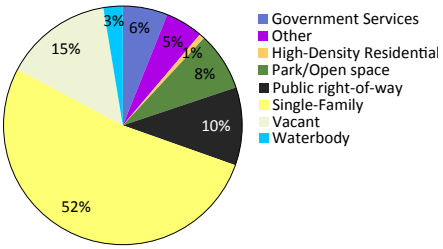
Land Use Opportunities and Constraints

- Opportunities for stormwater retrofits in existing developed areas
- Riparian conditions along Cherry Creek Tributary A vary; however, corridor is present (approximately 125 foot width) throughout, except for four road crossings. Channel and riparian restoration opportunities exist
- Residential development in the North UGA upon annexation presents an opportunity for implementing stormwater BMPs

Preliminary Management Priorities and Objectives

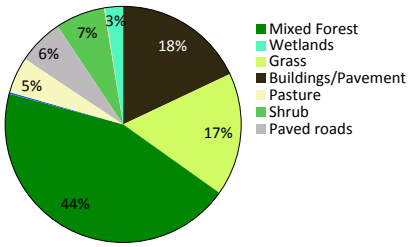
- Protect existing riparian corridor and wetlands, especially those along tributary streams and Lake Rasmussen
- Require use of LID approaches for water quality and water flow as new development occurs in North UGA
- Limit discharge of pollutants into Lake Rasmussen from contributing developed areas

Existing Land Uses

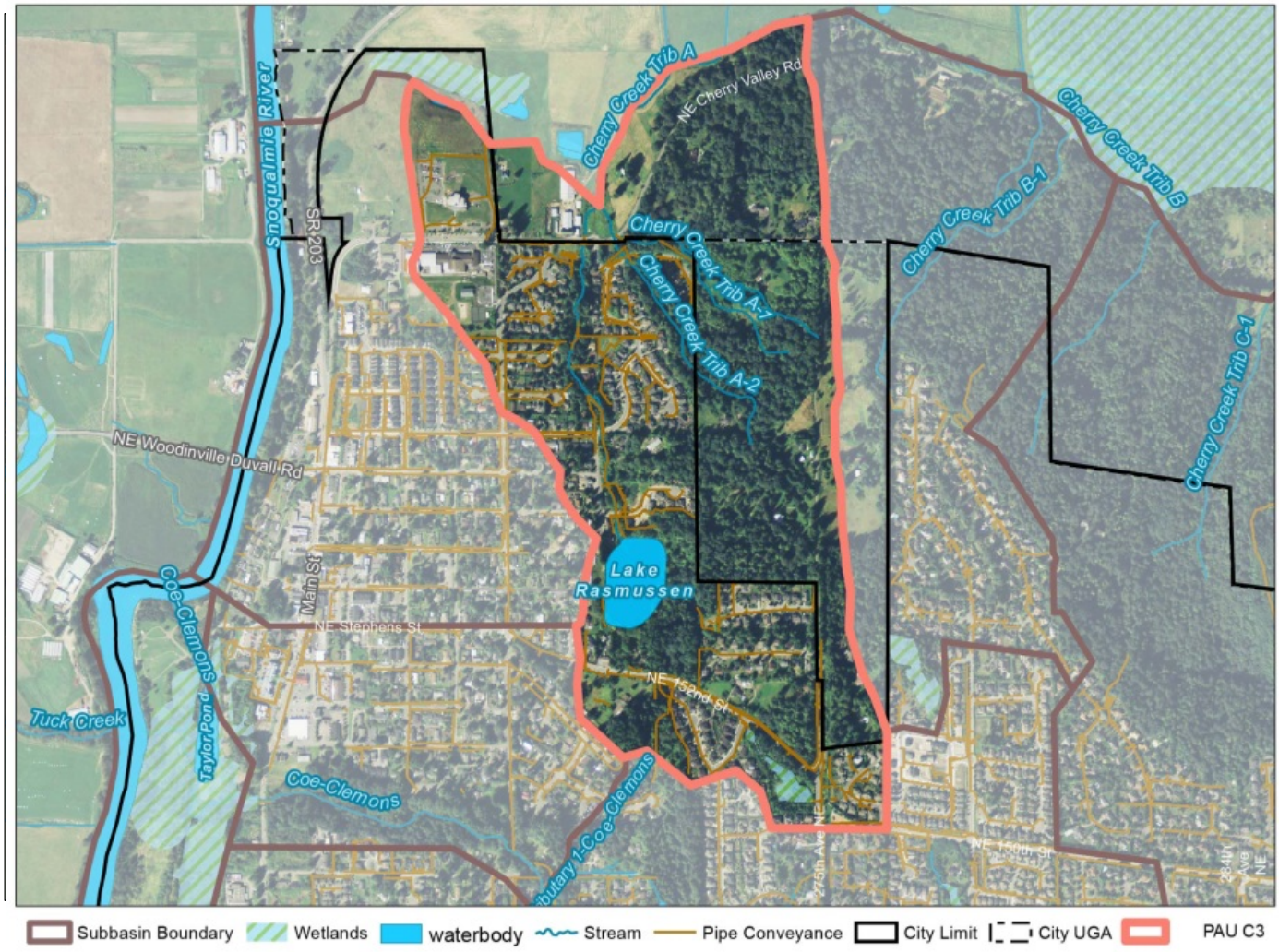


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



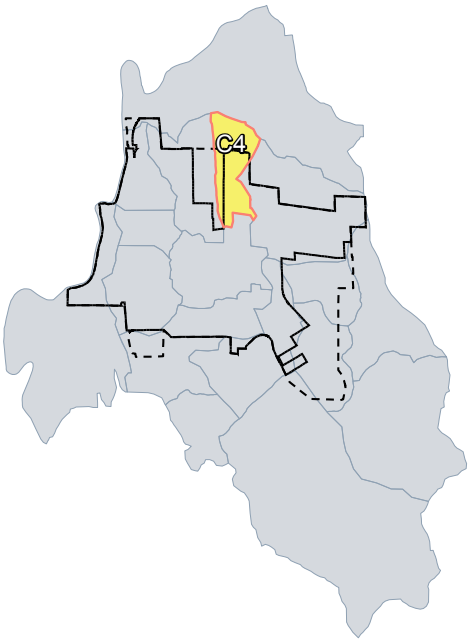
Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



SUBBASIN:

Cherry Creek B (PAU C4)

BASIN: Cherry Creek Tributaries



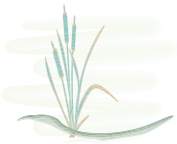
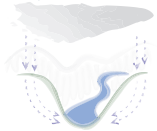
Management Recommendation: Group 2B Moderate Conservation

What Does this Management Recommendation Mean?

While this subbasin may be appropriate for some additional development, care should be taken to protect areas important for remaining watershed processes, especially recharge, discharge and habitat processes.

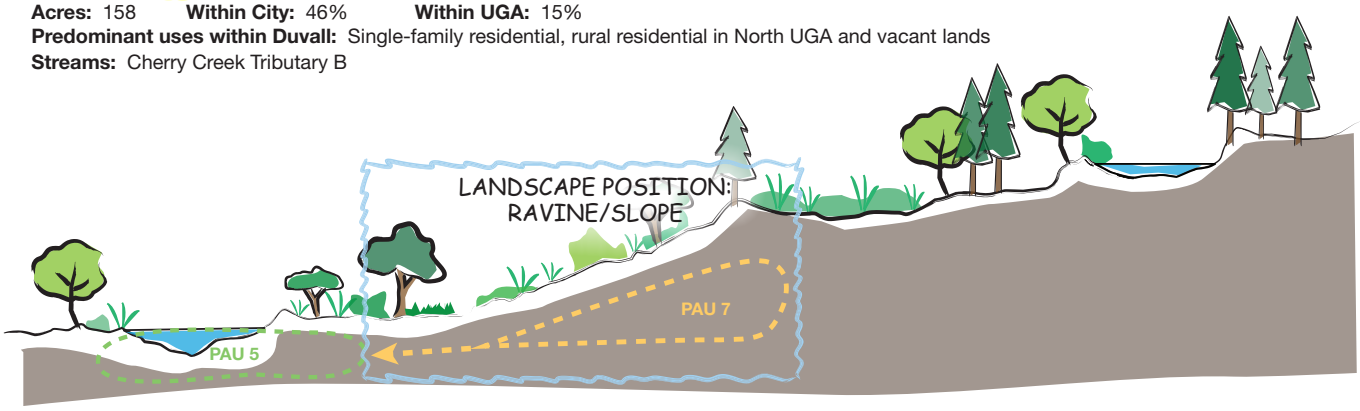
Why is this the Management Recommendation?

This subbasin scored relatively low to moderate for importance and moderate for degradation. Some important areas for maintaining watershed processes remain intact, including forested slopes / slope wetlands and tributary channels. These areas should be conserved; however, overall results suggest there are areas appropriate for new development. Analysis results are detailed below:

Surface Storage 	**The subbasin is of lower importance for surface storage processes:** • Limited storage opportunity due to steep slopes and lack of wetlands Surface storage that is provided (depressional wetland at southern edge of subbasin) is minimally degraded.	**Broad management priorities:** • Conserve depressional wetlands • Limit concentrated stormwater discharges to steep slope areas (consideration for both quantity and timing)
Groundwater and Base Flow Maintenance 	**Subbasin is very important for groundwater recharge and base flow maintenance processes:** • 7% permeable soils (support recharge) • Slope wetlands in forested areas Groundwater infiltration degraded due to high impervious surface cover. Base flow maintenance processes are likely to be more intact, occurring primarily in forested subbasin areas.	**Broad management priorities:** • Establish impervious surface limits, mass grading restrictions, and other strategies to maintain infiltration • Identify and protect slope wetlands along streams
Fish and Wildlife Habitat	**The subbasin is of moderate importance for fish and wildlife habitat:** • No documented anadromous fish presence; however Cherry Creek Tributary B-1 has low to moderate potential for Coho and Steelhead as well as downstream presence north of Cherry Valley Road • Forested areas are generally contiguous within subbasin (and to larger tracts to east) Existing roadways interrupt habitats within the subbasin and floodplain habitats to north.	**Broad management priorities:** • Coordinate with County to improve connectivity across Cherry Valley Road • Limit tree loss within contiguous forested area
Water Quality	**High sediment export potential indicates water quality importance:** • Large depressional wetland at southern edge of subbasin provides filtration and retains sediment • Extensive steep slope areas in northern subbasin have high potential to export phosphorus and sediment Stormwater infrastructure in recently developed areas (large residential subdivision) likely provides adequate water quality treatment; but may not fully address water quantity and flow control	**Broad management priorities:** • Assess the need for stormwater retrofit actions • Maintain depressional wetlands • Minimize new development and forest loss within northern forested area

SUBBASIN STATS

Acres: 158 **Within City:** 46% **Within UGA:** 15%
Predominant uses within Duvall: Single-family residential, rural residential in North UGA and vacant lands
Streams: Cherry Creek Tributary B



SUBBASIN:

Cherry Creek B (PAU C4)

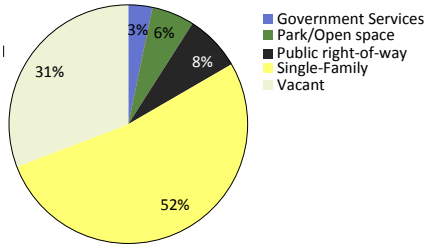
Land Use Opportunities and Constraints

- Protection of contiguous forest and slope areas to the north and east of existing development (extending into the subbasin to the east), including intact riparian forest along Cherry Creek Tributary B-1
- Protections for slope wetlands within subbasin to maintain important and intact recharge processes
- Residential development in the North UGA upon annexation presents an opportunity for implementing stormwater BMPs

Preliminary Management Priorities and Objectives

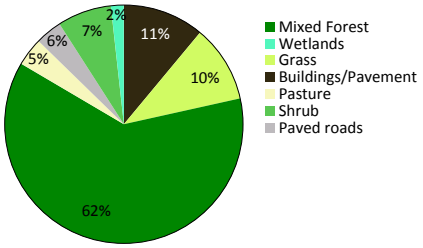
- Require use of LID approaches, especially those encouraging infiltration as new development occurs in North UGA
- Protect existing contiguous forest and slope areas along riparian corridor, including along Cherry Creek Tributary B-1
- Maintain depressional wetlands, especially the large wetland at the south edge of the subbasin, by protecting and restoring adequate buffers and wetland hydrology

Existing Land Uses

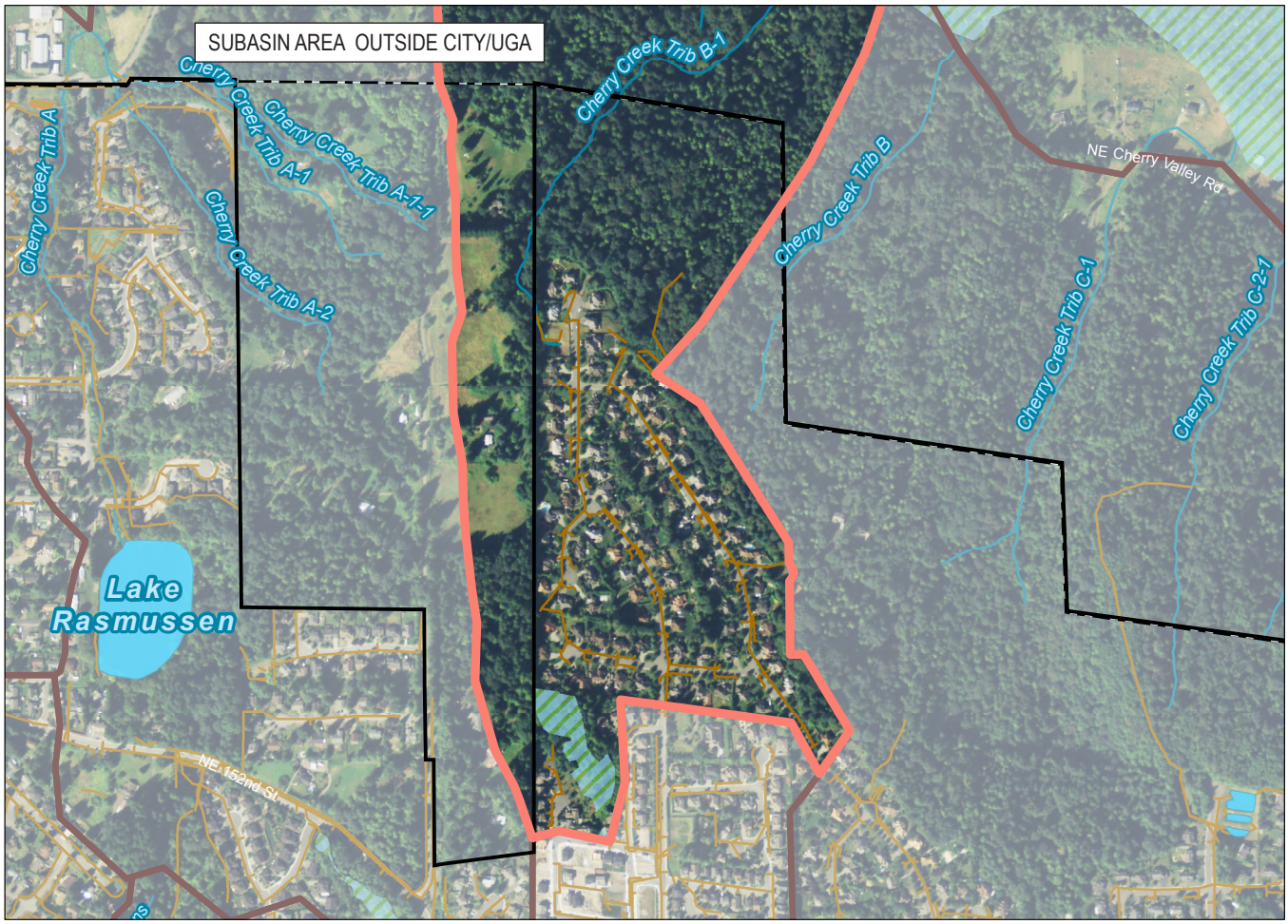


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



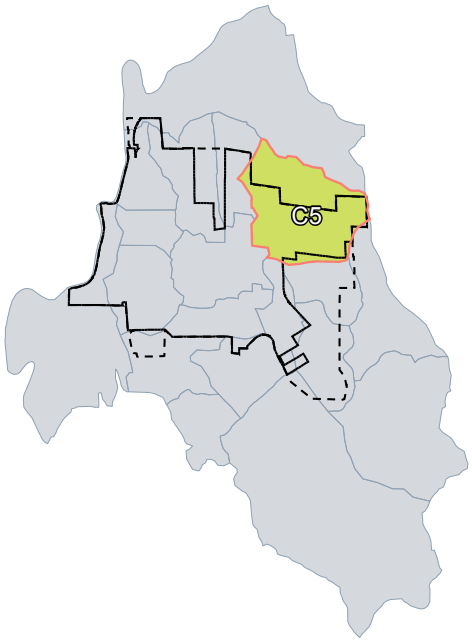
Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



SUBBASIN:

Cherry Creek C (PAU C5)

BASIN: Cherry Creek Tributaries



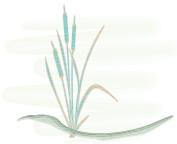
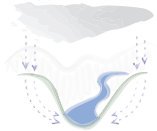
Management Recommendation: Group 2A Highest Conservation

What Does this Management Recommendation Mean?

This subbasin is highly important for multiple watershed processes and should be a high priority for protection and restoration.

Why is this the Management Recommendation?

The subbasin scored moderate for importance and low for degradation. Important areas for maintaining watershed processes and habitat remain intact, including forested slopes / slope wetlands and tributary channels across the northern edge of the city. These areas have generally been protected from past development, and conservation should continue into the future. Analysis results are detailed below:

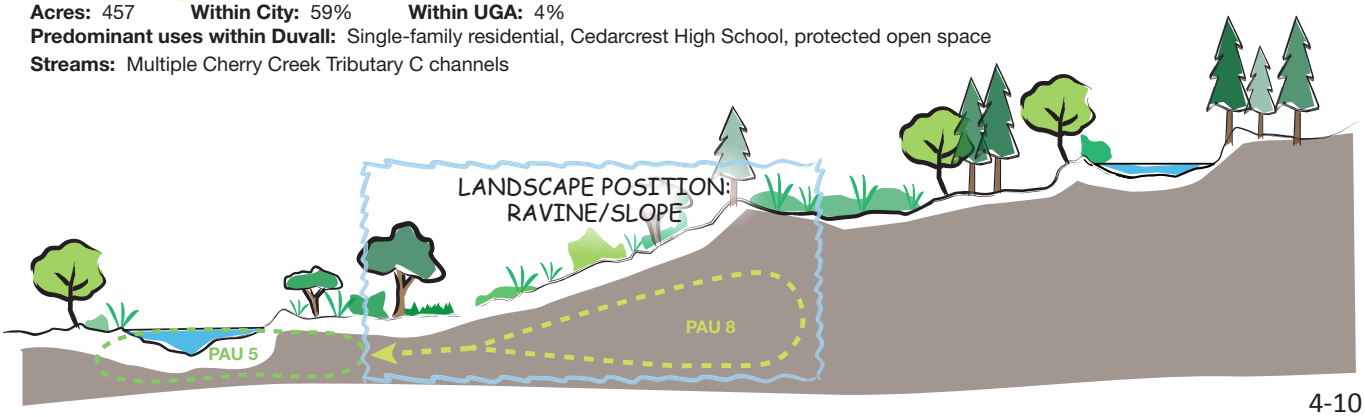
Surface Storage 	**The subbasin is of low importance for surface storage processes:** • Only 1% wetlands / other surface storage features • Steep slopes predominant Surface storage that was historically provided (depressional wetland at northern end of subbasin) are largely degraded by surrounding development.	**Broad management priorities:** • Conserve any remaining depressional wetlands • Limit concentrated stormwater discharge to steep slopes • Monitor existing stormwater outfalls (identify / address erosion issues)
Groundwater and Base Flow Maintenance 	**Subbasin is highly important for groundwater recharge processes:** • 36% permeable soils (support recharge) • Slope wetlands in forested areas Infiltration to groundwater moderately degraded due to high impervious surface cover within southern portion; however this process remains intact throughout undeveloped slope areas. Base flow maintenance processes are of lower importance.	**Broad management priorities:** • Establish impervious surface limits, mass grading restrictions, or other strategies to maintain infiltration • Protect forested slopes and slope wetlands
Fish and Wildlife Habitat	**The subbasin is moderately important for fish and wildlife habitat:** • No documented anadromous fish presence; however multiple Cherry Creek Tributary C channels have low to moderate intrinsic potential for Coho and Steelhead as well as downstream presence north of Cherry Valley Road • Forested areas are generally contiguous within subbasin (and to larger forested tracts to the east and west) Existing roadways interrupt habits within the subbasin and floodplain habitats to the north.	**Broad management priorities:** • Coordinate with County for improved connectivity across Cherry Valley Road • Limit tree loss within contiguous forested areas
Water Quality	**The subbasin has relatively high sediment export potential:** • Extensive steep slope areas in northern subbasin have high export potential for phosphorus and sediment • Export potential is due to erodibility of slopes and tributary channels More recently developed areas (large residential subdivisions; Cedarcrest High School) likely provide adequate water quality treatment; however impact flow quantity and timing.	**Broad management priorities:** • Assess the need for retrofit actions (monitoring subbasin slopes for erosion) • Protect contiguous forested areas (especially within erosion hazard areas)

SUBBASIN STATS

Acres: 457 **Within City:** 59% **Within UGA:** 4%

Predominant uses within Duvall: Single-family residential, Cedarcrest High School, protected open space

Streams: Multiple Cherry Creek Tributary C channels



SUBBASIN:

Cherry Creek C (PAU C5)

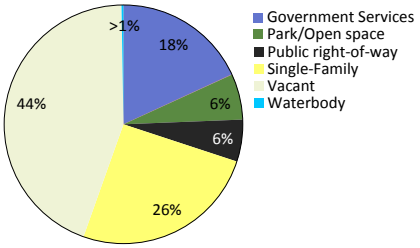
Land Use Opportunities and Constraints

- Contiguous forest and slope areas to the north of existing development (extending into the subbasins to the east and west), including intact riparian forest along Cherry Creek Tributary C channels
- Protections for slope wetlands and tributary stream channels within subbasin to maintain important and intact recharge processes
- Potential for additional forest loss in areas that do not have very steep slopes

Preliminary Management Priorities and Objectives

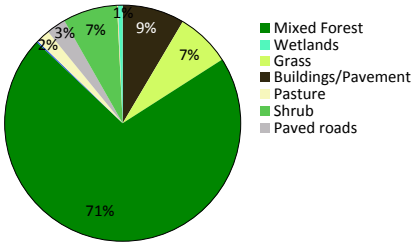
- Protect forested slope areas to the north of existing development, including intact riparian forest along Cherry Creek Tributary C channels.
- Manage and control stormwater discharges to steep slope areas (consideration of both quantity and timing)
- Monitor existing stormwater outfalls to identify and address slope erosion issues

Existing Land Uses

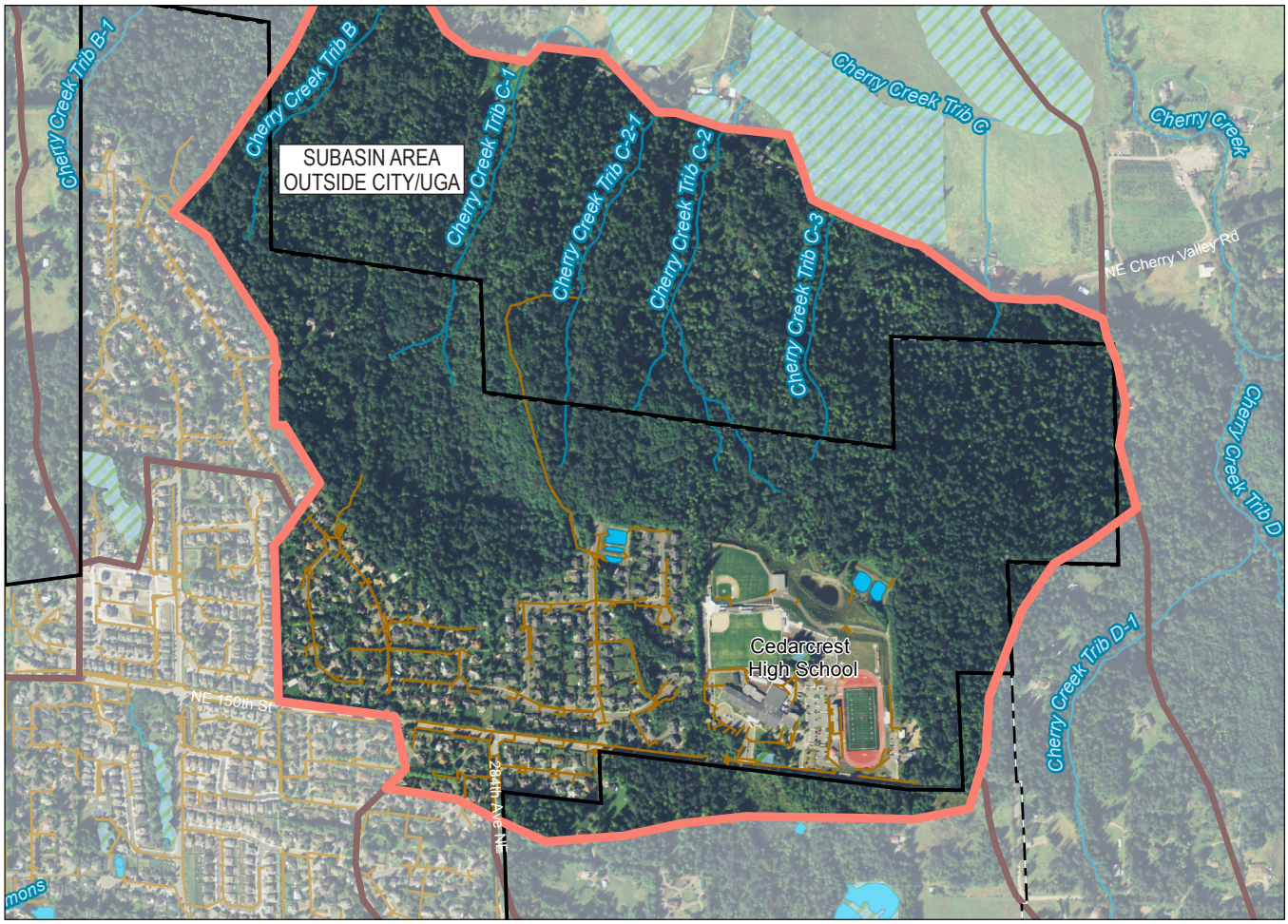


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.

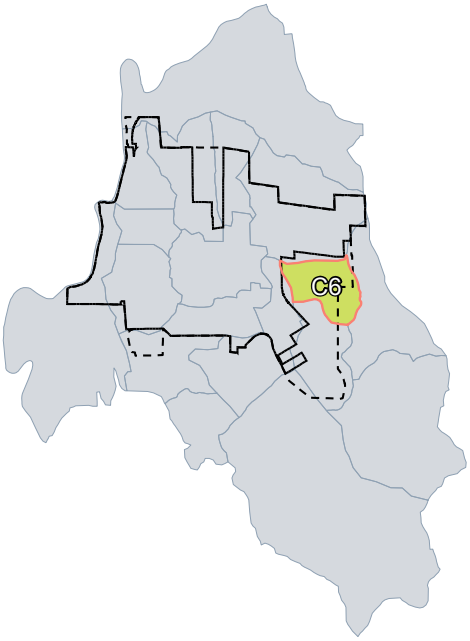


Subbasin Boundary | Wetlands | waterbody | Stream | Pipe Conveyance | City Limit | City UGA | PAU C5

SUBBASIN:

Cherry Creek D - West (PAU C6)

BASIN: Cherry Creek Tributaries



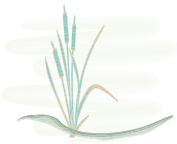
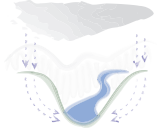
Management Recommendation: Group 2A Highest Conservation

What Does this Management Recommendation Mean?

This subbasin is highly important to multiple watershed processes and should be a high priority for protection and restoration.

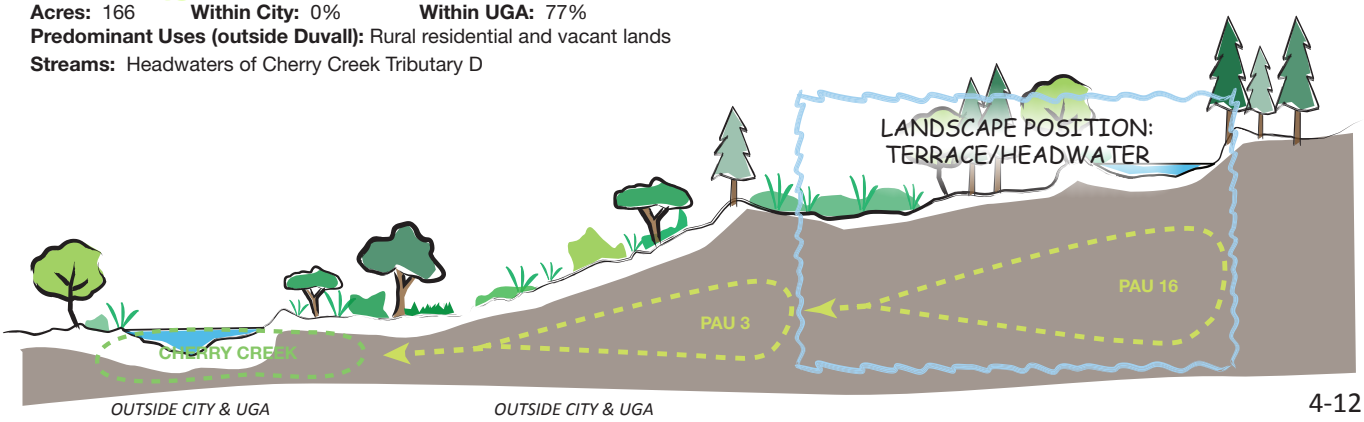
Why is this the Management Recommendation?

The subbasin scored moderate for importance and low for degradation. Important areas for maintaining watershed processes remain intact, including forested depressional wetlands in a headwater landscape to the south of NE 150th Street (the northern portion of the UGAR). These areas should be conserved; urban development may not be appropriate in this sub-basin. Analysis results are detailed below:

Surface Storage 	**Subbasin provides high levels of surface storage within a headwater landscape position:** • 23% wetlands and other surface storage features • Large forested depressional wetland complex to the south of NE 150th Street. Water storage processes have been minimally degraded, as there are low levels of existing development	**Broad management priorities:** • Limit future development (consider removing from UGAR) • Protect depressional wetlands • Maintain downstream flow pathways
Groundwater and Base Flow Maintenance 	**Subbasin is moderately important for base flow maintenance; less important for recharge:** • No areas of mapped permeable soils • Wetlands drain to Cherry Creek Tributary D channels Groundwater and base flow processes have been minimally degraded because there is little existing development. Low impervious surface cover and high forest cover throughout the subbasin support processes.	**Broad management priorities:** • Limit future development (consider removing from UGAR) • Protect depressional wetlands • Maintain downstream flow pathways
Fish and Wildlife Habitat	**The subbasin is moderately important for fish and wildlife habitat:** • No documented anadromous fish presence; although there is downstream presence of coho and steelhead within Cherry Creek Tributary D • Forested wetland areas provide habitat for the numerous bird, amphibian, and mammal species • Forested connection to larger undeveloped tracts to the east Rural development has resulted in some forest loss.	**Broad management priorities:** • Limit future development • Protect large forested wetland complex • Maintain habitat corridor to the east
Water Quality	**The headwater landscape of the subbasin supports sediment deposition and water filtration processes:** • Extensive areas of depressional wetlands suggest that the subbasin is a sediment and phosphorus sink • Wetlands provide water quality filtration before discharge to Cherry Creek Tributary D Water quality processes are relatively intact due to low levels of development throughout subbasin, especially areas surrounding large forested wetland complex.	**Broad management priorities:** • Limit future development • Protect large forested wetland complex

SUBBASIN STATS

Acres: 166 **Within City:** 0% **Within UGA:** 77%
Predominant Uses (outside Duvall): Rural residential and vacant lands
Streams: Headwaters of Cherry Creek Tributary D



SUBBASIN:

Cherry Creek D - West (PAU C6)

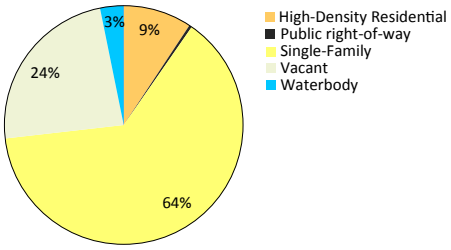
Land Use Opportunities and Constraints

- Area is entirely within the UGAR; limited existing development potential under County zoning (limiting future development is consistent with watershed management recommendation)
- Large forested depressional wetland complex in headwater landscape setting provides multiple important functions which should be a priority for protection

Preliminary Management Priorities and Objectives

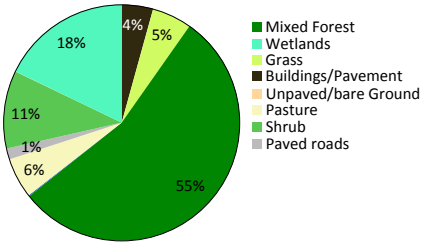
- Limit future development throughout the subbasin by removing from the UGAR or putting wetland areas (with substantial buffers) in conservation easement
- Maintain forested habitat corridors to the east, including downstream flow pathways from wetland complex to Cherry Creek Tributary D streams

Existing Land Use

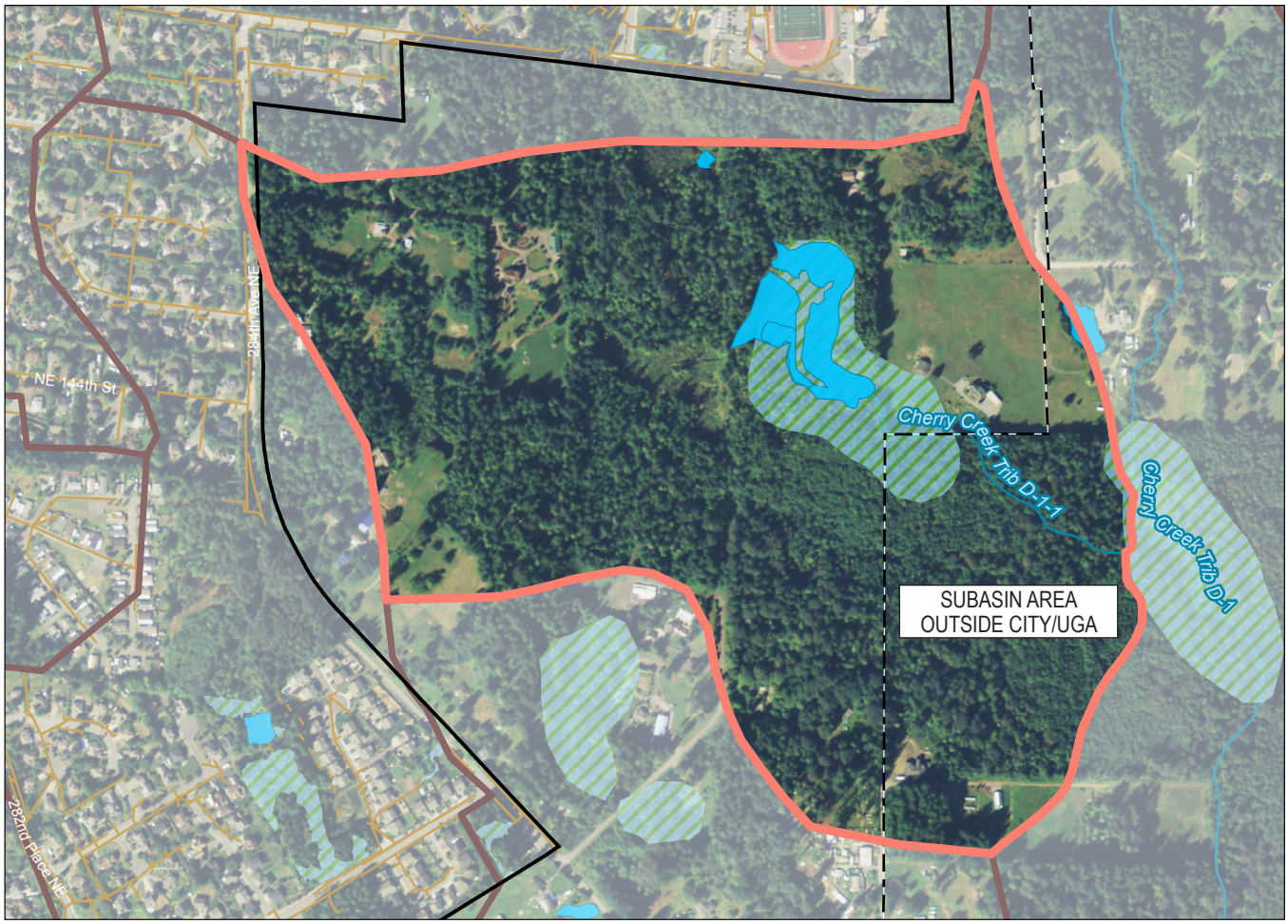


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



Subbasin Boundary | Wetlands | waterbody | Stream | Pipe Conveyance | City Limit | City UGA | PAU C6

4.3 Duvall Tributaries Basin

The Duvall Tributaries basin covers approximately 2,500 acres within the study area and discharges into the Snoqualmie River (see Chapter 2, Figure 2-3). The majority of the subbasins are developed, and watershed processes are heavily degraded. Surface storage, groundwater and base flow, and water quality importance tend to be low to moderate. Fish and wildlife habitat is moderate to high, which is primarily due to salmonid use of tributaries that feed into the Snoqualmie River. Only PAU D3 (Coe Clemons / Thayer Floodplain) retains the majority of watershed processes because it is largely undeveloped. Table 4-2 identifies the PAU folio sheets associated with the subbasins in the Duvall Tributaries basin.

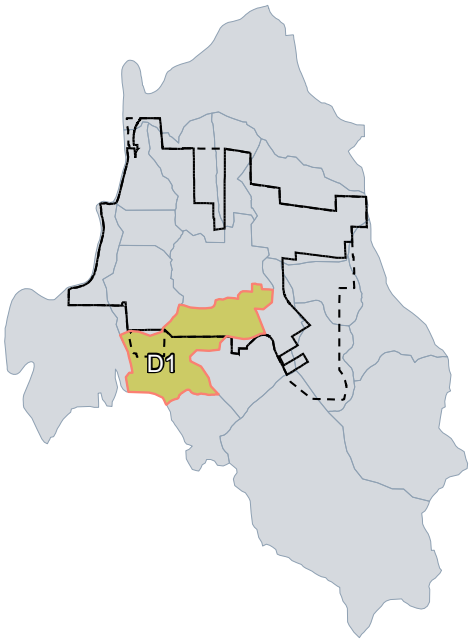
Table 4-2. PAU Folio Sheets in Duvall Tributaries Subbasins

PAU #	Subbasin Name
D1	Unnamed Southern Tributary - Lower
D2	Old-Town
D3	Coe Clemons/Thayer Floodplain
D4	Thayer
D5	Coe Clemons - Upper
D6	Coe Clemons - Lower
D7	Unnamed Southern Tributary - Upper

SUBBASIN:

Unnamed Southern Tributary - Lower (PAU D1)

BASIN: Southern Tributaries



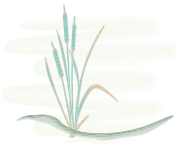
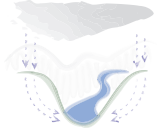
Management Recommendation: Group 2C Lowest Conservation

What Does this Management Recommendation Mean?

This subbasin is appropriate for more intense development; but as development occurs the resources and areas most important for watershed processes should be conserved.

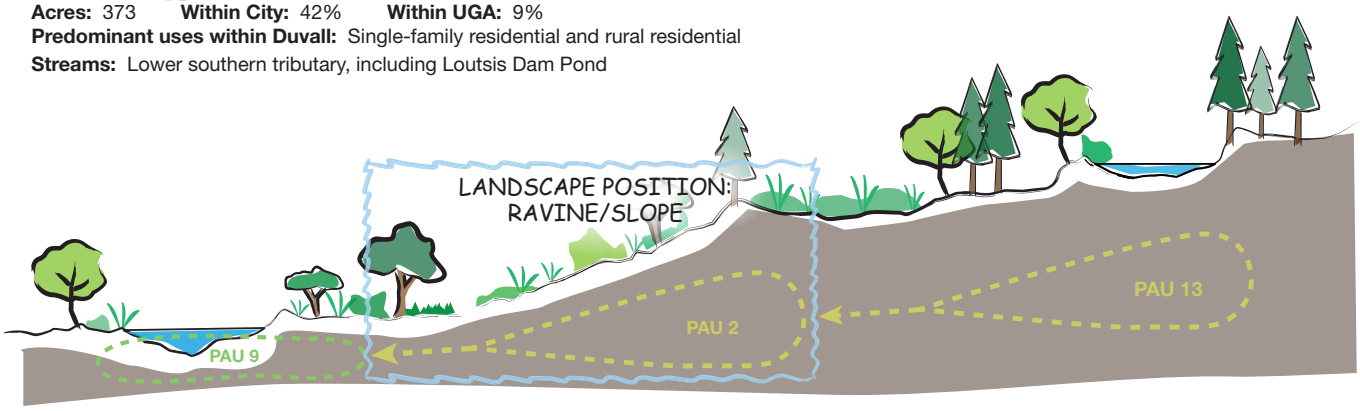
Why is this the Management Recommendation?

The subbasin scored relatively low for importance and high for degradation. New development, including in the South UGA and along the Big Rock Road corridor, could occur with less sever effects on processes compared to other subbasins, and may generate opportunities to improve important areas (wetlands and riparian corridors, Loutsis Dam pond). Analysis results are detailed below:

Surface Storage 	**Subbasin provides moderate levels of surface storage during storm events, reducing downstream erosion:** • 6% wetlands and other surface storage features (primarily Loutsis Dam pond) These processes remain largely intact, and should be protected	**Broad management priorities:** • Conserve / restore depressional wetlands / Loutsis Dam pond • Limit stormwater discharges to steep slope areas, especially adjacent to streams
Groundwater and Base Flow Maintenance 	**Subbasin is relatively low importance to groundwater and base flow maintenance processes:** • No mapped permeable soils • Few mapped slope wetlands; although these likely occur along riparian corridors Processes are minimally degraded due to low levels of existing development and wide, forested riparian corridor.	**Broad management priorities:** • Preserve forest cover • Preserve slope wetlands along stream corridors
Fish and Wildlife Habitat	**The subbasin is moderately important for fish and wildlife habitat:** • No documented salmonid presence; downstream presence mapped west of State Route 203 • Forested riparian and contiguous wetland areas, including surrounding Loutsis Dam pond, provide habitat for numerous bird, amphibian, and mammal species, as well as connections to subbasins to the east Northeastern portion of subbasin highly developed with single family residential. Rural development along Big Rock Road corridor has resulted in some forest loss.	**Broad management priorities:** • Provide adequate stream and wetland buffers • Maintain habitat corridors to the east
Water Quality	**This subbasin has low sediment export potentital:** • Sediment sources primarily channel erosion, due to soil erodibilty and channel bank conditions • Sediment sinks include Loutsis Dam Pond and other depressional wetlands Low levels of existing development suggest most water quality processes intact. Higher impervious surface levels in contributing subbasins likely increased channel erosion.	**Broad management priorities:** • Require use of LID approaches for water quality and water flow • Maintain remaining wetlands

SUBBASIN STATS

Acres: 373 **Within City:** 42% **Within UGA:** 9%
Predominant uses within Duvall: Single-family residential and rural residential
Streams: Lower southern tributary, including Loutsis Dam Pond



SUBBASIN:

Unnamed Southern Tributary - Lower (PAU D1)

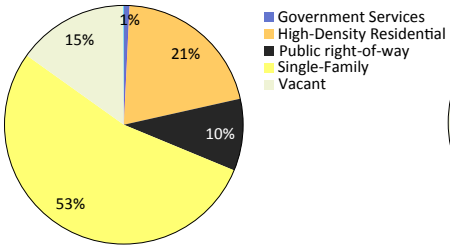
Land Use Opportunities and Constraints

- Loutsis Dam pond and riparian corridors, including ravine at lower end of subbasin, provide moderate ecological functions and should be protected
- Residential, commercial and industrial development along Big Rock Road corridor and South UGA upon annexation presents an opportunity for implementing stormwater BMPs
- Areas outside of city and UGA, to the south of Big Rock Road, may be appropriate for higher intensity development in the future

Preliminary Management Priorities and Objectives

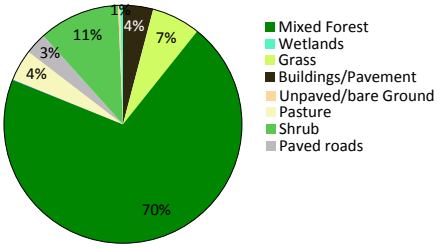
- Encourage higher density development along Main Street (western portion of subbasin, within City's UGA) and along Big Rock Road.
- While encouraging new higher density development, protect intact riparian forest along stream channels and surrounding Loutsis Dam pond
- Maintain slope wetlands adjacent to streams, and protect remaining depressional wetlands
- Require use of LID approaches for water quality and water flow as new development occurs

Existing Land Uses

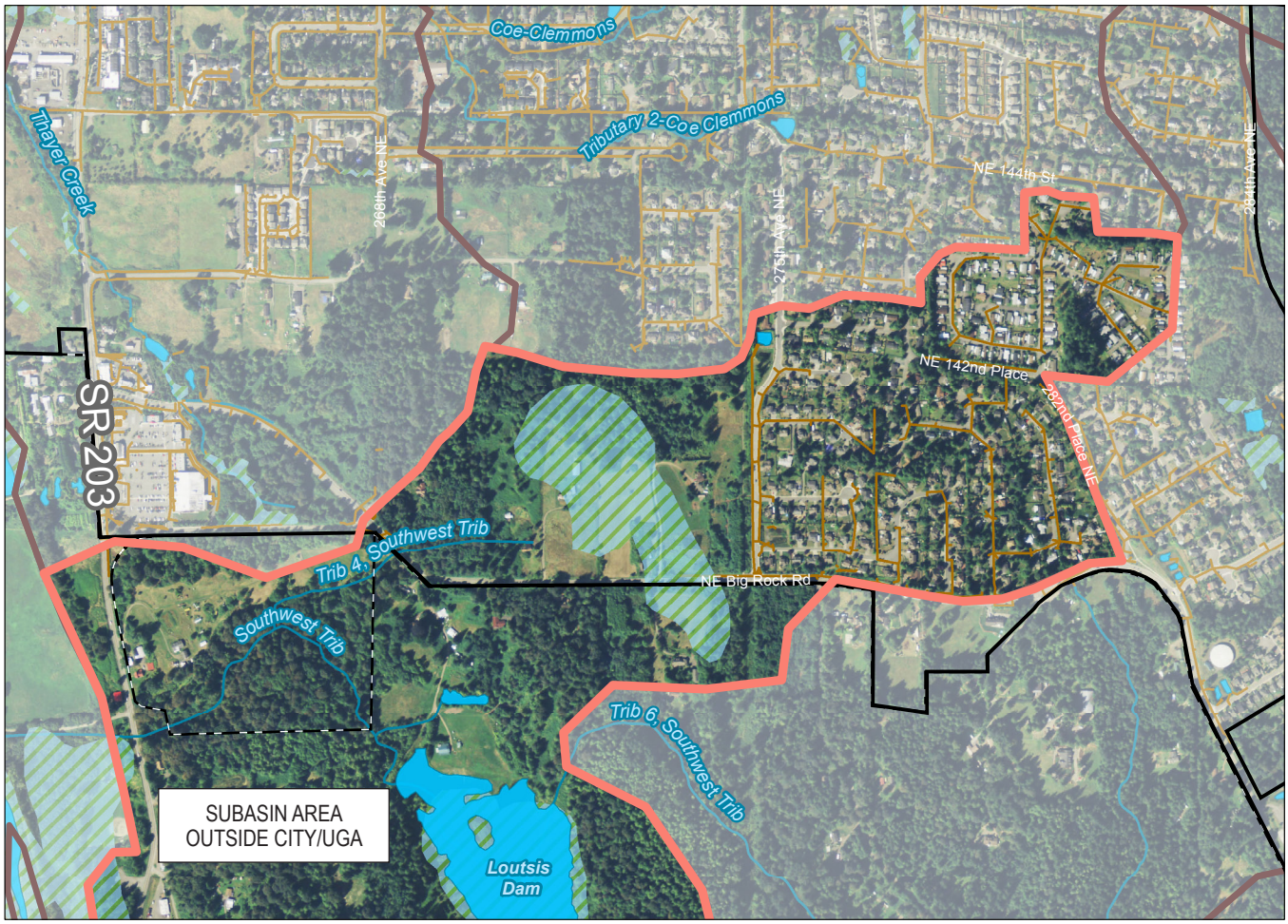


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.

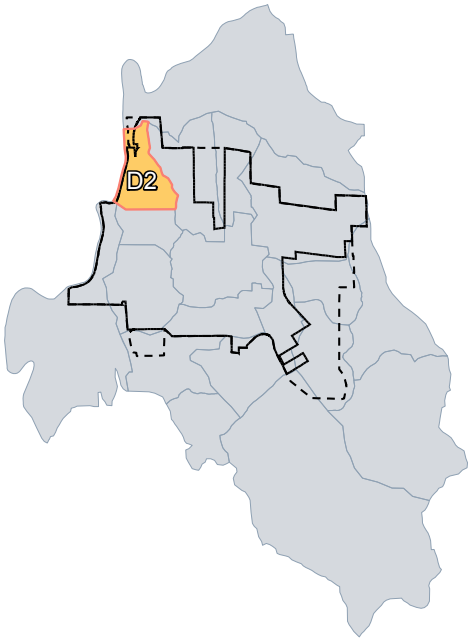


Subbasin Boundary | Wetlands | waterbody | Stream | Pipe Conveyance | City Limit | City UGA | PAU D1

SUBBASIN:

Old -Town (PAU D2)

BASIN: Duvall Tributaries – Direct to Snoqualmie River



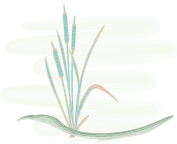
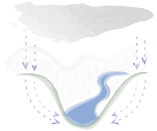
Management Recommendation: Group 3 Urban Development

What Does this Management Recommendation Mean?

This subbasin is an area of lowest importance to watershed processes and can be targeted for intense urban development.

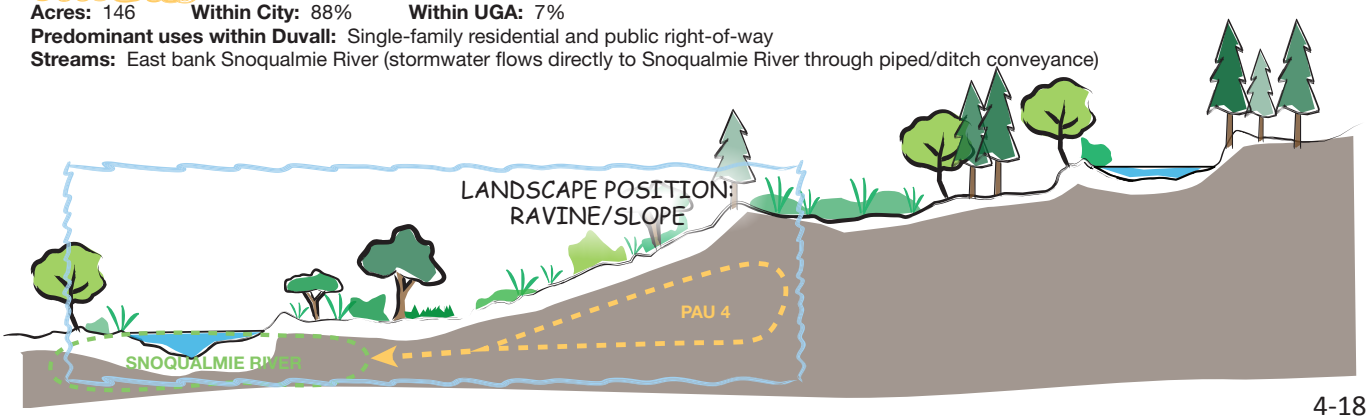
Why is this the Management Recommendation?

Compared to other areas of the city, this subbasin scored lowest for importance and highest for level of degradation (high impervious surface cover and altered conveyance of surface flows). As new development / redevelopment in the subbasin occurs, it should be paired with targeted restoration focused on improving Snoqualmie River conditions. Analysis results are detailed below:

Surface Storage 	**The subbasin has low importance for surface storage processes:** • Almost no wetlands or other surface storage features, outside of narrow Snoqualmie River floodplain at western edge • Previous development has resulted in piped / ditched conveyance directly to River Limited opportunity for storage enhancement due to slopes and existing development / infrastructure patterns.	**Broad management priorities:** • Limit new floodplain development • Reduce effective impervious surface • Eliminate flow control standard to encourage high density development (when consistent with DMC 19.06)
Groundwater and Base Flow Maintenance 	**Historicaly, subbasin features were moderately important for groundwater recharge and base flow maintenance processes; however these processes have been highly degraded:** • 14% permeable soils (supports recharge) • Very few wetlands Process degradation due to high impervious surface cover and altered flow pathways.	**Broad management priorities:** • Prohibit floodplain development • Increase infiltration by reducing effective impervious surface • Identify retrofit opportunities that provide infiltration
Fish and Wildlife Habitat	**The subbasin is moderately important for fish and wildlife habitat:** • Importance tied to anadromous fish presence within the Snoqualmie River, along western subbasin edge • Remaining subbasin highly impervious with no open channel or forest habitats Forest loss, development, and bank armoring within the Snoqualmie River riparian corridor have all contributed to degraded habitat quality.	**Broad management priorities:** • Prohibit further encroachment into Snoqualmie River riparian corridor • Restore riparian and river bank conditions • Identify retrofits to improve water quality functions
Water Quality	**The subbasin has moderate sediment export potential and direct discharge to Snoqualmie River indicates:** • Sediment sources primarily surface erosion due to soil erodibilty and subbasin slopes Impervious surface cover and stormwater conveyance (pipe and ditch) infrastructure has likely reduced export potential; however water quality issues related to runoff from developed areas has increased.	**Broad management priorities:** • Identify retrofit actions focused on water quality • Ensure adequate Temporary Erosion and Sediment Control (TESC) BMPs during clearing and grading activities

SUBBASIN STATS

Acres: 146 **Within City:** 88% **Within UGA:** 7%
Predominant uses within Duvall: Single-family residential and public right-of-way
Streams: East bank Snoqualmie River (stormwater flows directly to Snoqualmie River through piped/ditch conveyance)



SUBBASIN:

Old -Town (PAU D2)

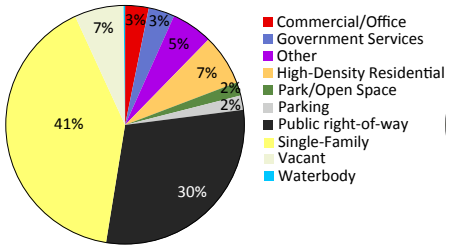
Land Use Opportunities and Constraints

- Opportunities for stormwater retrofits to improve water quality
- Riparian and bank conditions along the Snoqualmie River are degraded, with narrow corridor and invasive species within understory creating opportunity for restoration
- Is suitable fo additional residential density but redevelopment opportunity constrained by existing parcel and build-out pattern

Preliminary Management Priorities and Objectives

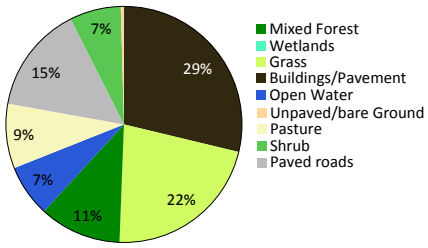
- Encourage high density development by eliminating flow control requirements (with enhanced water quality treatment) when consistent with DMC 19.06
- Reduce effective impervious surface by disconnecting non-pollution generating impervious areas (for example roofs, sidewalks)
- Prohibit further encroachment into Snoqualmie River riparian corridor / floodplain and restore habitat conditions
- Improve water quality functions throughout subbasin through redevelopment incentives and retrofit actions

Existing Land Uses

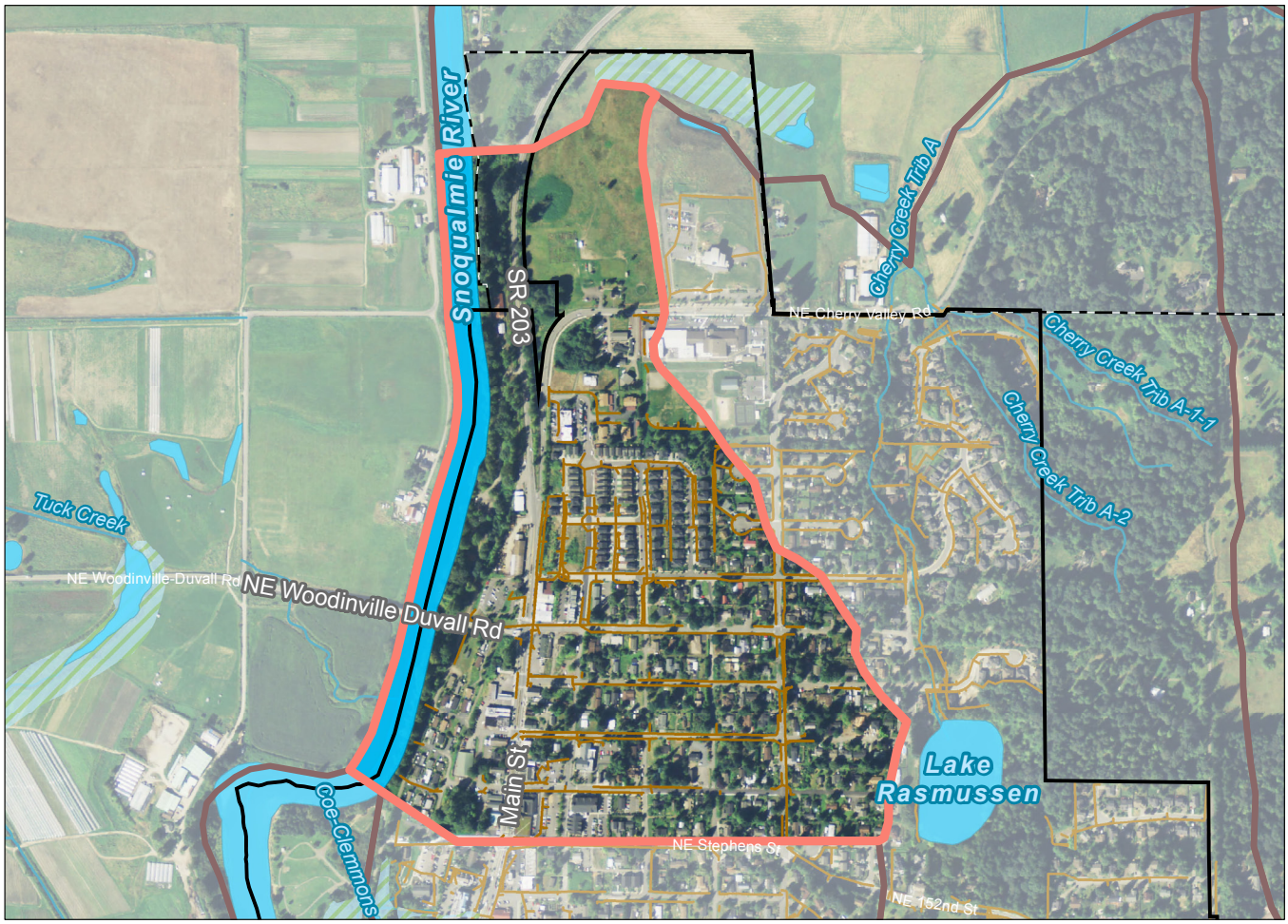


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.

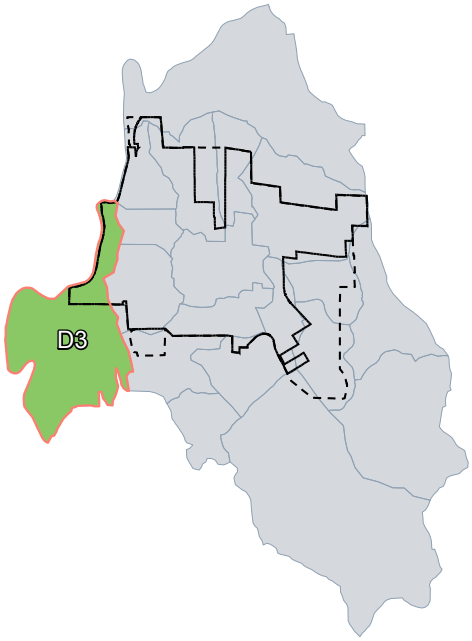


Subbasin Boundary | Wetlands | waterbody | Stream | Pipe Conveyance | City Limit | City UGA | PAU D2

SUBBASIN:

Coe Clemons/Thayer Floodplain (PAU D3)

BASIN: Duvall Tributaries - Coe-Clemons/Thayer Creeks



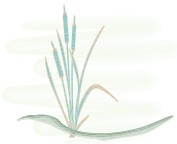
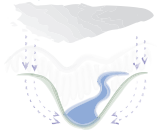
Management Recommendation: Group 1 Protect/Restore

What Does this Management Recommendation Mean?

This subbasin is highly important to multiple watershed processes and should be a high priority for protection and restoration.

Why is this the Management Recommendation?

The subbasin, which occurs within the Snoqualmie River floodplain, includes many features that support important water flow, water quality, and habitat processes. Degradation to these features is also relatively high, indicating that restoration should be prioritized. Analysis results are detailed below:

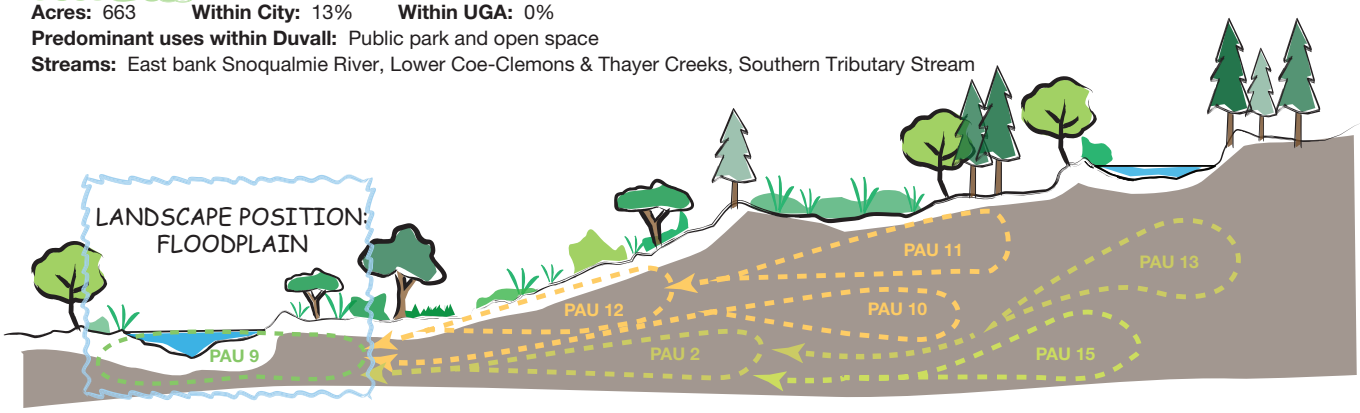
Surface Storage 	**Subbasin provides high levels of surface storage during floods, reducing hazards and providing refuge for salmon:** • 4% wetlands and other surface storage features • 100% floodplain (flooding from Snoqualmie River and tributaries) These processes are very degraded due to past agricultural uses (ongoing outside city limits) that resulted in stream and wetland loss. Conditions partially restored within the city limits.	**Broad management priorities:** • Wetland creation • Wetland restoration focused on increasing storage capacity • Improve stream sinuosity of tributaries
Groundwater and Base Flow Maintenance 	**Subbasin is important for maintaining agricultural and domestic water supplies as well as Snoqualmie River water temperature:** • 90% permeable soils within the floodplain (supports recharge) • Low levels of impervious surface Infiltration to groundwater largely intact due to low impervious surface cover. However, conversion of permeable/forested floodplain to park and agricultural uses has degraded processes.	**Broad management priorities:** • Increase forest cover • Limit new impervious surfaces
Fish and Wildlife Habitat	**The subbasin is highly important for fish and wildlife habitat.** • Extensive salmonid use within Snoqualmie River and tributary streams (coho, steelhead) • Large open space tract contiguous with surrounding pasture/riparian habitats Salmon habitat is impaired by stream channelization and crossings, and lack of riparian cover. Wildlife habitat is impaired by roadways, utility corridors, surrounding development, and habitat simplification.	**Broad management priorities:** • Improve tributary stream habitat/ connectivity • Increase Snoqualmie River riparian cover • Prohibit most new development • Increase forest cover throughout
Water Quality	**Floodplain and wetland landscape supports sediment deposition, water filtration, and shade processes:** • High wetland coverage / floodplain landscape • Permeable soils with low impervious surface cover Changes in land use have depleted forest and increased input of pollutants to subbasin, including metals (roadway runoff from upstream subbasins). Elevated water temperatures due to riparian forest loss and tributary impoundment.	**Broad management priorities:** • Increase forest cover • Manage stormwater from upstream subbasins • Limit new impervious surfaces

SUBBASIN STATS

Acres: 663 **Within City:** 13% **Within UGA:** 0%

Predominant uses within Duvall: Public park and open space

Streams: East bank Snoqualmie River, Lower Coe-Clemons & Thayer Creeks, Southern Tributary Stream



SUBBASIN:

Coe Clemons/Thayer Floodplain (PAU D3)

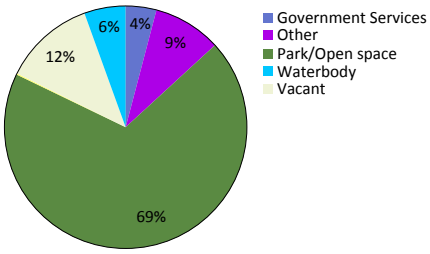
Land Use Opportunities and Constraints

- Restoration actions on ublicly owned park and open space lands could improve conditions throughout city-portion of subbasin
- Tributary streams are impaired by Snoqualmie Valley Trail, potentially contributing to increased water temperatures and degraded instrem habitat
- Limited area within City jurisdiction necessitates coordination with County to maximize protection and restoration opportunities

Preliminary Management Priorities and Objectives

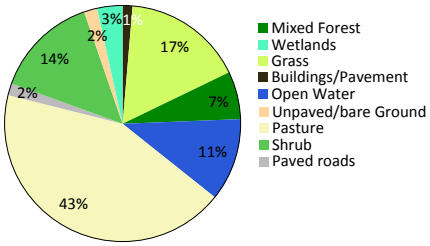
- Limit new impervious surfaces and increase forested cover in floodplain
- Protect existing wetlands and create or restore wetlands degraded by agricultural practices
- Prohibit new development and manage stormwater from upstream sources

Existing Land Uses

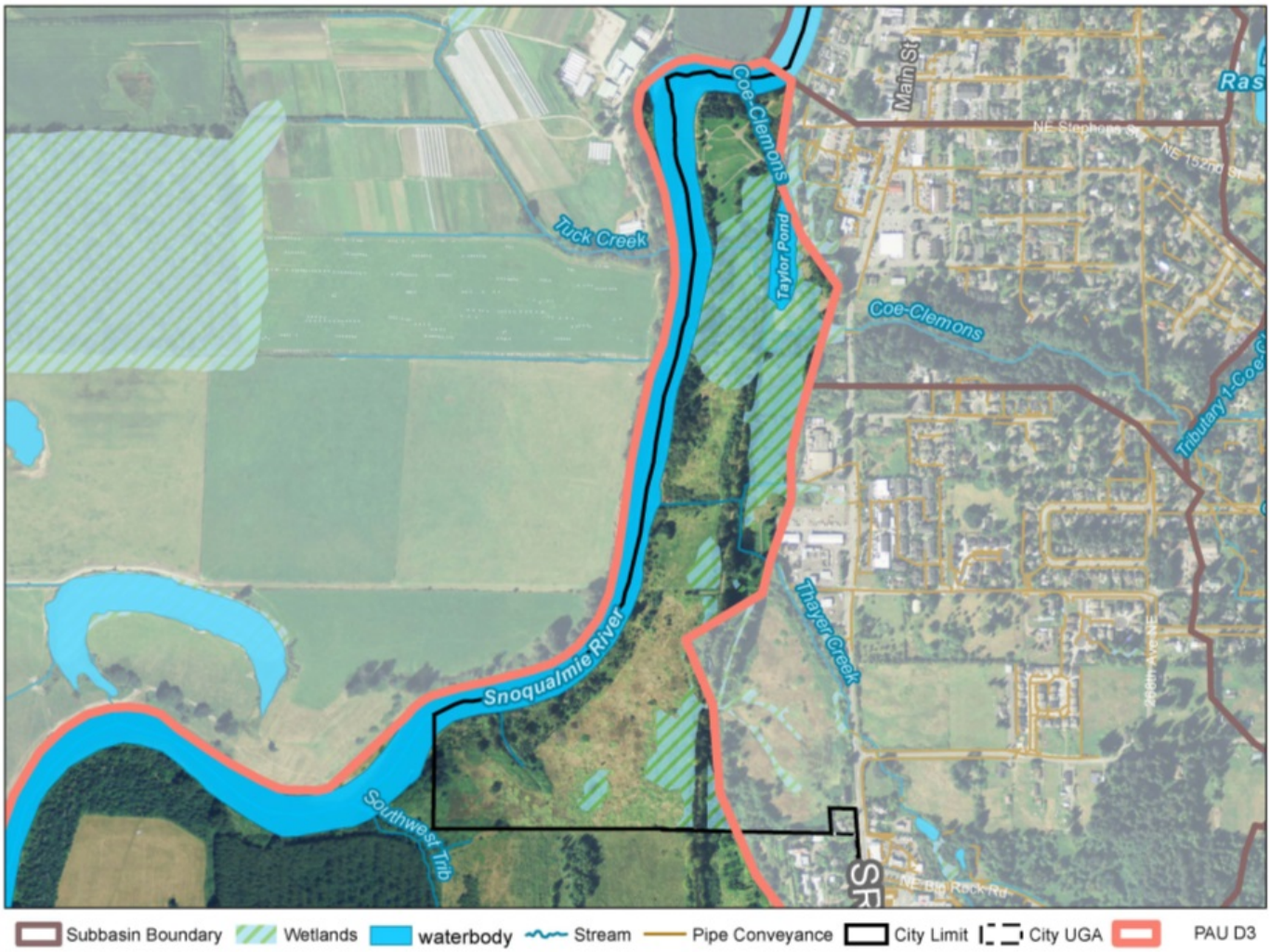


Depicts existing land uses for areas within the City. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



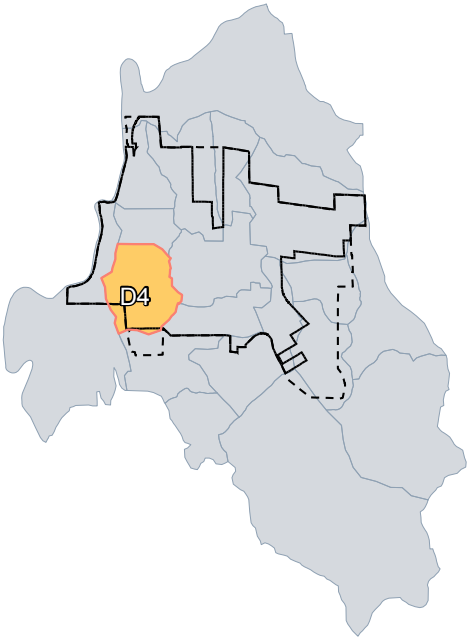
Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



SUBBASIN:

Thayer (PAU D4)

BASIN: Duvall Tributaries – Thayer Creek



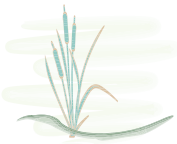
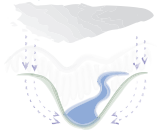
Management Recommendation: Group 3 Urban Development

What Does this Management Recommendation Mean?

This subbasin is an area of lowest importance to watershed processes and is suitable for more intense urban development.

Why is this the Management Recommendation?

Compared to other areas in the City, the subbasin scored amongst the lowest for importance and highest for level of degradation (high impervious surface cover and altered conveyance of surface flows). As new development / redevelopment in the subbasin occurs it should be paired with restoration along the Thayer Creek corridor. Analysis results are detailed below:

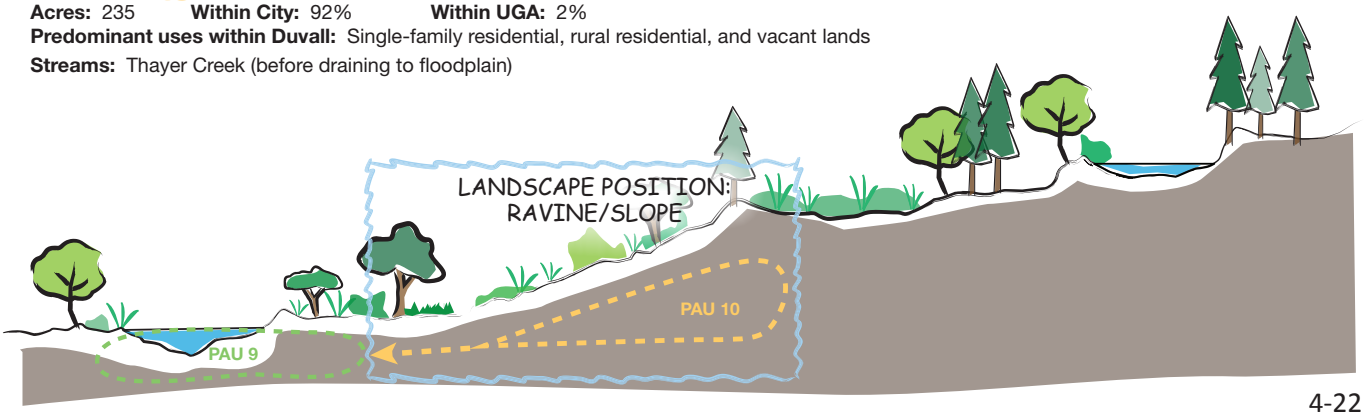
Surface Storage 	**The subbasin is of low importance for surface storage processes:** • Only 2% wetlands / other surface storage features • Previous development has resulted in piped / ditched conveyance directly to Snoqualmie River floodplain Limited opportunity for enhancing storage due to steep slopes and existing development / infrastructure patterns.	**Broad management priorities:** • Reduce effective impervious surface • Eliminate flow control standard (when consistent with Duvall Municipal Code 19.06) to encourage high density development
Groundwater and Base Flow Maintenance 	**Subbasin has relatively low importance to groundwater and base flow maintenance processes:** • 4% permeable soils (supports recharge) • Slope wetlands along Big Rock Road corridor Process degradation due to high impervious surface cover and altered flow pathways.	**Broad management priorities:** • Increase infiltration by reducing effective impervious surface (where feasible) • Preserve slope wetlands along stream corridors
Fish and Wildlife Habitat	**The subbasin is moderately important for fish and wildlife habitat:** • Documented coho presence in lower Thayer Creek, extending above Main Street and Big Rock Road (although culverts at these roads are partial fish passage barriers) Salmon habitat impaired by riparian encroachment from surrounding development and stream crossings. Low amounts of remaining forest canopy across subbasin.	**Broad management priorities:** • Improve Thayer Creek channel and riparian conditions • Remove fish passage barriers
Water Quality	**The subbasin has moderate sediment export potential and discharge to lower Thayer Creek / Snoqualmie floodplain:** • Sediment sources associated with surface and channel erosion, including soil erodibilty and subbasin / channel slopes Stormwater runoff directed to Thayer Creek affects channel erosion and water quality. Urban runoff is likely polluted with metals and other contaminants.	**Broad management priorities:** • Identify and implement retrofit actions focused on water quality • Control sediment sources

SUBBASIN STATS

Acres: 235 **Within City:** 92% **Within UGA:** 2%

Predominant uses within Duvall: Single-family residential, rural residential, and vacant lands

Streams: Thayer Creek (before draining to floodplain)



SUBBASIN:

Thayer (PAU D4)

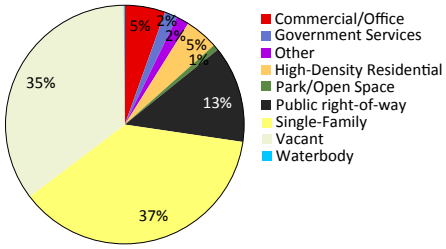
Land Use Opportunities and Constraints

- Opportunities for stormwater LID strategies focused on water quality (primarily for new development)
- Fish passage barriers at Main Street and Big Rock Road limit aquatic habitat; opportunity for culvert replacement and channel / riparian enhancement
- Encourage additional density in area with relatively low ecological functions (significant opportunity along 143rd Street corridor)

Preliminary Management Priorities and Objectives

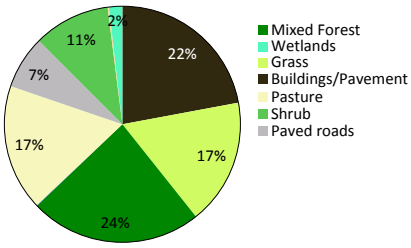
- Encourage high density development by eliminating flow control requirements (with enhanced water quality treatment) when consistent with DMC 19.06
- Reduce effective impervious surface by disconnecting non-pollution generating impervious areas (for example roofs, sidewalks)
- Restore Thayer Creek channel and riparian conditions downstream of Big Rock Road

Existing Land Uses

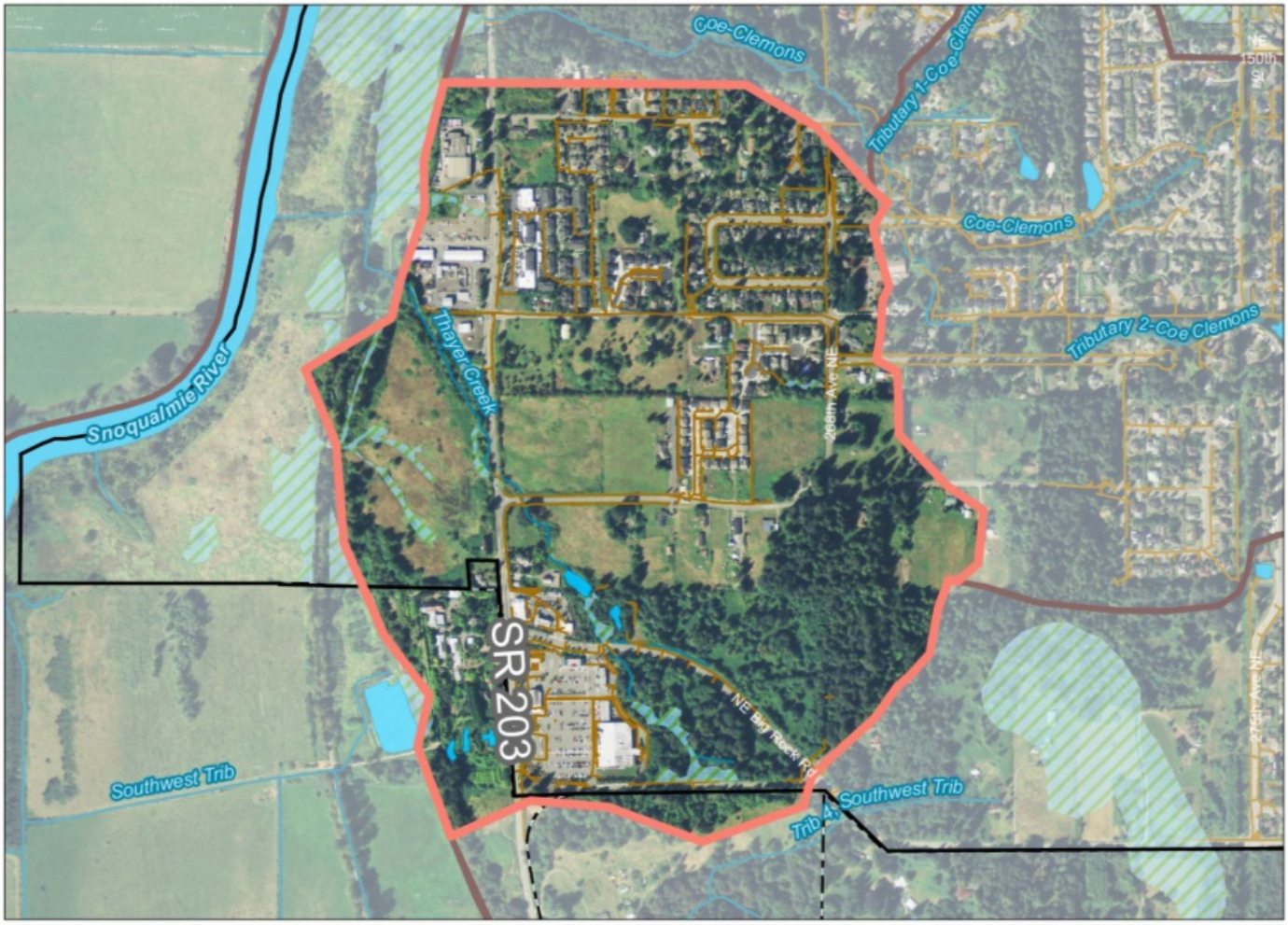


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



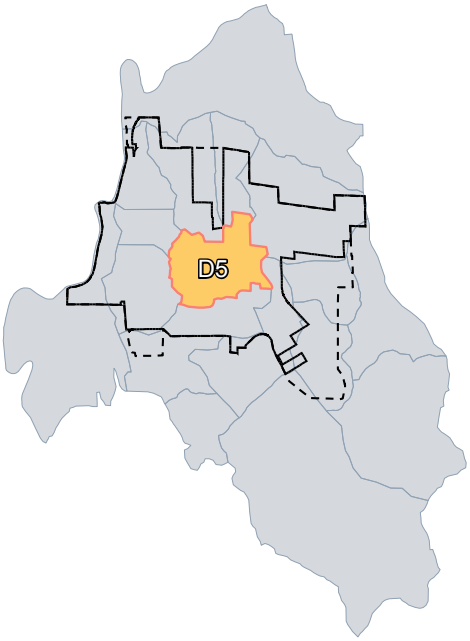
Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



SUBBASIN:

Coe-Clemons - Upper (PAU D5)

BASIN: Duvall Tributaries – Coe Clemons Creek



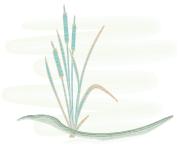
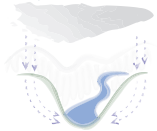
Management Recommendation: Group 3 Urban Development

What Does this Management Recommendation Mean?

This subbasin is an area of lowest importance to watershed processes and is suitable for more intense urban development.

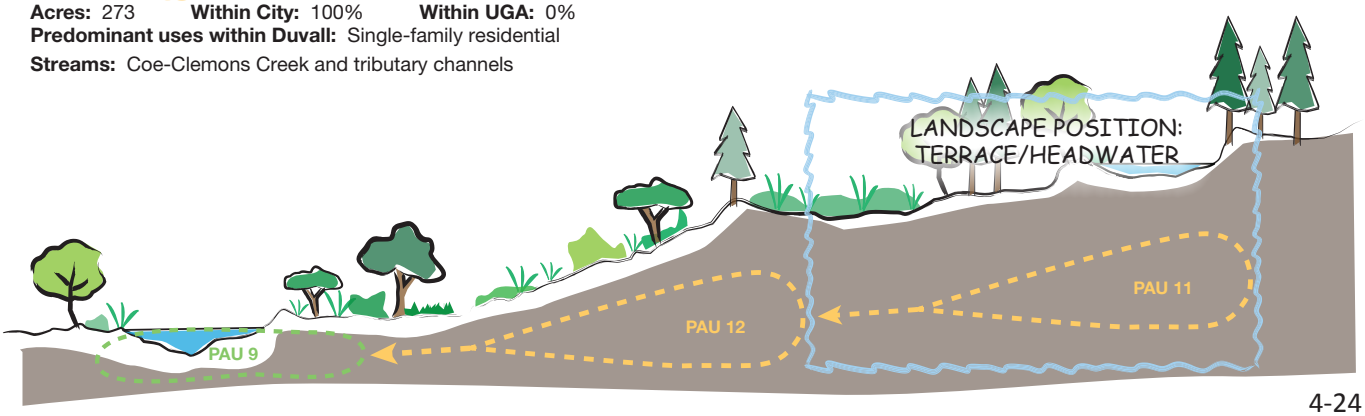
Why is this the Management Recommendation?

Compared to other areas in the city, this subbasin scored lowest for importance and highest for level of degradation (high impervious surface cover, wetland loss and altered conveyance of surface flows). As new development / redevelopment in the subbasin occurs it should be paired with targeted protection/restoration focused on remaining wetlands, stream and habitat corridors and improving surface storage. Analysis results are detailed below:

Surface Storage 	**This subbasin is moderately important for surface storage processes and is highly degraded:** • Only 1% wetlands / other surface storage features • Previous development has resulted in piped / ditched conveyance with inadequate flow control Significant opportunity for storage process enhancement through retrofits and other actions.	**Broad management priorities:** • Maintain remaining wetlands • Reduce effective impervious surface • Identify and implement stormwater retrofits that provide addition detention
Groundwater and Base Flow Maintenance 	**Subbasin was historically moderately important for groundwater recharge; however this process has been highly degraded:** • Many slope wetland areas along tributary channels Degradation of processes due to high impervious surface cover and altered flow pathways. Base flow maintenance processes are of lower importance.	**Broad management priorities:** • Increase infiltration by reducing effective impervious surface • Identify retrofit opportunities that provide infiltration (where feasible)
Fish and Wildlife Habitat	**The subbasin is moderately important for fish and wildlife habitat:** • No documented anadromous fish presence; Reaches at the edge of the subbasin have moderate potential for Coho and Steelhead • Coe-Clemons Creek riparian corridor interrupted by multiple road crossings • Wetland habitat loss from past development Wildlife habitat impaired by riparian encroachment and stream crossings (partial barriers downstream).	**Broad management priorities:** • Focus on water flow and water quality functions to improve downstream habitat conditions • Maintain and enhance remaining moderate value habitat
Water Quality	**The subbasin has low sediment export potential; and potential contributions to lower Coe-Clemons Creek (with known erosion issues):** • Sediment sources associated with channel erosion, including soil erodibilty and channel bank conditions Degradation related to impervious runoff has likely increased channel erosion and peak flows. Additionally, urban runoff is likely polluted with metals and other pollutants.	**Broad management priorities:** • Identify and implement stormwater retrofit actions for water quality and surface storage • Maintain remaining wetlands (sediment sinks)

SUBBASIN STATS

Acres: 273 **Within City:** 100% **Within UGA:** 0%
Predominant uses within Duvall: Single-family residential
Streams: Coe-Clemons Creek and tributary channels



SUBBASIN:

Coe-Clemons - Upper (PAU D5)

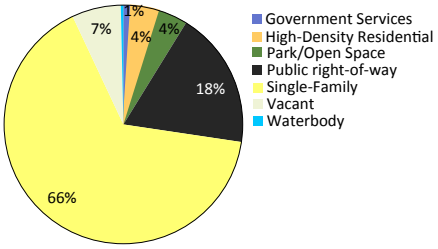
Land Use Opportunities and Constraints

- Opportunities for stormwater retrofit to improve water quality and water flow to downstream resources (lower Coe-Clemons and Snoqualmie River flood plain)
- Maintaining and restoring habitat corridors along upper Coe-Clemons tributary channels
- Encouraging additional density as new development and redevelopment occurs; redevelopment opportunity constrained by existing parcel and build-out pattern

Preliminary Management Priorities and Objectives

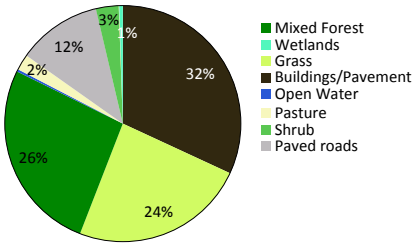
- Increase infiltration by reducing effective impervious surface (disconnect non-pollution generating impervious areas)
- Maintain and restore remaining wetlands (especially depressional wetlands, which serve as sediment sinks) and Coe-Clemons tributary corridors
- Identify and implement stormwater retrofit actions for both water quality and surface storage; monitor retrofit results by assessing downstream conditions.

Existing Land Uses

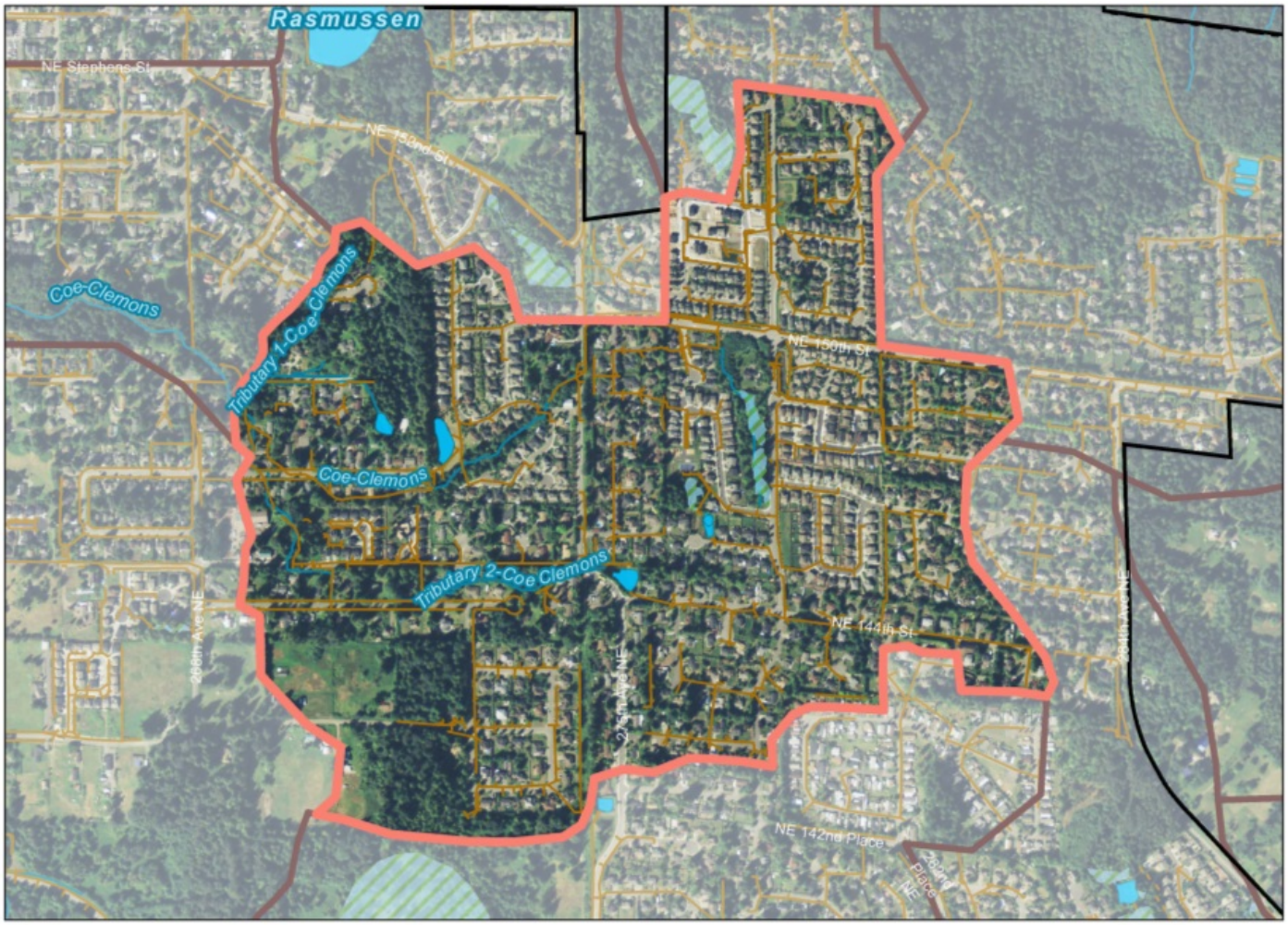


Depicts existing land uses for areas within the City. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



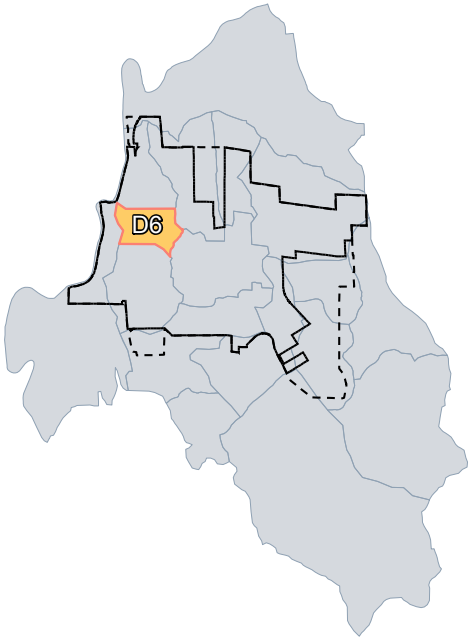
Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



SUBBASIN:

Coe-Clemons - Lower (PAU D6)

BASIN: Duvall Tributaries – Coe Clemons Creek



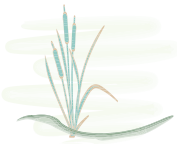
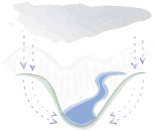
Management Recommendation: Group 3 Urban Development

What Does this Management Recommendation Mean?

This subbasin is an area of lowest importance to watershed processes and is suitable for more intense urban development.

Why is this the Management Recommendation?

Compared to other areas in the city, this subbasin scored lowest for importance and highest for level of degradation (high impervious surface cover and altered conveyance of surface flows). As new development / redevelopment in the subbasin occurs it should be paired with targeted restoration focused on improving lower Coe-Clemons riparian corridor conditions. Analysis results are detailed below:

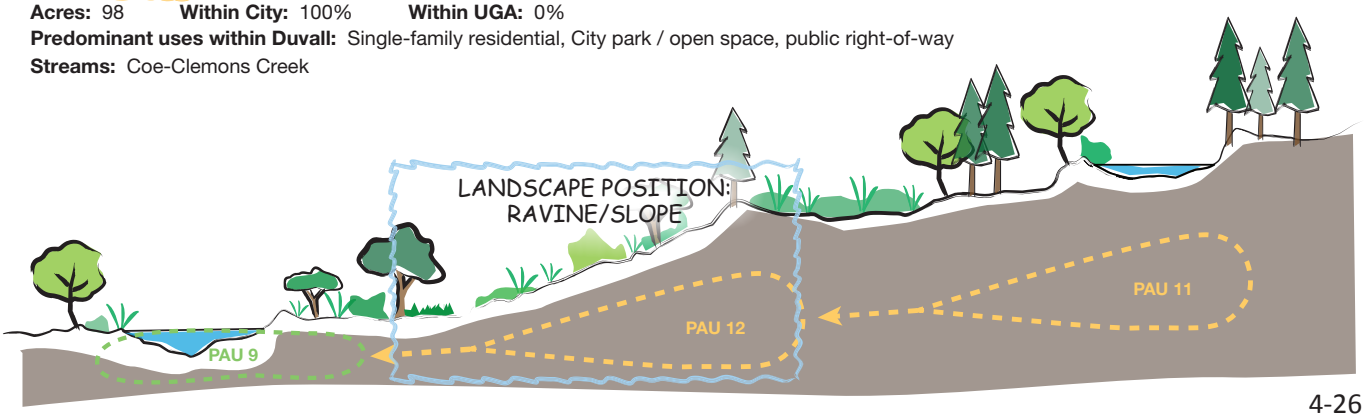
Surface Storage 	**The subbasin is of low importance for surface storage processes:** • Only 2% wetlands / other surface storage features • Previous development has resulted in piped / ditched conveyance directly to Snoqualmie River floodplain Limited opportunity for storage enhancement due to slopes and existing development / infrastructure patterns.	**Broad management priorities:** • Reduce effective impervious surface • Implement upstream flow control retrofits • Eliminate flow control standard (when consistent with Duvall Municipal Code 19.06) to encourage high density development
Groundwater and Base Flow Maintenance 	**Subbasin was historically moderately important for groundwater recharge; however, this process has been highly degraded:** • 8% permeable soils (supports recharge) • Slope wetlands along Coe-Clemons Creek ravine Degradation of processes due to high impervious surface cover and altered flow pathways. Base flow maintenance processes are of lower importance.	**Broad management priorities:** • Increase infiltration by reducing effective impervious surface • Identify retrofit opportunities that provide infiltration (where feasible)
Fish and Wildlife Habitat	**The subbasin is moderately to high important for fish and wildlife habitat:** • Documented coho presence in Coe-Clemons Creek, extending just above Main Street; Reaches have potential for Coho and Steelhead extending to top of subbasin • Intact forested areas around Coe-Clemons Creek (Taylor Park) Salmon habitat impaired by riparian encroachment and stream crossings (partial barriers downstream). Roadway interruption (Main Street) between subbasin and floodplain habitats to the west.	**Broad management priorities:** • Improve Coe-Clemons Creek channel and riparian conditions • Conserve riparian area and associated wetlands
Water Quality	**The subbasin has moderate sediment export potential and discharge to lower Coe-Clemons Creek (with known erosion issues):** • Sediment sources associated with surface and channel erosion, including soil erodibilty and subbasin / channel slopes Impervious surface cover and stormwater conveyance infrastructure directly to Snoqualmie floodplain has likely reduced export potential. Runoff from upstream areas (PAU 11) has increased channel erosion. Additionally, urban runoff is likely polluted with metals.	**Broad management priorities:** • Identify and implement retrofit actions focused on water quality (within subbasin and upstream areas) • Control sediment sources (including within PAU 11)

SUBBASIN STATS

Acres: 98 **Within City:** 100% **Within UGA:** 0%

Predominant uses within Duvall: Single-family residential, City park / open space, public right-of-way

Streams: Coe-Clemons Creek



SUBBASIN:

Coe-Clemons - Lower (PAU D6)

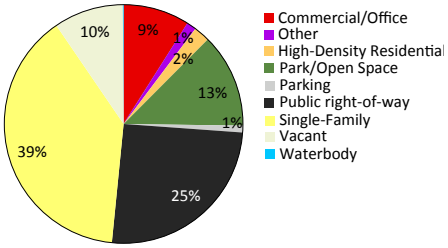
Land Use Opportunities and Constraints

- Opportunities for stormwater retrofit to improve water quality
- Coe-Clemons Creek riparian corridor protected within Taylor Park; opportunity for riparian and stream bank restoration
- Encouraging additional density as new development and redevelopment occurs; redevelopment opportunity constrained by existing parcel and build-out pattern

Preliminary Management Priorities and Objectives

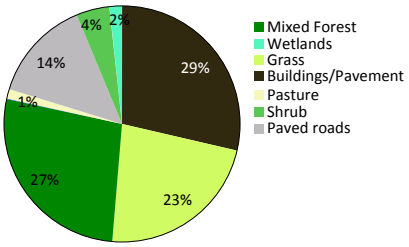
- Encourage high density development in all areas except the Coe-Clemons Creek corridor by eliminating flow control requirements (with enhanced water quality treatment) when consistent with DMC 19.06
- Reduce effective impervious surface by disconnecting non-pollution generating impervious areas (for example roofs, sidewalks)
- Restore Coe-Clemons Creek channel and riparian conditions within Taylor Park

Existing Land Uses

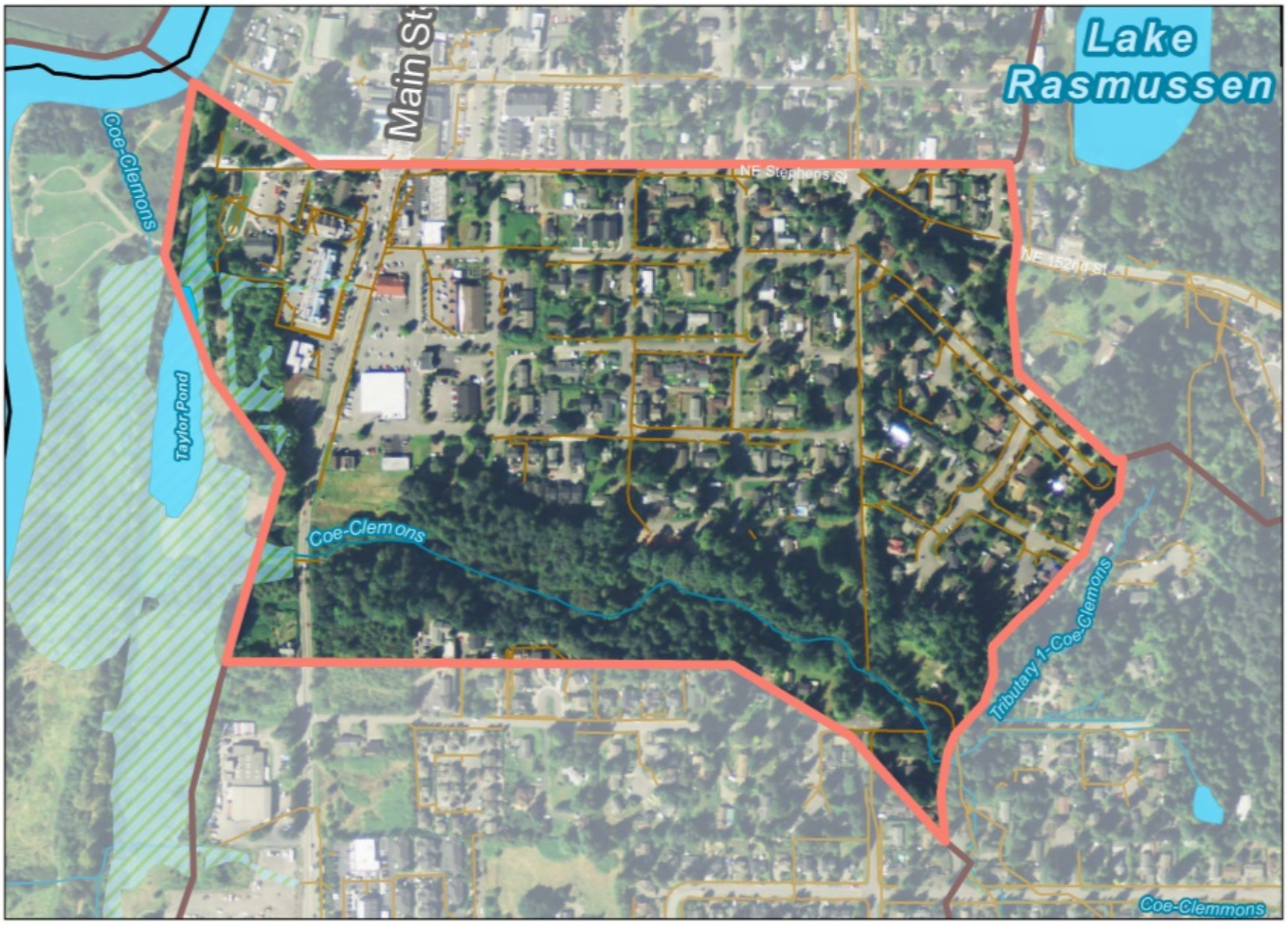


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Existing Land Cover



Depicts existing land cover for entire subbasin.

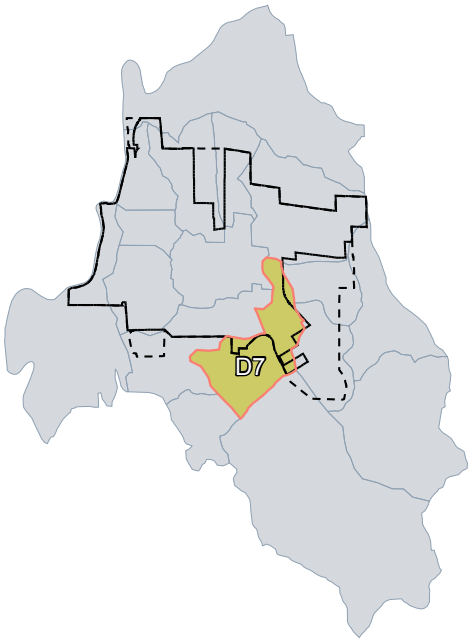


Subbasin Boundary | Wetlands | waterbody | Stream | Pipe Conveyance | City Limit | City UGA | PAU D6

SUBBASIN:

Unnamed Southern Tributary - Upper (PAU D7)

BASIN: Southern Tributaries



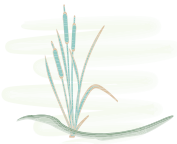
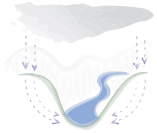
Management Recommendation: Group 2C Lowest Conservation

What Does this Management Recommendation Mean?

This subbasin is appropriate for more intense development; but as development occurs the resources and areas most important for watershed processes should be conserved.

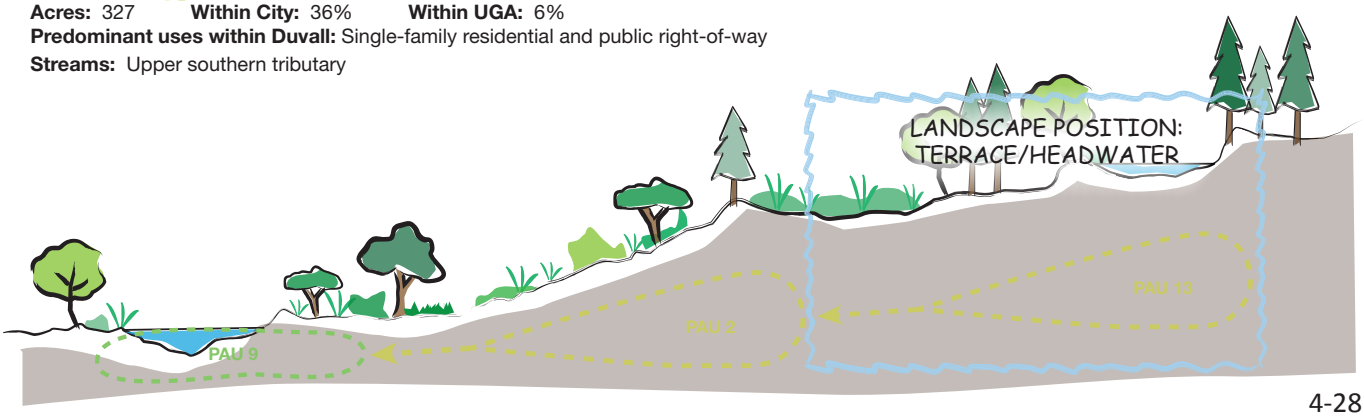
Why is this the Management Recommendation?

The subbasin scored relatively low for importance and high for degradation. New development could likely occur with less effect on processes compared to other basins, although development opportunity appears to primarily occur within rural areas south of the city. Analysis results are detailed below:

Surface Storage 	**Subbasin is of low importance for surface storage processes:** • Only 1% wetlands / other surface storage features • Previous development in NE portion (within city limits) has reduced storage Surface storage that is provided is minimally degraded, especially in areas outside of city limits.	**Broad management priorities:** • Conserve depressional wetlands • Encourage or require LID approaches for new development • Limit stormwater discharges to steep slope areas, especially adjacent to streams
Groundwater and Base Flow Maintenance 	**Subbasin has relatively low importance to groundwater and base flow maintenance processes:** • No mapped permeable soils • Few mapped slope wetlands; although these likely occur along riparian corridors Processes are minimally degraded due to low levels of existing development and wide, forested riparian corridors.	**Broad management priorities:** • Preserve forest cover • Preserve slope wetlands along stream corridors
Fish and Wildlife Habitat	**The subbasin is moderately important for fish and wildlife habitat:** • No documented anadromous fish presence; nearest downstream presence is within Snoqualmie River floodplain • Forested riparian corridor provides habitat for numerous bird, amphibian, and mammal species, as well as connections to subbasins to the east (PAUs 12 and 16), south and west Rural development has resulted in some forest loss, primarily along Big Rock Road corridor.	**Broad management priorities:** • Provide adequate stream buffers • Maintain riparian and upland habitat corridors to surrounding subbasins
Water Quality	**The subbasin has low sediment export potential; contributions to downstream channel (within ravine before crossing Snoqualmie floodplain):** • Sediment sources associated with soil erodibilty and subbasin slopes • Sediment sinks include depressional wetlands Degradation related to impervious surface runoff has likely increased channel erosion and peak flows in downstream areas. Additionally, urban runoff is likely polluted with metals and other pollutants.	**Broad management priorities:** • Identify and implement retrofit actions • Require use of LID approaches for water quality and water flow • Maintain remaining wetlands

SUBBASIN STATS

Acres: 327 **Within City:** 36% **Within UGA:** 6%
Predominant uses within Duvall: Single-family residential and public right-of-way
Streams: Upper southern tributary



SUBBASIN:

Unnamed Southern Tributary - Upper (PAU D7)

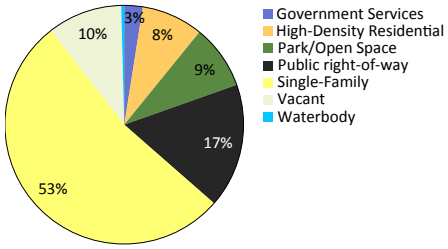
Land Use Opportunities and Constraints

- Opportunities for stormwater LID strategies focused on water flow and water quality (both as retrofit actions and for new development)
- Intact forested riparian corridors provide linkages in all directions, including to Upper Weiss Creek (PAU 17)
- Areas outside of city and UGA, to the south of Big Rock Road, may also be appropriate for higher intensity development in the future

Preliminary Management Priorities and Objectives

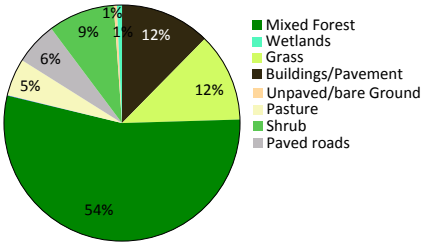
- Encourage higher density development in areas along Big Rock Road, including areas within City Limits to the south of the roadway; explore opportunities to focus additional higher density development in subbasin areas currently outside of the City and UGA
- While encouraging new higher density development, protect slope wetlands adjacent to streams, and maintain functions of remaining depressional wetlands
- Identify and implement stormwater retrofit actions to improve water flow and water quality to downstream resources
- Require use of LID approaches for water flow and water quality as new development occurs

Existing Land Use

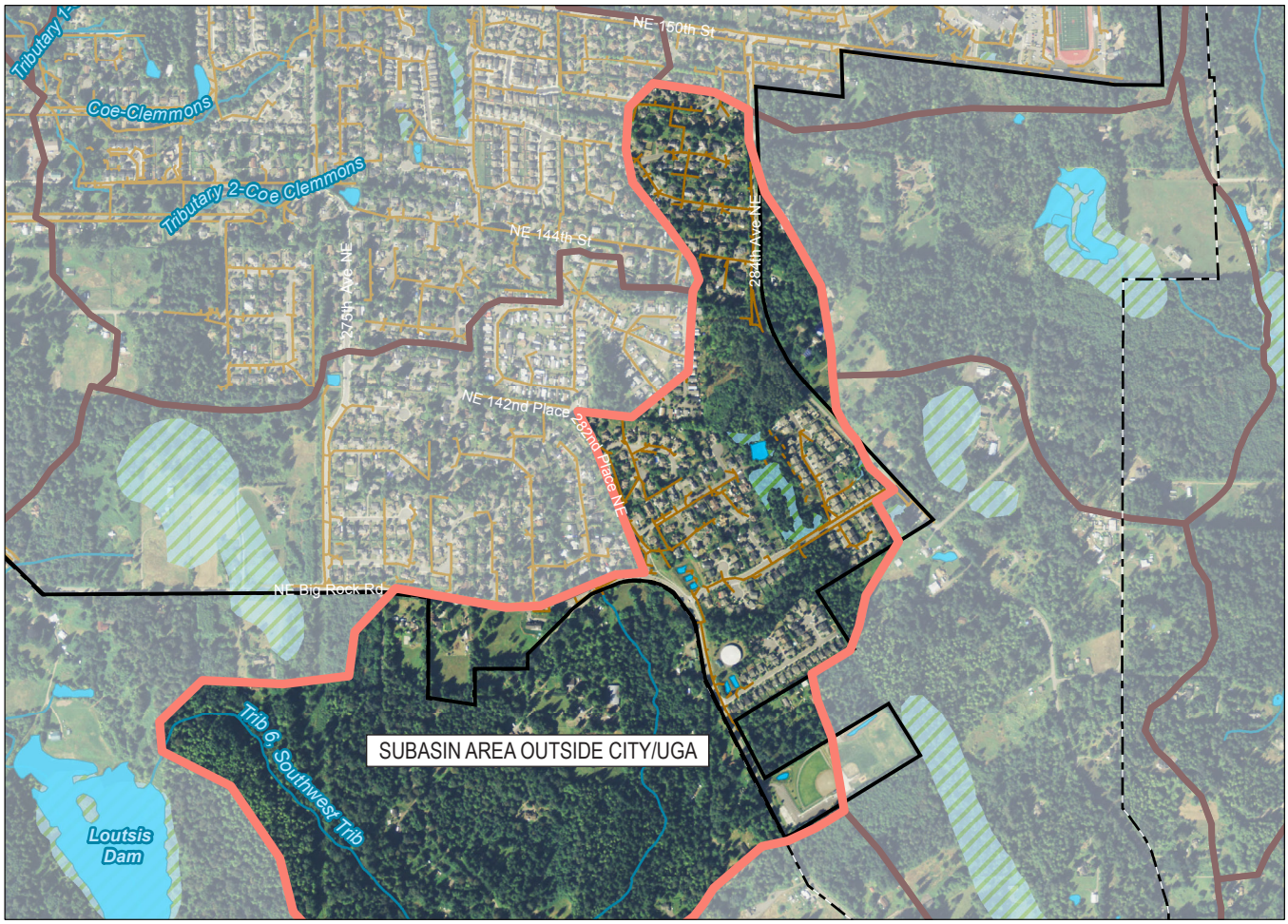


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



Subbasin Boundary | Wetlands | waterbody | Stream | Pipe Conveyance | City Limit | City UGA | PAU D7

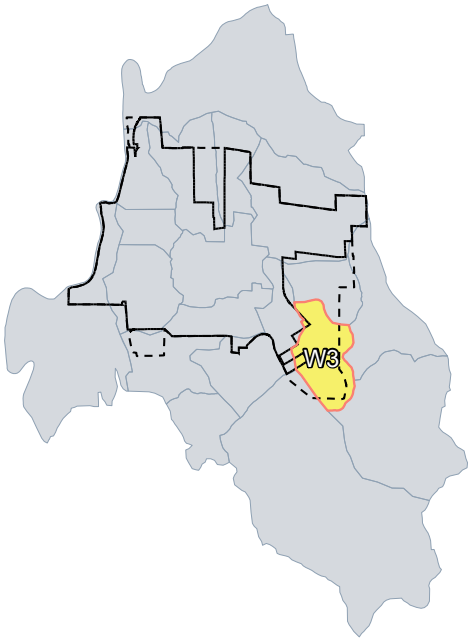
4.4 Weiss Creek Basin

Weiss Creek discharges into the Snoqualmie River upstream of the city (see Chapter 2, Figure 2-3). The majority of the basin has low to moderate development and watershed processes are moderately intact. Of the 2,169 acres in the study area, only Upper Weiss Creek (PAU W3) is within the city and urban growth area boundaries.

SUBBASIN:

Upper Weiss Creek (PAU W3)

BASIN: Southern Tributaries - Weiss Creek



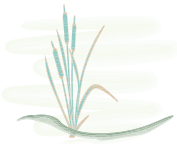
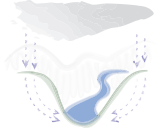
Management Recommendation: Group 2B Moderate Conservation

What Does this Management Recommendation Mean?

While this subbasin may be appropriate for some additional development, care should be taken to protect areas important for remaining watershed processes, especially delivery, discharge and habitat processes.

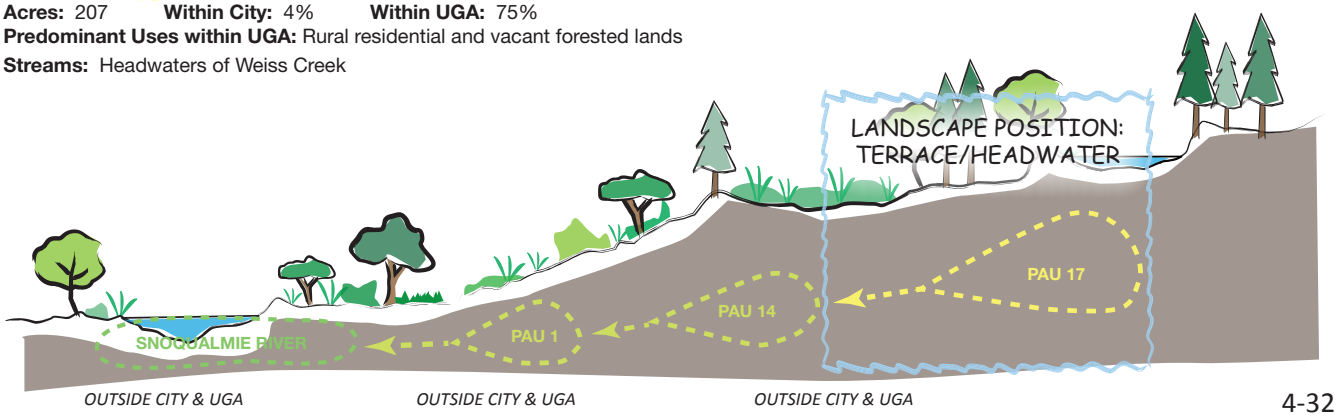
Why is this the Management Recommendation?

The subbasin scored low to moderate for importance and moderate for degradation. Some important areas for maintaining watershed processes remain intact, including extensive forested areas that include several large depressional wetlands. These areas should be conserved; however, overall results suggest there are other areas that may be appropriate for additional development. Analysis results are detailed below:

Surface Storage 	**Subbasin features provide moderate levels of surface storage within a headwater landscape position:** • 13% wetlands and other surface storage features • Large forested depressional wetland complex within UGAR, to the NE of Big Rock Ball Fields Park Storage processes are generally intact because there is little existing development.	**Broad management priorities:** • Protect depressional wetlands • Maintain downstream flow pathways
Groundwater and Base Flow Maintenance 	**Subbasin is moderately important for base flow maintenance processes; however less important for recharge:** • No areas of mapped permeable soils • Large headwater wetlands for Weiss Creek These processes have been minimally degraded, as there are generally low levels of existing development. Low impervious surface cover and high forest cover (especially within wetlands) support processes.	**Broad management priorities:** • Limit future development • Protect depressional wetlands • Maintain downstream flow pathways
Fish and Wildlife Habitat	**The subbasin is of moderately important for fish and wildlife habitat:** • No documented anadromous fish presence; although there is extensive downstream presence of coho within Weiss Creek (PAUs 14 and 1) • Forested wetland areas provide significant habitat for numerous bird, amphibian, and mammal species • Forested connection to larger undeveloped tracts to the north (PAU 16), west (PAU 13), south and east Rural development has resulted in some forest loss, primarily along Big Rock Road corridor.	**Broad management priorities:** • Limit future development to areas along Big Rock Road and Batten Road • Protect large forested wetland complex • Maintain habitat corridors
Water Quality	**The headwater landscape of the subbasin supports sediment deposition and water filtration processes:** • Extensive areas of depressional wetlands suggest that the overall subbasin is a sediment and phosphorus sink • Wetlands provide water quality filtration before discharging to Weiss Creek Water quality processes are relatively intact due to limited development throughout subbasin, especially areas surrounding the large forested wetland complex.	**Broad management priorities:** • Limit future development, and require use of LID approaches for water flow and water quality wherever development occurs • Protect forested wetland complex

SUBBASIN STATS

Acres: 207 **Within City:** 4% **Within UGA:** 75%
Predominant Uses within UGA: Rural residential and vacant forested lands
Streams: Headwaters of Weiss Creek



SUBBASIN:

Upper Weiss Creek (PAU W3)

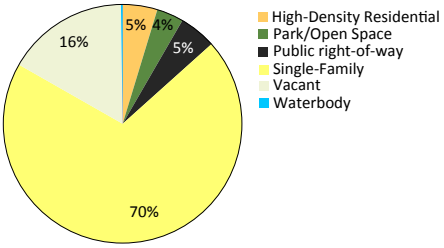
Land Use Opportunities and Constraints

- Contiguous wetlands and forested uplands extend throughout central portion of subbasin, and are located in headwater landscape position for Weiss Creek
- Subbasin is within existing UGAR; any future annexation would increase development pressure, especially along the Big Rock Road and Batten Road corridors

Preliminary Management Priorities and Objectives

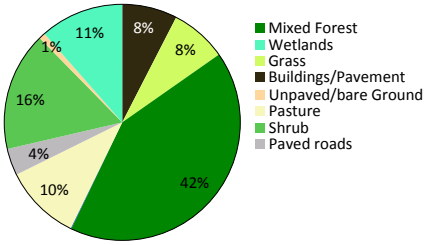
- Limit future development to areas along Big Rock Road and Batten Road, well away from forested depressional wetland complex
- Require use of LID approaches for water flow and water quality wherever development occurs.
- Maintain forested habitat corridors in all directions, including downstream flow pathways from wetland complex to Weiss Creek

Existing Land Use

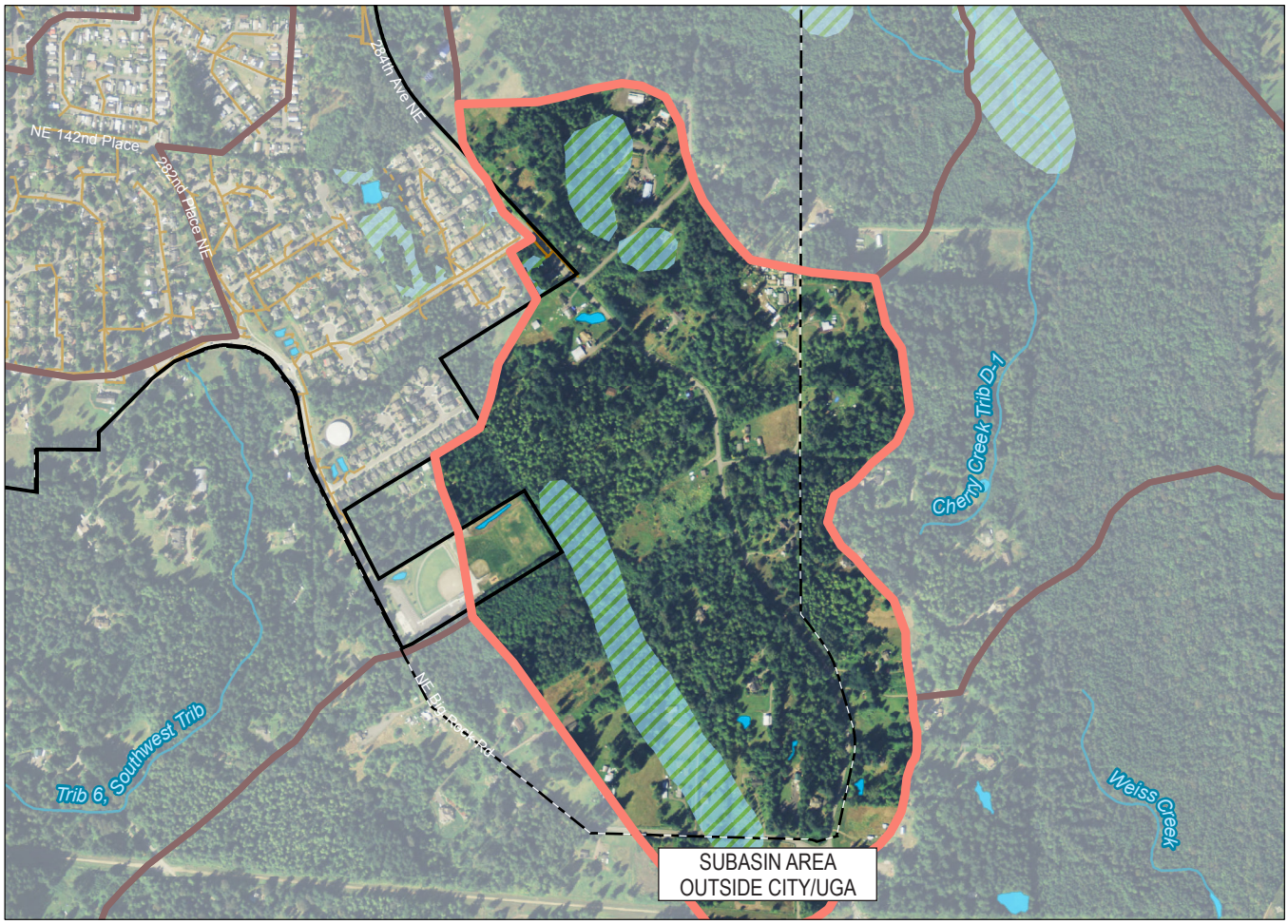


Depicts existing land uses for areas within the City/UGA. Other areas of the subbasin are typically agricultural and under County jurisdiction.

Land Cover



Depicts existing land cover for entire subbasin, including areas within County jurisdiction.



Subbasin Boundary | Wetlands | waterbody | Stream | Pipe Conveyance | City Limit | City UGA | PAU W3

CHAPTER 5. WATERSHED STRATEGIES FOR DEVELOPMENT STANDARDS

5.1 Development Regulations Strategies Overview

Objectives

Duvall Municipal Code (DMC) Title 14 regulates impervious surfaces, off-street parking, tree removal, subdivision and building designs, landscaping, sensitive areas, and open space. The chapter recommends revisions and additions to Title 14 that reflect the results of the watershed characterization. These management recommendations will guide the City with formulating new and modified code language to implement the goals and policies in Chapter 3. Some recommendations will require further refinement and development of supporting material should the City choose to pursue these changes. Described below are what actions could be taken, where in Duvall they apply, what existing code and programs may be affected, and what the outcomes would be for watershed processes.

Subbasin Prioritization Based on Watershed Analysis Results

The following recommendations are designed to: (1) protect subbasins that the watershed characterization identifies as performing important hydrologic and habitat functions, and (2) protect forested areas, which are important for water flow, water quality, and habitat processes. The recommendations include enacting more restrictive regulations in subbasins that scored high for importance while relaxing some restrictions for subbasins that scored low for importance and high for degradation. The recommendations are proposed as a series of actions that include changes to impervious surface limits, allowable density, and other development standards.

5.2 Implementing Watershed Approach for Development Standards

Zoning

DS-1 Action – Reduce Impervious Surface Limits by Zoning and Subbasin Management Groups

The impervious surfaces limits should be reduced for specific zoning designations within Management Groups 1 and 2.

What does the Duvall Municipal Code require now?

Title 14 Unified Development Regulations currently establishes maximum impervious surface limits for each of Duvall's 14 zoning districts. Impervious surface limits range from 60 to 100 percent. The lower range applies to residential zones and the higher range applies to commercial, mixed use, industrial, and public facility zones. Zoning districts located in Management Groups 1 and 2 include the following: Residential 4, Residential 6, and Public Facilities, along with the North urban growth area (to be zoned Residential 4 or Residential 4.5 upon annexation)[1]. Residential 4, Residential 4.5, and Residential 6 currently have a maximum impervious surface limit of 60 percent. Public Facilities has a maximum impervious surface limit of 80 percent. Management Group 3 encompasses all zoning districts in the city.

How should the code be changed?

Limiting impervious surfaces is important for protecting existing hydrologic functions in Management Groups 1 and 2. The City should establish an effective impervious surface limit of 40 percent per lot for new residential land uses in Residential 4, Residential 4.5, and Residential 6 when such zoning districts are located in Management Groups 1 and 2. To make sure this standard does not inadvertently preclude development, the City should require implementation of the following where achieving the 40 percent effective impervious limit proves infeasible:

1. Low impact development features, including dispersion trenches, amended soils, rain gardens, bioretention swales, green roofs, or pervious walkway;
2. Retention of existing tree canopy above and beyond current requirements;
3. Enhancement of wetland and stream buffers above and beyond current requirements;

[1]Additional zoning districts other than those listed here are located in Management Groups 1 and 2, but they correspond to a small amount of area (less than 40 acres).

4. Wider wetland and stream buffers above and beyond current requirements; and

5. Other strategies to reduce influx of clean stormwater (non-pollution generating surfaces) from stormwater conveyance and water quality facilities.

When evaluating existing and proposed new impervious surfaces areas as part of redevelopment or maintenance of existing improvements, consideration of low impact development approaches and other stormwater improvement approaches should be required in accordance with NPDES permit, King County Surface Water Design Manual, and other applicable documents and programs. See Action SW-3 in Chapter 6 for approaches to reducing impervious surface for properties that are redeveloping.

Which watershed processes would the recommendation benefit?

By reducing the amount of new impervious surface, the City can improve multiple water flow processes, including delivery, surface storage, and discharge. Delivery refers to the amount of flow generated in the watershed by precipitation. Impervious surfaces generally increase the total volume of runoff in a basin by reducing the amount of precipitation returned to the atmosphere through evapotranspiration and reducing infiltration to deep groundwater. Increases in impervious surfaces can also negatively impact surface storage functions provided within a subbasin, as flow pathways and areas important to surface storage (including wetlands and floodplains) are often disturbed or destroyed. Impacts to delivery and surface storage processes result in an increase in the magnitude and frequency of peak flow events (disruption of discharge processes), particularly in small stream systems (Booth, 1991; Burgess, 1998).

Where would this apply in Duvall?

These recommendations should apply to Management Groups 1 and 2.

DS-2 Action – Increase Residential Densities in Subbasins Prioritized for Development

Increase residential density standards for specific zoning districts in Management Groups 2C and 3 consistent with the Comprehensive Plan update process.

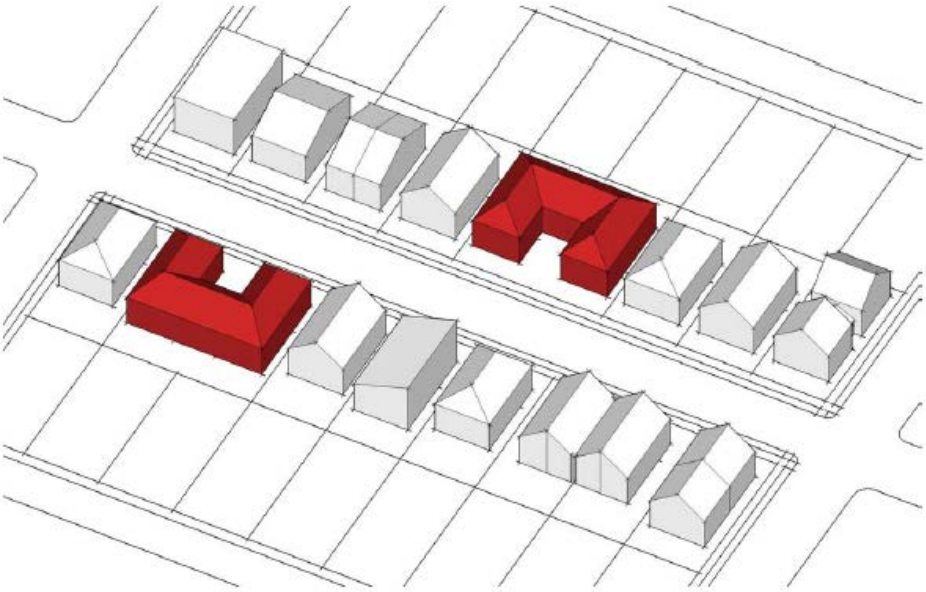
What does the Duvall Municipal Code require now?

Title 14 Unified Development Regulations currently establishes maximum residential density limits in the zoning districts that allow residential land uses (13 of the 14 zoning districts). Residential densities vary from a minimum of 4 units per acre in the most ubiquitous residential zones and no upper limit for upper floor residential units in zones that allow a mix of uses.

How should the code be changed?

Residential 4 and Residential 4.5 zoning districts encompass the largest area in Management Group 3. As part of the 2015 Comprehensive Plan update, the City should determine whether undeveloped or underdeveloped contiguous properties within these zoning districts could be appropriate for upzoning to a higher density. The City should also consider allowing infill development that complements the bulk and scale of single-family neighborhoods, such as courtyard housing, paired rowhouses (semi-detached houses), and corner attached housing (see Figures 5-1 through 5-3) (City of Portland Bureau of Planning, 2008). Incentivizing new subdivisions to provide a mix of housing types could also help to increase densities in appropriate areas of the city. Incentives could include allowing lot size averaging, density bonuses, and a higher percentage of allowed impervious surfaces.

Figure 5-1. Courtyard Housing



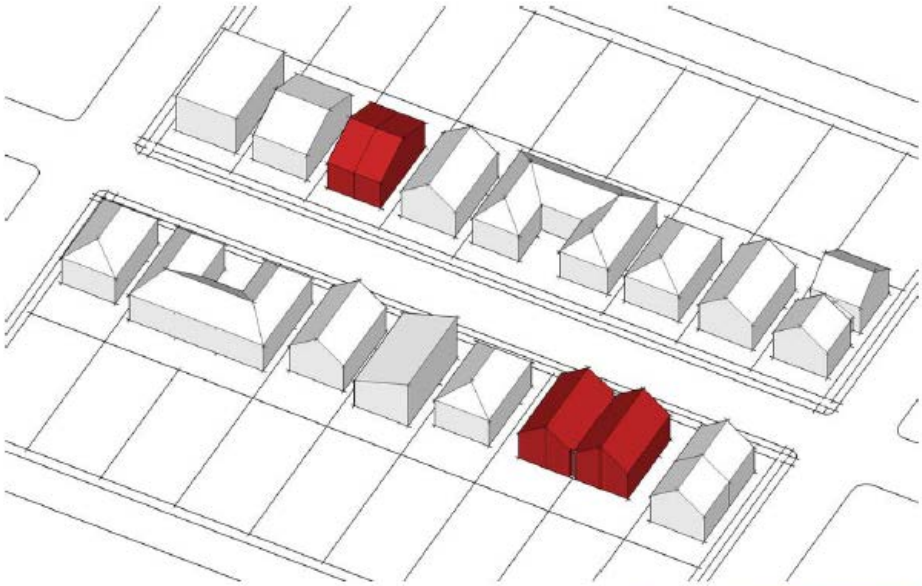
Courtyard housing. The divided massing of courtyard housing, especially when street-fronting units have house-like forms, provide opportunities to integrate higher-density housing into neighborhood patterns where detached houses predominate.

Recent courtyard housing examples with house-like forms at street frontages

1920s courtyard apartments. Form of end units reflects neighborhood context of detached houses.

Source: City of Portland Bureau of Planning, 2008

Figure 5-2. Paired Row houses



Paired rowhouses. Divide rowhouse projects into paired units, with massing reflective of nearby detached houses. Contextual fit can be optimized by pairing units under the same roof form, instead of using separate gables for each unit.

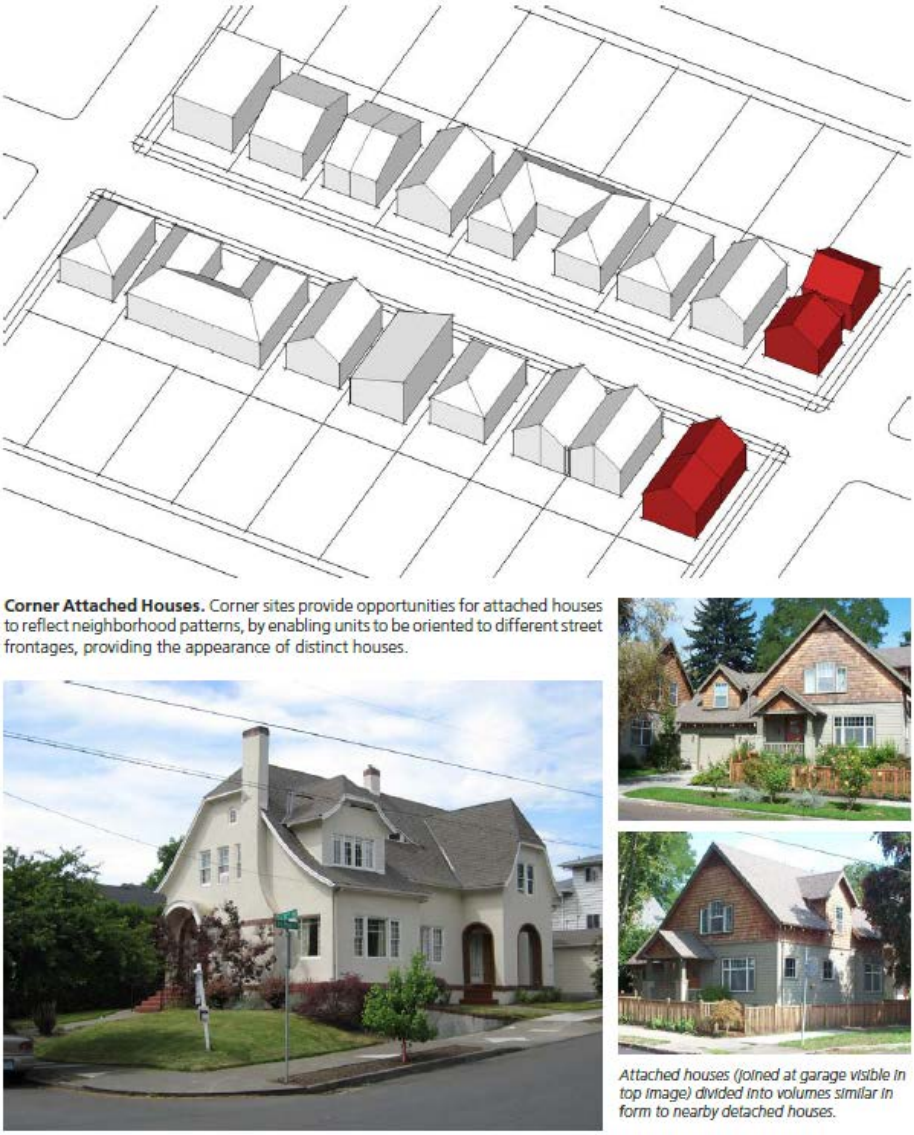
Four-unit rowhouse project divided into distinct building volumes, with two units under each gable, that reflect massing of nearby houses (pre-existing house visible to right)

Examples of paired rowhouses (also called semi-detached houses)—continue patterns established by houses on 50'-wide lots

"House" at center is actually two side-by-side rowhouse units, each only 10' wide. Their combination into a single house-like form avoids any appearance of being overly narrow and continues the neighborhood rhythm.

Source: City of Portland Bureau of Planning, 2008

Figure 5-3. Corner Attached Housing



Source: City of Portland Bureau of Planning, 2008

Which watershed processes would the recommendation benefit?

Increasing residential densities would not directly benefit any watershed processes. However, it could help relieve development pressure that would otherwise occur in areas of Duvall that have intact watershed processes, indirectly benefiting multiple water flow, water quality, and habitat processes where they are most important to preserve and restore, by encouraging development in less intact areas.

Where would this apply in Duvall?

These recommendations should apply to Management Groups 2C and 3.

DS-3 Action – Increase Allowances for Shared Parking for Commercial Uses

Improve shared parking allowances for commercial uses.

What does the Duvall Municipal Code require now?

Duvall Municipal Code 14.44.050 allows more than one use to share off-street parking provided certain criteria are met, including minimum parking area size, pedestrian connections, distance between uses, and written agreements. Reductions of up to 50 percent of the minimum parking requirement are allowed if an applicant can document different parking needs for the proposed uses. Maximum parking standards of 1.5 times the minimum number of parking spaces are also stipulated in the code. If the City receives a shell permit application, the City must assume that 20 percent of the commercial area would be a restaurant for purposes of calculating the required parking amounts.

How should the code be changed?

Revisit the minimum parking standards for each land use and zoning district and adjust requirements so that the land use, location, and intensity of development of each zoning district are taken into account along with Duvall's demographic characteristics and existing on-street parking supply. Consider basing these changes on a parking survey that evaluates peak-period occupancy. Allow new on-street parking spaces provided as part of frontage improvements to be counted toward required off-street parking. Revise standards in the Old Town zoning district to make sure all land uses allowed by the zone are not inadvertently precluded because of parking requirements. Apply flexible parking standards that acknowledge site constraints to sites that could redevelop with a mix of uses in the Old Town zoning district. Allow the developer to exceed the maximum standard only if they submit a parking demand study that shows a higher need for parking spaces than allowed.

Which watershed processes would the recommendation benefit?

Similar to Action DS-1, reducing the amount of new impervious surface can improve multiple water flow processes, including delivery, surface storage, and discharge.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups located within Duvall.

DS-4 Action – Provide More Parking Alternatives for Higher Density Residential Uses

Allow small decentralized parking lots rather than individual garages for townhomes, cottage housing, and multi-family developments.

What does the Duvall Municipal Code require now?

DMC Chapter 14.34 establishes design standards for front-loaded, tuck-under, side-loaded, and shared garages. DMC 14.44.040 establishes the minimum number of off-street parking spaces required for multi-family developments (1.3 to 3 parking spaces per unit, depending on unit size).

How should the code be changed?

Design guidelines that address multi-family off-street parking standards should be developed that identify approaches to providing convenient and centralized parking spaces for multi-family development as an alternative to individual garages. Parking design approaches that reduce the overall impervious surface should be added, including the following:

1. Small decentralized parking lots;
2. Rear access parking from the alley;
3. Limited number of access points;
4. Allowances for narrow or shared driveways; and
5. Structured parking beneath residential and commercial units.

Which watershed processes would the recommendation benefit?

Similar to Action DS-1, reducing the amount of new impervious surface can improve multiple water flow processes, including delivery, surface storage, and discharge.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups located within Duvall.

Landscaping

DS-5 Action – Improve Implementation of Existing Soil Standards

Improve implementation and compliance with existing soil standards for landscaping.

What does the Duvall Municipal Code require now?

DMC 14.38.130 (Planting standards) requires natural, sandy, fertile, and friable topsoil for grass and groundcover. Topsoil must be reasonably free from clay lumps, stones, stumps, debris, or roots and must meet certain minimum specifications on size. To enhance the hydrologic benefits of disturbed soils that have been graded and cleared of vegetation, the following soil specifications must be met: a 10 percent minimum amount of organic content, a pH between 5.5 and 7.0, and 2-3 inches of

mulch added to planting beds. Soil must be scarified or tilled to an 8-inch depth for a total amended soil depth of at least 12 inches.

How should the code be changed?

Although the code requirement is specific and stipulates a healthy soils environment for new landscaping, the City does not have a soils expert on staff to verify compliance with the regulations. The City should require developers to submit a soils report after soil has been amended but prior to installation of landscaping within common areas (public, condominium, or homeowner association-managed areas). The report should describe surface soil conditions, including compaction, size of particles, amount of organic content, pH, and soil type. The City could also charge the developer a fee so that a third-party consultant prepares the final soils report.

Soils reports for individual lots (e.g., backyards and front yards or other private open space areas) should be completed prior to landscape installation and final certificate of occupancy approval. The City should waive this this standard if the applicant submits a soils and planting plan as part of preliminary plat or building permit approval. If the applicant chooses this pro-active approach and chooses to submit a soils and planting plan, then City staff would conduct the soils inspection of the individual lots themselves. The code should grant the Planning Director the discretion to require third-party soils reports for individual lots if City staff determine that soil and landscaping conditions are inconsistent with the soils and planting plan.

These recommended changes to the regulations should be coordinated with Action SW-2 to avoid overlap or redundancy.

Which watershed processes would the recommendation benefit?

Improved soil standards for new development would result in improved landscaping success, which would not only benefit fish and wildlife habitats, but also maintain or restore water flow and water quality functions even as development occurs. Water flow processes associated with storage, recharge (infiltration), and discharge would be improved as precipitation and runoff move through these areas. Surface sedimentation would be reduced. Eliminating or reducing the need for fertilizers would further improve water quality processes.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups located within Duvall.

DS-6 Action – Establish Landscape Standards for Public Properties and Open Spaces

Establish landscaping standards for publically owned properties and open space lots.

What does the Duvall Municipal Code require now?

DMC 14.38.090 stipulates the type and width of landscaping for key land uses and development elements, although none apply to publically owned properties or open space lots required in residential zoning districts.

How should the code be changed?

Require publically owned properties and open space lots, along with other land uses not otherwise listed, to provide Type III - Low Cover landscaping at a width of 10-20 feet. Plantings should be native, drought tolerant shrubs and groundcover. The type of landscaping should conform to Type V Wildlife Corridor where the property is located within a mapped wildlife habitat corridor (see Figure 7-1 and Action SA1). The code should also provide the Planning Director with the discretion to waive these requirements or apply a different landscaping standard should there be unique site, design, safety, construction, or operational constraints.

Which watershed processes would the recommendation benefit?

New standards for publically owned properties and open space lots would directly improve habitat within Duvall, with the Type V Wildlife Corridor standards applied where most important for habitat processes. Use of native and drought-tolerant species would reduce or eliminate the need for irrigation and fertilizers, benefiting water quality processes.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups located within Duvall.

Tree Protection

DS-7 Action – Strengthen and Integrate Tree, Open Space, and Sensitive Areas Protections

Limit clearing of mature or native vegetation as new development occurs. Integrate open space requirements for residential zones with sensitive areas protections to preserve contiguous tracts.

What does the Duvall Municipal Code require now?

The City has an existing tree protection ordinance, adopted into the Unified Development Regulations as DMC Chapter 14.40. DMC 14.40.050 requires 35 percent of significant trees on a development site to be retained. Significant trees are trees that have a 16-inch diameter when measured 4.5 feet above the ground (excluding dead or hazard trees). Significant trees located in sensitive areas or buffers can be counted toward meeting the 35 percent requirement. Adjustments to open space, parking lot design, building setbacks, or grading and stormwater requirements are allowed if more than 35 percent of the significant trees are saved.

If applicants do not retain the required minimum of 35 percent of the significant trees on site, then trees must be replaced at a 3:1 ratio.

The remaining significant trees on the site must be replaced at a 1:1 ratio to ensure there would be no net reduction of the total number of significant trees on the site (does not include dead or hazard trees). Development sites with an average tree density of more than 20 trees per acre after development are not required to replace all the significant trees on the site due to the high density of trees.

DMC 14.40.080 requires that during construction, a fence at least 4 feet high must be installed along the outer edge of significant trees. Tree protection area signs must be posted on all sides of the fenced area. A permanent protection mechanism may be required to protect the trees and must be shown on the face of the deed, plat, or site plan and recorded with King County.

How should the code be changed?

Adjust the code to establish a "bright-line" minimum standard that protects a certain percentage of significant trees, tree canopy cover, or tree stem density. This will help to avoid a wholesale clear-cut of sites with a high density of trees as has been the case for past developments in Duvall.

Remove the outright allowance that lets the applicant apply the trees retained within sensitive areas and buffers to count toward the 35 percent requirement, instead incorporating this allowance into incentives that encourage tree protection in areas most important for watershed processes.

In addition, develop incentives for tree retention (e.g., density bonuses, lot size averaging, higher impervious surface standards, reduced public open space requirement, reduced private open space requirement and associated yard setbacks) to guide the applicant toward protecting contiguous tracts of trees according to the following hierarchy:

1. Within a mapped wildlife habitat corridor;
2. Within the reducible portion of sensitive areas buffers;
3. Adjacent to sensitive areas buffers;
4. Adjacent to the top and toe of steep slopes;
5. Adjacent to public parks and open space; and
6. Within and adjacent to perimeter landscaping areas.

Tree retention requirements or incentives should be strongest in management groups 1, 2A, and 2B, and/or targeted to address the most common types of development that occur in these management groups. Requirements should also

acknowledge differences among existing site characteristics (high density of trees, mix of trees and grasslands, minimal presence of trees) and scale of proposed development (short plats, preliminary plats, multi-family residential or commercial structures) so that infill properties are not unduly constrained by tree standards and sites that lack trees are replanted with new trees. Additional discussion of incentivized approaches for tree protection within and adjacent to habitat corridors and sensitive areas buffers is provided in Chapter 7 (Actions SA-1 and SA-3).

Require significant trees that are retained as part of large stands or groves, or located adjacent to public parks/open space and sensitive area buffers, to be placed in a native growth protection area tract. Continue to require evaluation of significant trees; however, identification of significant trees in sensitive areas should not be required, except as could be necessary through incentive approaches or to identity hazard trees in close proximity to proposed structures. All vegetation, including significant trees, within sensitive areas and the inner portion of sensitive areas buffers must be protected according to existing DMC 14.42 code requirements. As such, requiring tree surveys in these areas puts an unnecessary burden on developers.

Which watershed processes would the recommendation benefit?

Providing additional protection for existing native trees and contiguous forest areas would benefit multiple watershed processes, including water flow, water quality, and habitat. All aspects of water flow processes, including delivery, surface storage, recharge, and discharge would benefit from the recommendations, as natural flow pathways would be better maintained in important areas (wetlands and streams). Maintaining these flow pathways improves water quality processes by increasing the opportunity for filtration and reducing the potential for erosion and sedimentation. Protecting the sensitive area PLUS contiguous forested open space would result in wider tracts around riparian corridors and wetland buffers, directly benefiting fish and wildlife habitat functions. The recommended approach would implement the highest level of protection in subbasins most important for these processes (Management Groups 1 and 2).

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups located within Duvall, with special provisions applicable only to Management Groups 1, 2A, and 2B.

DS-8 Action – Strengthen Tree Protection and Mitigation Standards

Expand tree mitigation standards to include specifics on tree type, soil, location, and monitoring, including allowance for fruit and nut trees, native species, and smaller caliper plantings. Where clear-cuts occur adjacent to preserved riparian forest, require planting near edges to prevent windthrow.

What does the Duvall Municipal Code require now?

DMC 14.40.070 requires replacement deciduous trees to have a 2-inch caliper when measured 4.5 feet above the ground, and replacement evergreen trees to be 8 feet in height overall. Smaller-sized replacement trees can be used if the applicant demonstrates that smaller trees are more suited to the species, site conditions, purpose of the code section, and when planted in sufficient quantities. Replacement trees must be planted in locations appropriate to the species' growth habit and horticultural requirements, located to provide screening from adjacent properties, and planted in areas that connect to native growth protection areas or other open spaces. The Planning Director has the discretion to require trees to be native species. When individual significant trees or significant tree stands are protected, replacement trees should be planted to enhance such trees or tree stands.

How should the code be changed?

The existing code requirements stipulate appropriate locations for planting trees, although the City could consider strengthening the code language from *should* to *shall*. The significant tree definition should be revised to exclude cottonwood and red alder trees unless they are already located in a native growth protection area or easement. The code should be changed to require the use of native trees for replacement trees rather than leaving it to the discretion of the Planning Director. The planting plan should ensure long-term health and viability of replacement trees and promote the establishment of late-successional climax species. Fruit and nut trees could be allowed for backyards and other maintained landscaped areas. Where smaller caliper plantings are allowed, the code should specify a different replacement ratio. The requirements to submit reports on soil type prior to landscaping should also be applied to replacement trees (see Action DS-5). To ensure the replacement trees are adequately maintained, the City could require monitoring reports to be submitted by the applicant identifying the health of the replaced trees, recommendations to address any tree loss, and bonding provisions. These reports could be submitted as part of any sensitive area mitigation reports already required by DMC. Monitoring reports may be submitted by the applicant or by the City's third-party consultants.

Which watershed processes would the recommendation benefit?

The recommended updates to tree protection and mitigation standards would directly benefit habitat processes and water flow processes. See additional discussion in Action DS-5 for more details.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups located within Duvall.

Subdivision

DS-9 Action – Cluster Residential Development

Encourage subdivisions to cluster lots to minimize mass clearing and grading by establishing design guidelines that encourage open space.

What does the Duvall Municipal Code require now?

DMC 14.66.040 (Preliminary subdivision and short subdivision review and approval criteria) requires the layout of lots, and their size and dimensions, to take into account topography and vegetation so that buildings are reasonably sited, and the disruption to topography and vegetation is minimized. Identified hazards and limitations to development must be considered in the design of streets and lot layout to ensure that street and building sites are on geologically stable soil considering the stress and loads to which the soil may be subjected.

DMC 14.34.030 (Grading, stormwater management and site coverage) stipulates similar requirements to minimize changes to existing topography and requires developments to avoid mass grading and clearing of lots. Sites must blend into the existing topographic contours and minimize cuts and fills. Where there are large grade changes, the area should have a series of benches and landscaped terraces.

How should the code be changed?

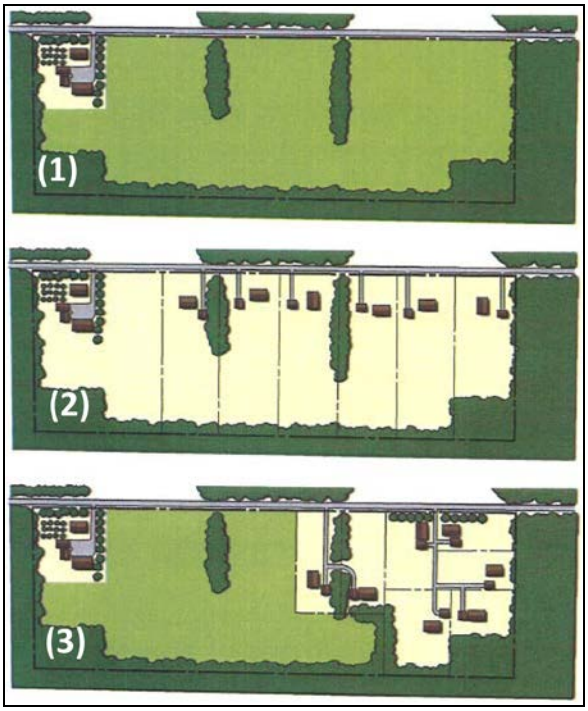
Add design guidelines that address lot configurations for subdivisions to encourage layouts that set aside sensitive areas, wildlife habitat corridors, and forested areas in contiguous tracts and that cluster development, as the following images showcase. The City should also consider changing their density calculations from gross density to net density for residential developments[2]. Net density calculations provide opportunity to account for sensitive areas inherent to a site. This ensures better predictability for developers so that they can understand the actual capacity for residential units on a site rather than assuming the underlying zoning density automatically applies. Net density calculations may also facilitate more opportunity for protection of contiguous natural areas, and provide opportunity to incentive cluster development approaches.

Clustering requirements could be developed to ensure a variety of lot and residential unit types and sizes, sensitive area impact minimization, grading minimization, and increased tree and vegetation retention. Incentives should be established to encourage applicants to cluster, including lot size averaging, density bonuses, higher impervious surface standards, reduced public open space

[2] Per the existing gross density calculation method, the maximum allowed number of dwelling units is determined by multiplying the gross useable area by the applicable residential density (DMC 14.64.040). Converting to a net density calculation method would exclude sensitive areas and sensitive areas buffers in determining the maximum allowed number of dwelling units.

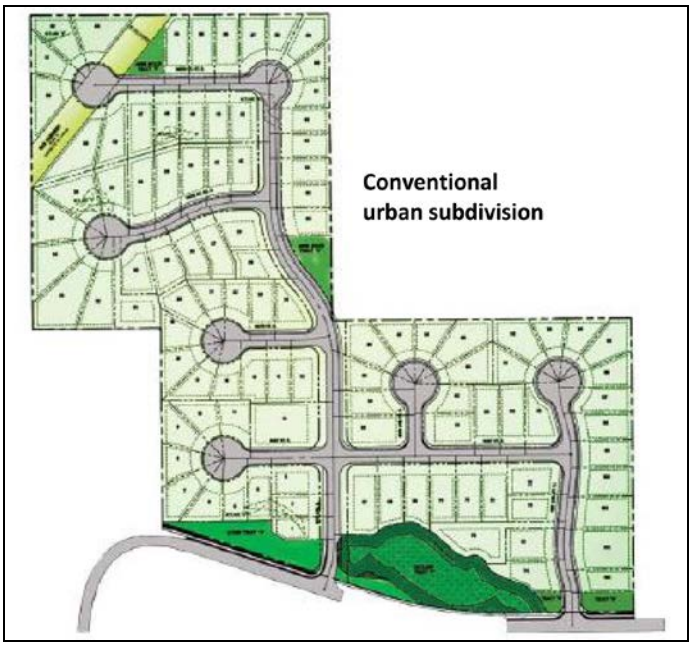
requirements, and reduced private open space requirement and associated yard setbacks. The Planning Director may have the discretion to waive clustering design guidelines where there are unusual site or access constraints or when clustering would not benefit watershed processes.

Figure 5-4. Lot Configurations: (1) Predevelopment, (2) Conventional, and (3) Open Space Subdivision Design



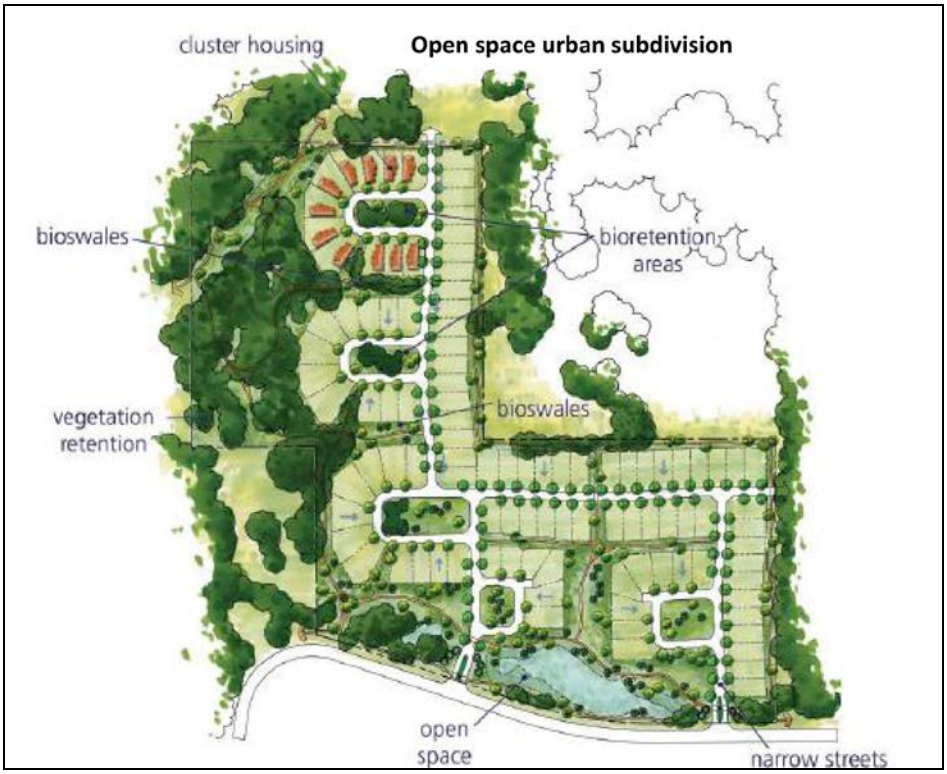
Source: Arendt, 2010

Figure 5-5. Conventional Urban Subdivision



Source: PSAT, 2005

Figure 5-6. Open Space Urban Subdivision



Source: PSAT, 2005

Tying the lot configuration to retention of significant trees (see Action DS-7) will strengthen the existing code and help to avoid mass clearing and grading.

Which watershed processes would the recommendation benefit?

Providing additional open space as future development occurs would benefit multiple watershed processes, including water flow, water quality, and habitat. All aspects of water flow processes, including delivery, surface storage, recharge, and discharge, would benefit from the recommendations, as natural flow pathways would be better maintained (especially if development is clustered away from wetlands and streams). Maintaining these flow pathways would benefit water quality processes by increasing the opportunity for filtration and reducing the potential for erosion and sedimentation. Open space provided around riparian corridors and wetland buffers (through protection of the sensitive area PLUS contiguous forested open space) would directly benefit fish and wildlife habitat functions.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups located within Duvall, but they would likely be most appropriate for Management Groups 2A, 2B, and 2C.

DS-10 Action – Update Open Space Standards to Improve Tree and Habitat Preservation

Revise regulations that require open space as a percentage of the subdivision so that reforestation, protection of existing trees, and sensitive area buffer enhancements are options in addition to providing open space for recreation.

What does the Duvall Municipal Code require now?

DMC 14.64.240 requires 10 percent of a property's developable area to be set aside as open space in residential zoning districts (R4, R4.3, R6, R8, R12, and MU12). Sensitive areas can be counted toward the open space requirement provided a trail is placed in the outer portion of the sensitive area's buffer. A viewing or seating area and interpretative signage must also be established. The open space area must have a minimum width of 25 feet, although this width requirement does not apply to sensitive areas. DMC 14.40.060 requires the open and recreational space to be designed and located to protect existing stands of trees.

How should the code be changed?

Adjust the open space requirements to give discretion to the Planning Director on the appropriate location and makeup of the open space lot. Criteria should be developed for the code that identify the most appropriate use of the open space. If the applicant chooses to cluster development or retain significant trees, then the open space standard could be met by establishing a trail on the outer edge of the tract set aside for protection. This incentive could be more strongly encouraged in Management Groups 1 and 2. Open space may be best suited as a recreational area for the development's residents in Management Group 3. Maintenance of open space areas and associated trails should be the responsibility of the condominium, homeowner associations, or property owners.

Which watershed processes would the recommendation benefit?

Recommendations would benefit multiple watershed processes; benefits would be very similar to those provided by Actions DS-7 and DS-9 (see these sections for additional detail).

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups located within Duvall, with differing criteria depending on the management group.

Clearing and Grading

DS-11 Action – Establish Limits on Mass Grading

Limit wall height and mass grading for residential subdivisions.

What does the Duvall Municipal Code require now?

DMC 14.34.030 (Grading, stormwater management and site coverage) requires retaining walls that are more than 3 feet tall to be limited to no more than two 4-foot terraced walls within 100 horizontal feet of one another.

How should the code be changed?

The code already establishes a height limit of 4 feet, although the language could be rewritten to make that more clear. Consider adding a limit to the number of terraced walls or total length of terraced walls to avoid mass grading for residential subdivisions that submit for a preliminary plat. The City should identify the exact trigger for the requirement based on the size of the proposed subdivision or a certain volume (cubic feet) of proposed grading. To avoid precluding development, the Planning Director should have the discretion to waive requirements of this section if the applicant demonstrates that site constraints would preclude development if terraced wall requirements were enforced. The code should be revised to allow private and public open space areas to be sloped in cases where that would reduce clearing and grading and use of walls. This requirement combined with Actions DS-7, SA-1, and SA-7 should result in a reduction of mass grading.

Which watershed processes would the recommendation benefit?

Recommendations to limit mass grading as future development occurs would benefit both water flow and water quality processes, primarily by maintaining water flow and filtration pathways as future development occurs. Minimizing the need for significant grading as future development occurs maximizes the opportunity to maintain native soils and native vegetative cover; native soils and vegetation maximize the opportunity for precipitation and runoff to be stored, infiltrated, and filtered. Recommendations may additionally provide opportunity to minimize impacts to intact forest vegetation where occurring on slopes, which would help maintain slope stability and storm flows (moderated by established vegetation).

Where would this apply in Duvall?

These recommendations should apply to management groups 1 and 2.

5.3 Outcomes of Watershed Approach

Integrating a watershed approach with DMC Title 14 will strengthen the protection of habitat and forested areas and minimize impervious surface. Increased restrictions for subbasin management groups that scored high for importance and low for degradation will protect, restore, and conserve hydrologic processes, which also support other ecological processes such as water quality and habitat functions.

CHAPTER 6. WATERSHED STRATEGIES FOR STORMWATER MANAGEMENT

6.1 Stormwater Strategies Overview

Objectives

Duvall Municipal Code (DMC) Chapter 9.06 (Storm Drain Utility) regulates the management of stormwater facilities to promote sound development, preserve the City's watercourses, maintain groundwater resources, and ensure safety and drainage of public and private property. Currently in 2015, the City utilizes the King County Surface Water Design Manual (DMC 9.06.30) and all related amendments to the manual. Additionally, the City issues an annual Stormwater Management Program (SWMP) Report that describes efforts being made to meet the requirements of the Phase II National Pollutant Discharge Elimination System (NPDES) municipal separate storm sewer system (MS4) Permit issued by the Department of Ecology authorizing discharge of stormwater to waters of the State of Washington in accordance with the Federal Clean Water Act. The SWMP is designed to reduce the discharge of pollutants from the city to the maximum extent practicable and to protect water quality through the regulation of stormwater runoff and associated programs. Public education and outreach are required by the permit and the City has developed programs to educate and inform homeowners, businesses, developers and staff. All references to current (2015) stormwater standards in this chapter will likely be updated in the future to maintain consistency with design guidelines and stormwater management requirements of the Washington State Department of Ecology and King County. The City's stormwater standards and requirements will be updated in the future to comply with changes in the NPDES permit, the King County Surface Water Design Manual, and other applicable documents and programs.

This chapter provides guidance for improving stormwater management in Duvall. Described below are what actions could be taken, where in Duvall they apply, what existing code and programs may be affected, and the outcomes to watershed processes. The goal of this chapter is to provide a framework for identifying and prioritizing actions that the City can pursue to improve upon and strengthen current regulations and programs. Recommended actions are intended to implement the goals and policies located in Chapter 3.

Subbasin Prioritization Based on Watershed Analysis Results

The primary objective of this chapter is to recommend actions for new development and retrofit when redevelopment occurs that are specific to subbasin management groups (see Figure 2-5). Chapter 2 describes how subbasin management groups were identified based on similarity of importance and degradation of watershed processes within Project Assessment Units (PAUs). In Chapter 4, specific recommendations are given for each PAU based on physical and biological conditions, as well as the development expectations for each subbasin.

Actions are recommended with the goal of providing measurable improvements to the quality of instream habitat, maintain the quality of service expected from the City's stormwater infrastructure, and encourage city-wide participation. Additionally, recommendations are designed to meet NPDES MS4 permit requirements by providing guidance on low impact development (LID) best management practices (BMPs), incentive and voluntary programs, green infrastructure standards, and education and outreach that can be applied both city-wide and for specific PAUs.

6.2 Implementing Watershed Approach for Stormwater Strategies

Strategies for addressing stormwater were developed for Duvall and organized into four categories (1) City-wide LID strategies, (2) small-site strategies, (3) large-site / centralized strategies, and (4) additional strategies. Each strategy was reviewed by the Advisory Committee and ranked by feasibility and importance for achieving the City's stormwater management goals.

City-wide LID Strategies

Low impact development (LID) approaches to stormwater management could be integrated into land use types occurring across the city; and would likely be feasible and appropriate for both small-site and large-site developments, including single and multi- family residential developments, commercial developments, public buildings, churches, and schools as well as for retrofit of existing development and existing stormwater facilities. LID approaches should be integrated through updates to DMC Chapter 9.06 and the Public Works Development Design Standards as well as through future stormwater capital improvement planning identifying system retrofit opportunities.

A City-wide program could also inform where capital project retrofit efforts would have the greatest benefit. Before developing a city-wide program, additional retrofit options should be identified and the cost-benefit of retrofit opportunities considered. Stormwater retrofit efforts would contribute directly to meeting recovery targets established in the Puget Sound Partnership's Action Agenda strategic initiatives related to focusing development pressure in urban areas where most consistent with protection and restoration of watershed processes, maintaining natural land cover, improving water quality from urban land uses, and protecting summer stream flows. Additional public outreach and education about small-scale (homeowner) retrofits could also be included as part of the City of Duvall NPDES public outreach requirements.

SW-1 Action – Define and Require LID BMPs

Define the most useful and applicable LID BMPs and require their use in new development activities.

What does the Duvall Municipal Code require now?

Currently, the City encourages developers to implement LID measures in accordance with the Public Works Development Design Standards (PWDDS), the requirements of Appendix A of the NPDES Phase II Permit, and requirements of the King County Surface Water Design Manual (KCSWDM). The City has a goal of promoting use and implementation of LID measures during the development design and permitting process for all development projects (SWMP Section S5.C.4). Appendix B of the 2013 SWMP Report provides a description of currently available LID BMPs and plans for implementation as of 2015. LID BMP options, strategies, and requirements will likely change as BMP technology evolves and as local, state, and federal requirements are updated or revised.

The City evaluates new developments using the 2009 KCSWDM. The KCSWDM requires matching developed stormwater runoff to particular pre-development flow conditions and encourages LID by crediting the downsizing of flow control facilities. Chapter 5 of the KCSWDM provides descriptions of LID techniques and guidance for design of on-site facilities.

Additional stormwater control measures may be required for redevelopment greater than 2,000 square feet based on City requirements or if the need has been identified through a basin plan, watershed ranking process under Chapter 400-12 WAC, or through Growth Management Act Planning (DMC 9.06.050). An administrative departure may be granted at the discretion of the Public Works Director if there are physical site constraints that significantly hamper retrofit and there is no significant impact to stormwater quality.

How should the code be changed?

New standards for using LID BMPs within stormwater management regulations should be added to DMC 9.06 to reinforce adopted City policies and standards including requirements from King County and the Department of Ecology. Updates to the code should work in conjunction with existing stormwater management regulations. LID BMP facilities generally fall into one or more of the following categories:

- **Dispersion:** these facilities attempt to minimize the hydrologic changes created by impervious surfaces by restoring natural drainage patterns of sheet flow to surface waters and/or to groundwater (as dispersed infiltration). Dispersion facilities generally require significant area and can be challenging in urban settings;

- **Infiltration or partial infiltration:** these facilities also attempts to minimize the hydrologic changes created by impervious surfaces; however focuses stormwater runoff into areas or facilities that provide for more rapid percolation into groundwater. Infiltration facilities can be challenging in areas where soils are not well drained;

- **Filtration:** these facilities attempt to provide water quality treatment for stormwater runoff by providing a filter media (soil, sand, and/or gravel and vegetation) through which solids and pollutants are removed. Can be configured in decentralized small-scale inlets which allows for runoff to be treated close to its source without additional collection or conveyance infrastructure;

- **Rain capture and reuse:** these facilities traditionally have been used in environments where rainfall or other conditions limit water supply; however can provide opportunity to reduce effective impervious surface from a site by capturing clean (roof) runoff instead of conveying it to stormwater systems.

LID BMPs that should be considered for use within Duvall and inclusion in DMC 9.06 include:

- Soil amendments/restoration
- Bioretention – cells, planters, swales
- Rain gardens
- Vegetated filter strips
- Grassed modular grid pavement
- Vegetated roofs[1]
- Tree and native growth retention
- Tree and native growth restoration
- Perforated pipe connections
- Disconnect downspouts
- Permeable pavement (non-grassed)

- Rainwater harvesting
- Minimum disturbance foundation
- Wheel strip driveways
- Open grid decking over pervious area
- Rain barrels
- Constructed wetlands [1]
- Wetland restoration [1]
- Drywells and trenches [1]

This list of LID BMPs should be further discussed and refined, based on what is currently being used in Duvall and recommendations on what may be feasible in the city that are provided in this chapter[2].

Infiltration is a key mechanism for LID. Infiltration structures are used to store, capture, and infiltrate stormwater runoff into the surrounding soils. The use of this BMP is suitable for urban residential lots with limited stormwater dispersion potential. In general, infiltration structures function most effectively in well-draining soils, which are present in only a few areas of Duvall. Even within areas with poor or moderately-draining soils, BMPs that include infiltration can also result in improved water quality, storage, and peak flow attenuation. Examples of strategies that commonly rely on infiltration or at least partial infiltration include rain gardens, permeable pavement, dispersion, and bioretention cells, swales, and planters. For small projects creating impervious area less than 2,000 square feet, the best options most commonly are rain gardens and bioretention planters because they are straight-forward to construct and typically fit well into other landscaping.

Rain garden and bioretention systems are commonly shallow depressions that consist of a conditioned (compost-amended) soil bed and plantings, which are used to treat stormwater runoff from rooftops, streets, and parking lots. The stormwater runoff is filtered by plant material and infiltrates into the growing medium. These systems provide stormwater benefits by removing pollutants and reducing the amount of runoff that reaches streams. These stormwater benefits reduce the negative effects of urbanization by more closely matching the natural hydrologic cycle associated with native forests and meadows. When planted with diverse native species, rain garden and bioretention systems provide habitat for many types of desirable wildlife.

[1] These LID BMPs may require more involved design methods and approval by an engineer.

[2] The list of LID BMPs is primarily focused on new strategies for stormwater management that are not commonly used in Duvall currently; this list is not intended to exclude future use of existing commonly used stormwater BMPs, such as ponds and vaults used for detention, retention, and water quality treatment. Listed LID BMPs may provide beneficial alternatives to these commonly used stormwater BMPs in the future; however their application may also be appropriate for some development situations in the future.

LID BMPs that infiltrate will be most effective in PAUs with permeable soils or where soil amendments make infiltration more feasible. Examples of good locations for rain gardens include PAUs C4 and C5.

Depending on whether the rain garden or bioretention system is infiltrating, partially infiltrating or just a filtration facility, it can provide flow control and/or water quality benefits. Ideally, for a typical residential development, each lot would have its own small, separate LID stormwater system to manage lot-specific stormwater. This use of many, small stormwater facilities in a residential subdivision would meet the LID goal of decentralized treatment of stormwater. The code could require that LID BMPs be installed to treat rainwater from several dwellings, or commercial / industrial structures in accordance with City standards and requirements.

On development sites where space is limited, the City could require LID BMPs such as planters, trenches and drywells. Stormwater planters or swales are structural landscaped reservoirs designed to capture stormwater runoff from impervious areas. The stormwater runoff is filtered by plant material and infiltrates into the growing medium. Stormwater planters constrained by curb and sidewalk can be designed with vertical walls, reducing the area required for stormwater treatment. Trenches consist of a continuously perforated pipe within a subsurface, rock-filled trench that is wrapped with a geotextile fabric. Drywells are subsurface storage structures that temporarily store and infiltrate stormwater runoff from rooftops.

The code could require use of bioretention on its own or in conjunction with another type of LID facility. A vegetated swale (or bioswale) is a gently sloping vegetated channel used to receive and treat stormwater runoff from rooftops and road surfaces. This can be an effective onsite facility for improving water quality in PAUs D4 and C3, and even in D1 if infiltration can be improved. The primary purpose of a vegetated swale is to transfer stormwater runoff from the source to the appropriate infiltration/dispersion LID BMPs, providing a reduced-cost alternative to traditional curb and gutter systems. As stormwater flows through the swale, the velocity is slowed by vegetation allowing water to infiltrate into the ground. Swales can contain check dams (made of stone, earth, or other materials) to enhance infiltration capacity and slow runoff.

Dispersion is the discharge of stormwater runoff from impervious surfaces to existing vegetated areas onsite. The use of this BMP is suited primarily to rural lots with existing native vegetation cover and would have limited use within the City or urban growth area boundary. It may be a good alternative for development in PAU D3. However, depending upon site conditions, dispersion can be used successfully on smaller lots in combination with other BMPs. Flow from gutters, ditches, pipes, or other channelization structures must be slowed and spread out in order to prevent erosion and aid infiltration. This is accomplished through the use of splash blocks and dispersion trenches. Additional drainage measures, including downslope

cut-off drains, may be required at small lots to limit impacts associated with downslope overland flow or seepage onto adjacent parcels.

Installation of permeable pavement could be a feasible alternative for impervious surfaces such as driveways, parking areas and other hardscapes. Although this is most easily installed for new development, it can also be an option for small redevelopment projects. PAUs D2, D4 and D6 have permeable soils, especially D2, and are either highly developed or have new development planned. These PAUs would be good locations to consider permeable pavement. Permeable pavements are currently not utilized within the Public Right-of-Way because of high life-cycle cost, high maintenance needs, and low lifespan when compared with standard pavements.

Detention and water quality facilities can be used in conjunction with infiltration LID BMPs or stand-alone. Common small-scale examples are rain barrels or cisterns, which are structures that collect and store roof stormwater runoff that would otherwise flow offsite. The captured water can then be used later for beneficial purposes, such as lawn and garden irrigation. Rain barrels are most appropriate for smaller lots and/or sites with slow-draining soils, such as PAUs D1 and D5, where soils and geology preclude complete infiltration onsite. Rain capture and reuse structures are suitable for all site conditions and development types. Ideally, the captured water can be used in landscaped areas that require irrigation, and suitable filtration structures to treat overflow water during large storm events. Large-scale facilities include ponds, vaults, and other systems engineered to accommodate centralized flow from larger drainage areas.

Amending soils with organic compost can improve infiltration capacity. PAUs D5, D1, D7, W3 and C6 either have no mapped permeable soils or a very low percentage of permeable soils and would benefit from soil amendments. Amendments are explained in more detail under Action SW-2.

Wetlands provide both water quality and flow control opportunities. Stormwater treatment wetlands are constructed with varying topography and are designed to treat and store stormwater runoff from impervious areas. Generally these wetlands are most appropriate where development levels are low and there are large lots available for construction, such as PAUs D3, C6 and W3. Wetlands are designed to be frequently saturated like a natural wetland and will support plants and wildlife suited to wetland environments. The stormwater runoff is filtered by plant material and infiltrates into the ground. The facility provides stormwater benefits by removing pollutants and reducing the amount of runoff that reaches streams.

Which watershed processes would the recommendation benefit?

A variety of watershed processes may benefit, city-wide, depending on which LID BMPs are implemented. Delivery, surface storage, recharge and discharge processes, all associated with how water moves through the landscape, would benefit as varied

LID BMPs are implemented across the city. Water quality processes would also benefit through enhanced stormwater runoff treatment provided by many of the LID BMPs discussed for action SW-1.

Where would this apply in Duvall?

These recommendations would apply to all subbasin management groups city-wide. The feasibility of individual strategies varies throughout the city and depends on land ownership, existing topography, soils, hydrology and land cover. Implementation of any specific strategy requires additional site specific analysis such as land survey, infiltration testing of soils, wetland delineation, and engineering. For example, infiltration is not considered appropriate in locations adjacent to a steep slope or landslide hazard area (KCSWDM 2009). Additionally, infiltration is not appropriate in locations where contamination is an issue.

SW-2 Action – Improve Soil Amendment BMP

Improve soil amendment BMP in DMC 14.38.130 for clarity, ease of understanding and enforcement.

What does the Duvall Municipal Code require now?

DMC 14.38.130 provides soil specifications for enhancing hydrologic benefits of disturbed soils. Compacted soils should be scarified or tilled to a minimum depth of 8 inches or more if necessary to reach a total of 12 inches of uncompacted, amended soil. Within the drip line of existing trees, soils should not be tilled or scarified within three feet of the drip line and the soil amendment should not be incorporated more than three or four inches to reduce damage to the roots. A minimum of 10 percent organic dry weight must be provided in planting beds and it should be mulched with 2 to 3 inches of organic material. In turf areas, there should be a minimum of five percent organic content. Organic matter must have pH between 5.5 and 7.0.

How should the code be changed?

Many of the soils in the city do not infiltrate well and create other challenges for gardens, landscaping and lawns. Amending such soils can improve plant performance significantly in addition to reducing stormwater runoff. Soil amendment can restore the health and function of disturbed soils by breaking up compacted soils and adding organic material such as compost. Amendments can reduce long term maintenance of landscaping by minimizing or eliminating the need for pesticides, herbicides, and irrigation. Soil improvements can save money for homeowners and tenants by reducing irrigation demand. Additionally, builders or developers can significantly reduce the size of required flow control facilities by amending soils.

The general procedure for amending compacted soils is as follows:

- Minimize construction disturbance as possible to preserve native soils and maintain vegetated stormwater flow pathways.
- Prior to disturbance, onsite soils with an organic content of at least 5 percent can be stockpiled and reused to amend compacted soils
- To amend compacted soils, start by scarifying or tilling soils to a minimum 8-inch depth (or 20 inches for major compaction). Do not scarify soil within the drip lines of trees to be retained. Tilling should only be performed on dry soils.
- Apply stockpiled soils and/or compost and thoroughly till to develop a minimum 12-inch depth of amended soil.

PAUs D5, D1, D7, W3 and C6 either have no mapped permeable soils or a very low percentage of permeable soils and would benefit from soil amendments. Specific challenges with existing soil amendment BMPs should be identified, with specific suggestions made for code updates. Recommended changes to the code would apply to DMC 14.38.130, DMC 9.06 and to Chapter 5 of the Public Works Development Design Standards. These recommended changes to the regulations should be coordinated with Action DS-5 to avoid overlap or redundancy.

Which watershed processes would the recommendation benefit?

Providing better infiltration through amended soils can benefit watershed processes associated with both the recharge of groundwater and discharge of groundwater to surface water. Recharge is an important process because it indirectly affects the volume of precipitation discharging into the stream. Under natural conditions, precipitation soaks into the ground and becomes shallow subsurface flow before concentrating in streams as surface flow. A decrease in soil storage capacity decreases residence time of precipitation entering the watershed. This change can increase the magnitude of peak flow events and erosive power in the stream system leading to erosion and downcutting, potentially affecting existing development and utility infrastructure. Increasing the capacity of a soil to infiltrate precipitation can reduce or prevent the magnitude of peak flow events.

Where would this apply in Duvall?

This recommendation should apply to all subbasin management groups city-wide.

Small-site Strategies

Small-site management strategies are intended to be applied at the site scale, and are generally applicable for development or redevelopment projects with less than

2,000 square feet of new or replaced pollution generating impervious surface. These strategies may be appropriate for a variety of land use types such as parks, residential developments, small commercial developments, public buildings, and potentially churches and schools. In general, these strategies require minimal engineering and could be promoted through outreach, education or other incentives programs, as well as through updates to DMC Chapter 9.06. Implementation of these strategies may not be appropriate for development or redevelopment of impervious area larger than 2,000 square feet (strategies for these larger projects is discussed in Large Site / Centralized Strategies section).

SW-3 Action – Small-site Stormwater Enhancement.

Define the most useful and applicable LID BMPs and stormwater enhancement approaches for small sites; require their use in new development and redevelopment activities on small sites.

What does the Duvall Municipal Code require now?

New development and redevelopment on small lots (projects that generally include less than 2,000 square feet of new or replacement pollution generating surface), are required to minimize impervious surface area to maximize stormwater infiltration and reduce offsite transfer of stormwater (DMC 14.34.030). However, there are no standards requiring incorporation of LID approaches or for reducing effective impervious area when redevelopment occurs.

How should the code be changed?

Recommended strategies for retrofit should be incorporated into DMC 9.06 and could potentially be included as recommended actions for new development in DMC 14.12-14.32. Redevelopment strategies that can be used to reduce impervious areas include disconnecting downspouts, replacing paved parking lots with permeable surfaces, or installing vegetated roofs.

An initial priority should be requiring existing developments and redevelopment projects to disconnect downspouts and infiltrate where infiltration capacity is high. Where infiltration rates are low, downspout disconnection can be encouraged, but the downspout disconnect would need to occur in tandem with the placement of additional facilities, such as rain gardens or rain barrels, to temporarily store water that would pond or runoff during a precipitation event and give it time to infiltrate. Subbasins in management group 3 are highly developed and have more degraded water flow processes, therefore, could benefit from reducing effective impervious area and providing enhanced water quality treatment with new or retrofitted stormwater facilities. PAUs D2 D6, and C4 have permeable soils, especially D2. A program for disconnecting downspouts should be implemented City-wide, with greatest emphasis placed on subbasin management groups 2B, 2C and 3 especially within PAUs with more permeable soils.

A more expensive, but still affordable small site retrofit approach to reduce impervious area is to replace impervious surfaces. Impervious surfaces associated with parking, driveway, and other hardscape footprints can be retrofit by removing the impervious surface and replacing with porous asphalt, pervious concrete, permeable paver blocks, or reinforced plastic grids with grass. Opportunities for replacing pavement with permeable materials should be focused in PAUs with permeable soils. A pervious pavement system consists of a porous surface underlain by a storage reservoir placed on uncompacted subgrade to facilitate stormwater infiltration. With porous asphalt, stormwater drains through the surface where it is temporarily held in the voids of the storage reservoir (coarse aggregate), and then slowly infiltrates into the underlying, uncompacted subgrade. The storage reservoir can be designed with an overflow control structure so that peak rates are controlled during large storm events. It may even be possible to completely remove the pavement and decrease the number of parking stalls or create more efficient driveway widths.

The most expensive and labor intensive small site approach (for either new facilities or retrofit) is to install vegetated roofs (also known as green roofs). Because the installation of a vegetated roof usually requires additional structural reinforcement, this is frequently more cost-effective during new construction. A vegetated roof consists of a light-weight soil mix planted with ground cover vegetation. The benefits of vegetated roofs include increased energy efficiency, improved air quality, improved aesthetics, and improved stormwater management.

Other new facility or retrofit opportunities that will target impaired processes at a site include many of the BMPs described in Action SW-1, including amending soils (see Action SW-2) and installing rain gardens, vegetated swales or filter strips. However, specific site characteristics should be considered when selecting BMPs and will need to include BMP design restrictions. For example, current design restrictions in the 2015 NPDES permit (Appendix 1) allow installation of non-engineered rain gardens (as opposed to engineered bioretention facilities) at new development sites with less than 5,000 square feet of new plus replaced hard surface. The NPDES, King County, and City of Duvall LID BMP standards will likely change as BMP technology evolves and as local, state, and federal requirements are updated or revised.

Generally, installation of infiltration facilities will be more successful in D2 and D6 in subbasin management group 3 and C4 in subbasin management group 2B, than will efforts in other PAUs located in management groups 2B, 2C or 3. The other PAUs have either low percentages of permeable soils or no mapped permeable soils, thus centralized facilities or integrated approaches may be a good alternative to onsite infiltration.

The watershed analysis completed for this Plan could serve as a foundation for supporting and promoting private, small-scale (lot specific) retrofits. City support

of these types of retrofits could include education and design assistance as part of the City's SWMP.

Which watershed processes would the recommendation benefit?

A variety of watershed processes may benefit from recommended actions for LID approaches and retrofit actions on small lots. Reductions in impervious surfaces can increase recharge of groundwater, which can reduce discharges that create extreme erosion or flooding. Additionally, a reduction in impervious surfaces will increase storage, thus decreasing the total volume of runoff in a basin. Providing storage can attenuate peak flows.

Table 6-1 describes some commonly used small-site management strategies and the watershed processes each can influence. These strategies may also be included as components of Large Site and Centralized strategies

Table 6-1. Onsite management strategies and watershed processes. A bold "X" indicates strategy primarily benefits the key watershed process, a small "x" indicates minor benefits to that watershed process

Onsite Management Strategy	Key Watershed Process			
	Delivery	Surface Storage	Recharge	Water Quality
Soil amendment/restoration	**X**		x	x
Preserve, Restore, and Plant Vegetation	**X**	x		x
Rain gardens	**X**	x	**X**	**X**
Vegetated filter strips	**X**		x	**X**
Disconnect downspouts	**X**		**X**	**X**
Cisterns / Rain Barrels		x		

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups city-wide, though are likely most appropriate for Management Groups 2B, 2C and 3.

Large Site and Centralized Strategies

Large site and centralized strategies are intended to cover projects that would serve areas greater than a single site (i.e., greater than 2,000 square feet of new impervious area and / or greater than 11,000 square feet of grading) and would require detailed analysis and engineering design. These strategies would likely involve large residential and/or commercial development projects, most likely with improved public rights-of-way and/or facilities that would be owned and

maintained by the City. Projects would likely be constructed by developers; however could also be funded as a Capital Improvement Projects and may be incorporated into street or other City facility improvement plans. These projects may also include restoration projects if they have grading impacts that exceed 11,000 square feet.

SW-4 Action – Establish Flow Control Exemption

Create a flow control exemption for portions of the city that are predominantly built-out and already drain directly to the Snoqualmie River through pipe or ditch infrastructure.

What does the Duvall Municipal Code require now?

Currently, the entire city is governed by DMC 9.06, which adopts by reference the KCSWDM. In the KCSWDM, flow is controlled either through a site-level or project-level approach (Section 1.1.). Stormwater runoff standards differ depending on the size of the development/redevelopment, natural site conditions, and amount of stormwater runoff generated. Generally, new development projects are not allowed to create a new drainage problem (i.e., increase peak flows or volumes so that after development the frequency of conveyance overflows or water surface elevation exceeds the thresholds). For most projects in Duvall, the Conservation (Level 2) flow control standard requires matching half of the 2-year to the 10-year peak flow flow for pre-developed (forested) conditions. When projects or portions of projects cannot be met by discharging to a LID BMP, the flow control BMPs must supplement or otherwise provide flow mitigation where flow control facilities are not required (Section 5). Projects that discharge to the Snoqualmie River floodplain via less than ¼ mile of improved flowpath (pipes or ditches) are flow control exempt per section 1.2 of the KCSWDM.

How should the code be changed?

Portions of the city already drain directly to the Snoqualmie River through pipes or ditches. Discharges from this limited area do not adversely impact local stream bed and banks and impacts on the Snoqualmie River are negligible. The City could create an expanded flow control exemption for projects in the highly developed Management Group 3 PAUs to incentivize the increased use of LID BMPs. The City could also consider development of a program to provide stormwater control transfer to focus rehabilitation in priority PAUs, maximizing environmental benefit. This program could be modeled on the City of Redmond's Stormwater Control Transfer Program (SWCTP), or could include other program elements that consider specific issues associated with new and existing development in Duvall.

The first step in developing an expanded flow control exemption approach for the City is to delineate the area that is currently exempt in accordance with KCSWDM standards and a new expanded area that would be exempt from flow control.

Discharge from this area should be modeled to better understand the impacts to receiving waters. Water quality requirements for pollution generating surfaces would not be included in the exemption. Likely the program would require enhanced water quality treatment through use of integrated LID BMPs.

The recommended change in code to allow for this program would apply to DMC 9.06 and the Public Works Development Design Standards. Additionally, feasibility of the program needs to be evaluated.

Which watershed processes would the recommendation benefit?

Water flow and quality processes in the priority watersheds receiving the transfer may be improved depending on how the program is implemented.

Where would this apply in Duvall?

This recommendation applies to PAUs D2, D4 and D6 within Management Group 3.

SW-5 Action – Explore Centralized Facilities within Urban Growth Areas

In urban growth areas, create centralized stormwater facilities to off-set onsite detention requirements.

What does the Duvall Municipal Code require now?

While DMC 9.06 does not prohibit centralized approaches for stormwater management, the code also does not require or establish a preference for such facilities. Areas where large amounts of new development are anticipated (including urban growth areas upon annexation) would be developed under the same stormwater standards as all other areas within the City.

How should the code be changed?

DMC 9.06 could be updated to require centralized stormwater facilities when an urban growth area is being incorporated, to offset localized detention requirements. Infiltration ponds could be used in PAU C5 and possibly C4, where there is open space and high infiltration capacity. Detention ponds are an alternative in urban growth areas where space is available and soils are less permeable, such as PAUs in subbasin management group 2C (PAUs C6 and W3). Infiltration chambers, infiltration vaults and detention vaults are other alternatives that may be sized appropriately for combined use. This action is a lower priority strategy, as it may be infeasible in a portion of the City's urban growth areas.

Which watershed processes would the recommendation benefit?

A variety of watershed processes may benefit, depending on which centralized strategies are implemented. Table 6-2 describes some centralized management strategies and the watershed processes each can influence. Centralized facilities can improve water quality.

Table 6-2. Summary of watershed processes influenced by centralized strategies. A bold "X" indicates strategy primarily benefits key watershed process, a small "x" indicates minor benefits to that watershed process

Centralized Strategy	Key Watershed Process			
	Delivery	Surface Storage	Recharge	Water Quality
Detention/retention pond		**X**		**X**
Constructed wetlands		x		**X**
Restore depressional wetlands		X		**X**
Permeable pavement	**X**		X	**X**
Bioretention cells and planters	x	x	X	**X**
Bioretention swale	**X**		X	**X**

Where would this apply in Duvall?

These recommendations should apply to subbasin management groups 2B and 2C in the urban growth area.

Additional strategies

Strategies that benefit hydrologic and water quality processes, but are not covered in stormwater regulations are detailed in this section.

SW-6 Action – Incentivize Stormwater LID Standards

Create and incentivize stormwater LID standards.

What does the Duvall Municipal Code require now?

No incentive program currently exists. Residents and developers are encouraged to use LID BMPs to meet standards described in the KCSWDM.

How should the code be changed?

LID BMPs could be encouraged throughout the city using an incentive program. The first step is to determine what incentives are feasible for the City. Incentives that

could be considered include a relaxation of buffer limits for sensitive areas (especially in PAUs within subbasin management groups 2C and3), or allowances that provide additional development opportunity within a given site (density increases, increased lot coverage, or other similar strategies). Additionally, the City could facilitate certification of LID BMPs for development such as "Salmon-Safe," "sustainable sites," and "Living Futures".

Credits could be associated with the percentage of runoff expected to infiltrate. A reasonable expectation for infiltration in permeable soils in this region is 90 percent.. A lower infiltration percentage may be an appropriate target for the tighter, less permeable soils generally encountered in Duvall. Credit could be given for infiltration in excess of that in coarse soils. An example of this method was developed for the Birch Bay (Whatcom County) LID Manual, which was never adopted and made public by the County (see Figure 6-1). Alternatively, LID BMPs in these soils could be focused on water quality and credits could be based on the percentage of water treated instead of the percentage infiltrated.

Figure 6-1. Example of credit system for onsite stormwater management, as developed for the un-adopted Birch Bay LID Manual.

Percentage of Property Set Aside as a Permanent Open Space Reserve Area[1]				
Within UGA	< 10 %	10 – 20 %	> 20 %	Conservation Easement or Non-Building Tract
Outside of UGA	< 50 %	50 – 65 %[3]	> 65 %	
Points Received	0 points	6 points	12 points	+ 4 points[2]

An incentive system in the City of Duvall could be developed to incorporate several actions and options discussed within this chapter. For example, utilization of SW-4 (flow control exemption) could be approved only when it can be demonstrated that a minimum number of LID BMP's "points" have been included as part of the project. Additional incentives for including LID BMP's "points" could include: credit against the Storm Drain Area Charge applied at final plat; accelerated review, reductions in staff charges for stormwater-related review fees; increased density or allowances for smaller lots; or other incentives that promote development consistent with Comprehensive Plan policies while encouraging implementation of effective stormwater LID techniques. The incentive program could be established in DMC 9.06.

Which watershed processes would the recommendation benefit?

As described for Action SW-1, a variety of watershed processes may benefit, depending on which LID BMPs are implemented.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups city-wide.

SW-7 Action – Improve Standards for Landscape Strips in Roadways

Incorporate new standards for landscape strips in roadways.

What does the Duvall Municipal Code require now?

Street and sidewalk regulations are described in DMC 14.34.040. Sidewalks in residential areas are generally 5-foot wide with a 5-foot wide landscape strip. Along primary pedestrian corridors within commercial and mixed use areas, sidewalks must be a minimum of 12 feet in width with 8 feet unobstructed by street trees or other features and 10 feet in width with 6 feet unobstructed for a secondary corridor. Planting areas must be a minimum of 5 feet wide as described in DMC 14.38.130 and must meet requirements for traffic and safety. New city streets are required to include curbs, sidewalks, lighting, street trees, and landscaping. Trees are recommended to be spaced every 30 feet.

How should the code be changed?

Adjust the landscape strip for street trees to be a minimum of 6-8 feet in width to ensure adequate space for successful growth, which would provide the added benefit of increased infiltration and retention of stormwater (SDOT, 2014). An incentive for wider landscape strips could include allowing the proposed increased direct discharge exemption or through providing open space credit when developers dedicate more area for landscape strips. In addition to providing more room for successful landscaping and tree growth, wider landscape strips also provide opportunities for LID stormwater approaches to be integrated into the streetscape.

For internal roadways (subcollectors, subaccess and minor access streets), allowing the sidewalk to be located adjacent to the curb-line, with the landscape area (standard 5-foot or consolidated 10-foot) adjacent to residential landscape areas would provide opportunity to maximize landscape width and viability. This approach could also be effective for roadways with dedicated on-street parking; in these instances, parking lane would provide a barrier between the pedestrian sidewalk and travel lanes of the roadway, and vehicle operators using on-street parking would have improved access (directly onto sidewalk as opposed to crossing

a landscape strip). For minor permanent roadways, including tracts or dead-end roads and cul-de-sacs serving less than 10 residences, sidewalk installation on one side of the roadway only could be considered as a developer incentive for installing LID BMPs.

An additional strategy could consider opportunities for allowing landscape strip consolidation on one side of the street to maximize available width, provided that street trees are planted within landscape buffer or private landscape areas on the other side of the street outside of the right of way. For streets where landscape strip consolidation is considered, driveways should be consolidated to the maximum extent feasible (maintaining the benefit of the wider landscape strip over the maximum extent of the right-of-way). Maintenance requirements to ensure vegetation success with landscape strips should also be considered, including enforcement of requirements for adjacent property owner (or home owner association) maintenance, and standards to ensure long-term plant survival and maintenance to prevent sight distance or sidewalk impacts.

Maintenance standards and responsibilities should be clearly described to ensure that landscaped areas and associated LID BMP's function as designed, operate effectively for the full design life, and are aesthetically pleasing. Duvall Municipal Code 8.02 requires property owners to maintain sidewalks and landscaping fronting their property. This requirement, along with the additional property owner or Owner's Association requirements to maintain common LID BMP vegetation, should be expanded to include minimum maintenance goals, standards, and annual LID BMP maintenance reporting requirements.

The greatest opportunities will be associated with new development, though standards could also be established for redevelopment. However, streetscape aesthetics, increased maintenance requirements (citizen and/or City), and potential implications for reduced developable property area should all be considered prior to updating DMC 14.43.040 should be made to provide the new standards for green infrastructure.

Which watershed processes would the recommendation benefit?

Providing increased infiltration opportunity along roadways allows for recharge of groundwater and attenuation of peak flows. By capturing a greater percentage of runoff from sidewalks, water quality may also be improved. Wider planted strips can also provide habitat opportunities (native trees and shrubs) and wider open space corridors.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups city-wide.

SW-8 Action – Create Educational Outreach Programs

Enhance the current City of Duvall NPDES educational outreach program to include workshops, informational handouts, and website updates on: stormwater quality, amended soils, rain gardens, native landscaping and rainwater harvesting, landscaping management best practices, and environmental stewardship.

What does the Duvall Municipal Code require now?

As required in the Phase II NPDES permit, a public education and outreach program was developed to reduce or eliminate behaviors and practices that may contribute to adverse stormwater impacts. Section S5.C.1 of the SWMP includes a program designed for residents, businesses, industries, elected officials, policy makers and employees of the City. The City measures improvements in audience comprehension of stormwater issues and adjusts how resources are spent to continuously improve behaviors. Educational and outreach activities include open houses, classroom presentations, providing resources on website, collection of hazardous waste, marking storm drains, and plans to develop an LID program.

How should the code be changed?

DMC 9.06 should be updated to reflect the educational and outreach programs to promote LID BMP use in the city that have been developed. The SWMP (2013) provides a number of actions that should continue and recommendations that should be pursued.

In addition, as part of this Watershed Plan, a LID Manual was created for the City (Appendix C). The purpose of the LID Manual is to provide guidance for residents in selecting LID BMPs appropriate for use in Duvall. For more detailed information on how to install and maintain the BMPs, existing relevant resources from other jurisdictions or organizations are referenced in the manual. The manual as well as links to the resources should be provided on the City website. Educational materials that could be created specifically for the City include brochures or information sheets that describe City regulations and standards. Additionally, the City could develop materials for target audiences such as landscaping services or streamside landowners to help prioritize education efforts.

Which watershed processes would the recommendation benefit?

This action would have an indirect effect on both flow and water quality processes. Increased storage of flow is a likely outcome of improved understanding and use of LID BMP tools. Providing surface water storage can attenuate peak flows. Additionally, encouraging local infiltration of stormwater can improve water quality by increasing residence time of water, giving stormwater more opportunity to interact with plants and the soil.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups city-wide.

6.3 Outcomes of Watershed Approach

Stormwater runoff creates many negative impacts on watershed processes. Generally, there is no one process affected by the decrease in infiltration and increase in peak flows associated with development. Considering a watershed approach when planning new development or redevelopment allows for impacts to stormwater to be minimized by balancing strategies across the city. This method provides opportunities for growth where such activities can be best absorbed and protects areas that can provide broader benefits for the watershed.

The next step is for the City to create a comprehensive Stormwater Strategies Plan that incorporates LID BMPs and provides more detailed prescriptions for updating stormwater code and programs. The Plan will set goals and targets for meeting stormwater management objectives to maintain and improve water processes city-wide.

CHAPTER 7. WATERSHED STRATEGIES FOR SENSITIVE AREAS MANAGEMENT

7.1 Sensitive Areas Strategies Overview

Objectives

Duvall Municipal Code (DMC) 14.42 (Sensitive Areas Regulations) regulates sensitive areas, including wetlands, fish and wildlife habitat conservation areas, geologic hazard areas, frequently flooded areas, and critical aquifer recharge areas. These regulations designate sensitive areas and prescribe development requirements that protect these resources, while allowing reasonable use of private property (DMC 14.42.010—Purpose). Sensitive areas discussed in this chapter include wetlands, fish and wildlife habitat conservation areas (including streams), and geologic hazard areas. Frequently flooded areas were excluded from discussion because they are adequately protected by the City's recently updated Shoreline Master Program (adoption anticipated in 2015), as well as through the City's compliance with Federal Emergency Management Agency guidance for protection of endangered species within floodplain areas. Critical aquifer recharge areas were also excluded from discussion because current DMC 14.42 standards provide adequate protections, and because mapped critical aquifer recharge areas are predominantly located outside of the city limits and urban growth area. Mapped critical aquifer recharge areas (shown as areas of medium susceptibility to groundwater infiltration) are generally located within the Snoqualmie River floodplain (PAU D3) and extend up upslope from the Cherry Creek floodplain (PAU C2) into the Cherry Creek Tributary C subbasin (PAU C5; see also City's existing critical aquifer recharge areas mapping: http://www.duvallwa.gov/DocumentCenter/View/105). In these limited areas within the city, existing critical aquifer recharge areas protections provided within DMC 14.42 will be strengthened further by implementing land use and stormwater management approaches recommended in this Plan.

The intent of this chapter is to provide management recommendations for revisions and additions to DMC 14.42 that reflect the results of the watershed characterization. These management recommendations will guide code revisions and assist the City with formulating new and modified code language to implement the goals and policies located in Chapter 3. Some recommendations will require further refinement and development of supporting material (e.g., rating forms) should the City choose to pursue these changes. Described below are what actions could be taken, where in Duvall they apply, what existing code and programs may be affected, and the outcomes to watershed processes.

Subbasin Prioritization Based on Watershed Analysis Results

Management recommendations are designed to: 1) strengthen existing sensitive areas regulations, 2) protect or restore subbasins the watershed characterization identifies as performing important hydrologic functions, and 3) direct development to subbasins that lack significant surface water storage functions (i.e., lack extensive depressional wetlands, unconfined floodplains, widespread permeable soils, and slope wetlands). The outcome of the recommendations would be to implement more restrictive regulations in subbasins ranked as having high importance while relaxing some restrictions for subbasins where hydrologic functions are impaired.

7.2 Implementing Watershed Approach for Sensitive Areas Standards

SA-1 Action – Identify and Protect Habitat Corridors

Identify and establish methods to create and protect fish and wildlife habitat corridors within all subbasin management groups.

What does the Duvall Municipal Code require now?

DMC 14.42 regulates fish and wildlife habitat conservation areas, including streams, but does not regulate fish and wildlife habitat corridors (DMC 14.42.310). The code specifies buffer widths based on several factors such as fish presence, proximity to development, and location within the watershed (DMC 14.42.320). Stream buffers may be reduced or averaged. For buffer reductions, buffers can be reduced to no less than 50 percent of the standard buffer (DMC 14.42.320.F) and 25 percent of the standard buffer when averaging the buffer (DMC 14.42.320.G).

How should the code be changed?

Establishment of fish and wildlife habitat corridors between sensitive areas and undeveloped land is important to maintain physical connections for fish and wildlife throughout the watershed and minimize habitat fragmentation city-wide. DMC should require a two-step process to identify and assess fish and wildlife habitat corridors: 1) establish a habitat corridor map that shows areas where site evaluation would be required; and 2) evaluate the onsite habitat corridor through addition of new criteria within DMC 14.42 and/or use of a rating form.

The City should adopt a fish and wildlife habitat corridors map that identifies habitat corridors located city-wide. Figure 7-1 presents a fish and wildlife habitat corridors map, with corridors established along stream riparian corridors, wetland areas, and forested upland areas within the city. These areas link remaining habitat areas within Duvall and to surrounding habitat areas around the city. The map

identifies 350-foot wide habitat corridors throughout the city and urban growth areas[1]. A standardized corridor width, as opposed to a corridor width that varies dependent on the width of continuous native vegetation, will reduce confusion for property owners and the City in determining whether a development site is located within or outside of a corridor.

Developments proposed within a fish and wildlife habitat corridor should be required to evaluate the onsite habitat corridor using additional criteria integrated into DMC 14.42.300 (standards for fish and wildlife habitat conservation areas), or through use of a habitat corridor rating form[2]. Evaluation would consider: size of habitats, number of vegetation community types, interspersion, distance to roads, and presence of priority species, among other criteria. Once the habitat corridor has been evaluated, the permit applicant should meet with the City to discuss the development proposal and onsite habitat conditions, and to determine options to protect existing habitat conditions and/or restore a portion of the property to improve or re-establish the habitat corridor (i.e., plant native coniferous trees). In addition to the habitat ratings, the City should consider the scale of the proposed development (e.g., short plats, preliminary plats, multi-family residential or commercial structures[3]) to ensure that habitat corridor protection requirements are consistent with the intensity of the proposed land use and the scale of alteration to the existing habitat corridor. For example, redevelopment or short plat proposal occurring as in fill development typically have fewer alternative siting options and have a relatively lower level of impact on surrounding habitat than large-scale developments). As with other sensitive areas, the reasonable use allowance should apply for habitat corridors where standard application for habitat corridor protections would deny all reasonable use of a property.

Development proposals located outside of mapped fish and wildlife habitat corridors, but located adjacent to mapped corridors, should not be required to evaluate onsite habitat conditions. The permit applicant should, however, work with the City to either minimize impacts to existing vegetation or restore onsite habitat.

For residential subdivisions and other developments requiring dedication of open space, the City should integrate habitat corridor protections with open space and tree protection requirements. Standards should be developed to encourage

[1] Habitat corridors totaling 350 feet in width typically provide sufficient area for many species of wildlife to migrate, breed, and forage (Hennings and Soll, 2010).

[2] A habitat corridor rating form has not been developed at this stage but would be created once the City begins to develop regulations pertaining to habitat corridors.

[3] Habitat corridor protection criteria for specific development activities would be identified during development of habitat corridor regulations. In general, habitat corridor regulations would be developed to be consistent with existing land cover and land use conditions and the intensity of proposed land use.

protection of significant trees within preserved habitat corridors, as well as providing new allowances for required community open space and rear-yard setbacks to be incorporated within preserved habitat corridors, Encouraging tree protection within habitat corridors could be achieved by providing additional credit for preservation of significant trees within these areas. These and other opportunities to incentivize and integrate habitat corridor protections with other development regulations should be considered by the City during code development.

These recommended additions would apply to multiple subsections in DMC 14.42.300-14.42.370.

Which watershed processes would the recommendation benefit?

Habitat corridors provide fish and wildlife with breeding, foraging, and resting opportunities and also perform multiple ecological functions for the greater watershed. Corridors offer wildlife dispersal and landscape linkages to more intact and significant habitat areas. These corridors also allow for the maintenance of or increase in biodiversity, and help sustain the viability of the watershed by maintaining ecological functions, such as: species migration, nutrient recycling, life cycle links, and habitat for resident species.

Fish and wildlife habitat corridors are not intended to preclude development, but are local amenities that not only support wildlife populations but enhance the quality of life for Duvall's citizens.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups located within Duvall.

SA-2 Action – Increase Protections for Depressional Wetlands

Identify additional regulatory mechanisms to increase protection of depressional wetlands.

What does the Duvall Municipal Code require now?

Wetland buffer widths are determined by habitat function points calculated from the Washington State Wetland Rating System for Western Washington rating system. DMC 14.42.210.B & C allow for buffer reductions and buffer averaging, respectively, if certain criteria are met. Typically, up to 25 percent of the standard buffer can be reduced for Category I and II wetlands and up to 50 percent for Category III and IV wetlands. A variance process is also in place to provide relief from wetland protections and buffer regulations under special circumstances and when specific criteria are met.

How should the code be changed?

Allowances for averaging and reduction of depressional wetland buffers should be updated consistent with recommendations within SA-5. New restrictions for limiting reduction of wetland buffers within Management Groups 1, 2A, 2B and 2C (as recommended by SA-5 applicable to all wetlands) will support protection of the hydrologic functions associated with depressional wetlands, as well as the habitat functions provided by these aquatic resources.

Actions SA-2 and SA-5 both relate to protections and allowances for wetlands; recommendations for updates to existing sensitive areas standards for wetlands should be considered comprehensively. Removing and/or limiting allowances for buffer reductions or averaging (as recommended by SA-5), as opposed to only limiting allowances for buffer modifications and use, would better preserve the hydrologic, water quality, and habitat functions associated with depressional wetlands.

In addition to regulations that pertain directly to depressional wetland buffers, the City's Sensitive Areas Ordinance should encourage development techniques, such as LID, that maintain a wetland's ability to store surface water (see Chapter 6). To maintain site hydrology post-development, the City should require permit applicants to analyze pre- and post-development hydrologic conditions and assess whether the proposed site design supports a stable wetland hydrologic regime. These recommended additions would apply to DMC 14.34.030 (Grading, stormwater management and site coverage). See Figure 7-2 for mapped wetlands.

Which watershed processes would the recommendation benefit?

Most depressional wetlands provide multiple functions that benefit not only a particular site, but also downstream resources and the watershed as a whole. Most notably, depressional wetlands store water and moderate the flow of water down gradient. The water storage function can reduce downstream flooding after storm events and the erosive flows within stream channels. Depressional wetlands also recharge groundwater, which replenishes aquifers and supports stream flows during the dry months. Other functions provided by this wetland type include: removal of sediment, nutrients, and metals, along with providing suitable habitat for a variety of wildlife. The storage of stormwater and associated reduction in potential flooding, along with groundwater recharge and the removal of pollutants, benefit people and property located down gradient from areas with appreciable depressional wetland area.

Where would this apply in Duvall?

This recommendation applies to Management Groups 1, 2A, 2B, and 2C, which are generally located within the western and eastern city limits or urban growth areas. The Project Assessment Unit folio sheets identify subbasins that contain important surface storage processes and a significant extent of depressional wetlands (see Chapter 4).

SA-3 Action – Link Sensitive Areas Buffer Standards with Tree Protection

Revise wetland and stream buffer standards to more closely align with tree protection standards in order to conserve functions provided by wetland and stream buffers.

What does the Duvall Municipal Code require now?

Only dead, dying, or hazard trees are allowed to be removed from sensitive areas, sensitive areas buffers, or native growth protection areas (DMC 14.40.030.D). If removed, the material must be used for habitat purposes within the area and typically, at least one coniferous tree must be planted for each tree removed. Tree replacement may be made through an in-lieu fee in accordance with DMC 14.40.070.

DMC 14.40.050.B states that of the 35 percent of trees required for retention, a minimum of 3/4 of those trees can be located in sensitive areas or buffers; however if significant trees occur outside of sensitive areas, a minimum of ¼ of the total site significant trees to be saved must be located outside of sensitive areas. If all significant trees are in a sensitive area or buffer, all of those trees must be retained. In addition, the City has a preference for the retention of trees that are part of a grove that extend into sensitive areas buffers, among other preferences (DMC 14.40.060.A.3.d).

How should the code be changed?

Standards for tree protection should be integrated with sensitive areas provisions to encourage protection of significant trees (and associated habitat) adjacent to sensitive areas. Under current requirements of DMC 14.42, there is little incentive for developers not to maximize allowances for reduction of wetland, stream, landslide hazard, and severe erosion hazard buffers. Along with changes to significant tree counting allowances recommended by Action DS-7, the City should incentivize protection of trees within the outer (reducible) portion of sensitive areas buffers by allowing significant trees to be counted in these areas, and/or requiring an increased replacement ratio for any significant trees impacted within these areas.

Which watershed processes would the recommendation benefit?

Integration of wetland and stream buffer regulations with tree protection standards will improve stormwater storage and filtering within wetlands, wetland habitat, stream bank stability, increase stream nutrient input, moderate stream temperatures, and increase habitat structure and diversity.

In addition, establishment of fish and wildlife habitat corridors in proximity to forested wetland and stream buffers will provide additional protection of large tracts of mature trees, better enabling protection of functions associated with sensitive areas buffers.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups in Duvall.

SA-4 Action – Create Mechanisms to Protect Mitigation Sites

Establish a regulatory mechanism for long-term protection and management of mitigation sites for sensitive areas buffers.

What does the Duvall Municipal Code require now?

DMC 14.42.210 (Wetland buffer standards) and 14.42.320 (Fish and wildlife habitat conservation areas—Stream buffers) allows for the alteration of wetland and stream buffers through buffer reduction or buffer averaging. Sensitive areas regulations require a notice on title for plat and site plans to indicate limitations and restrictions on uses and actions affecting the sensitive area and/or buffer (DMC 14.42.100; Notice on title-plat map-site plan). This notice also requires specific responsibility by the owner for management of the sensitive area (DMC 14.42.100.A.2).

In addition, DMC 14.42.100.B states that sensitive area buffers and setbacks on plats, short plats, site plans and similar land use decisions must be placed in a tract to provide for permanent protection and integrated management of the sensitive area and buffer. The applicant must also submit proof that the notice, dedication or easement has been filed for public record before the City will approve any final plat or final site plan (DMC 14.42.100.D).

How should the code be changed?

At the federal level, the US Army Corps of Engineers requests that permittees place mitigation sites in a conservation easement or similar site protection mechanism (e.g., restrictive covenant). These site protection mechanisms are easier to legally enforce compared with tracts or notice to title, and should be the preferred protection mechanism required by the City's code for wetland or fish and wildlife habitat conservation area mitigation sites, and their associated buffers. Additionally, the code should require applicants to specify mitigation site performance standards for the wetland and stream, and also for their associated buffers.

These recommended changes would apply to DMC 14.42.100 (Notice on title-plat map-site plan), DMC 14.42.240 (Wetland Mitigation), and DMC 14.42.370 (Fish and wildlife habitat conservation areas—Management standards). See Figure 7-2 for mapped wetlands and Figure 7-3 for mapped streams.

Which watershed processes would the recommendation benefit?

Establishment of legally robust conservation easements, or similar site protection mechanisms, is necessary to protect wetlands and fish and wildlife habitat conservation area and their associated buffers. These protections will minimize

functional loss at the watershed level that is associated with buffer degradation and the accompanying wetland and fish and wildlife habitat conservation area degradation.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups in Duvall.

SA-5 Action – Create Buffer Allowances for each Subbasin Management Group

In order to avoid impacts to sensitive areas and preserve their buffers, prohibit buffer modifications to wetland and fish and wildlife habitat conservation area buffers in Management Groups 1 and 2A. Allow limited buffer modifications for Management Groups 2B and 2C.

What does the Duvall Municipal Code require now?

DMC 14.42.210.B & C allow for wetland buffer reductions and buffer averaging, respectively, if certain criteria are met. Typically, up to 25 percent of the standard buffer can be reduced for Category I and II wetlands and up to 50 percent for Category III and IV wetlands.

Similarly, stream buffers may be reduced or averaged. For buffer reductions, buffers can be reduced to no less than 50 percent of the standard buffer (DMC 14.42.320.F) and 25 percent of the standard buffer when averaging the buffer (DMC 14.42.320.G).

How should the code be changed?

Within Management Groups 1 and 2A, no buffer modifications to wetlands and fish and wildlife habitat conservation areas should be allowed, except through a variance process. These restrictions are intended to protect wetlands and fish and wildlife habitat conservation area and watershed-level functional processes in areas where these processes are most important (and frequently, most intact).

Within Management Groups 2B and 2C, buffer modifications (e.g., buffer reduction or buffer averaging) should become progressively more limited, as the conservation value of the Project Assessment Unit increases, to help preserve the water quality, water quantity, and habitat functions that these sensitive areas buffers provide. Alternatively, if buffer modifications continue to be permissible within Management Groups 1 and 2A, the extent of allowable buffer reduction or buffer averaging should be minimized (see Action SA-2).

Recommended reductions are consistent with 2012 Ecology guidance for protection of wetlands (updated in 2012 and can be found in *Wetlands and CAO Updates: Guidance for Small Cities, Western Washington Version*; Bunten et al., 2012). This guidance recommends limited allowances for reductions to standard buffer widths, and suggests that where proposed that an applicant should be required to demonstrate that a smaller

buffer will protect wetland functions and values, with additional mitigation measures applied where needed to support "no net loss" of those functions and values (Bunten et al., 2012 and Granger et al., 2005). Proposed updates to sensitive areas buffer reduction allowances within Duvall are consistent with Ecology guidance, and also incorporate an approach that considers watershed functions and ecological importance.

Recommended changes would apply to DMC 14.42.210 (Wetland buffer standards) and DMC 14.42.320 (Fish and wildlife habitat conservation areas—Stream buffers).

Which watershed processes would the recommendation benefit?

Eliminating wetland and stream buffer modifications Management Groups 1 and 2A and limiting buffer alterations within Management Groups 2B and 2C would preserve or sustain the functions provide by wetlands and streams and their associated buffers. Functions such as stormwater retention and flow control; filtering sediments, toxins, and nutrients; and providing feeding and breeding habitat are critical to sustaining ecological processes throughout the watershed. Strengthened wetland and stream buffer protections would indirectly benefit people by reducing stormwater flows and filtering pollutants.

Where would this apply in Duvall?

These recommendations should apply variably to Management Groups 1 and 2A and Groups 2B and 2C. Existing allowances for sensitive areas buffer reduction and alteration would be maintained within Management Group 3.

SA-6 Action – Link Open Space Standards to Watershed Protection

Encourage open space within subdivisions beyond the 10 percent requirement by also requiring reforestation, protection of existing trees, and enhancement of sensitive areas buffers in addition to providing open space for recreation. Other measures could include conservation of mature forests and limiting vegetation clearing.

What does the Duvall Municipal Code require now?

DMC 14.64.240 (Open space standards-Residential) states that open space must be distributed throughout the site. Ten percent of the developable area (not including sensitive areas or right-of-way) must be established as open space and neighborhood recreation facilities. However, DMC 14.64.242.D allows for a portion of the sensitive area to be counted toward open space; the portion that includes a trail in the outer portion of the sensitive areas buffer and that includes a small viewing area or seating area, and interpretive signage.

According to DMC 14.64.240.F, except for sensitive areas, the open space area must be a minimum width of 25 feet. The length of the open space area must be no more than twice the width unless approved by the planning director. Open space must

also include both passive and active spaces and should be centrally located within the neighborhood if provided for recreation.

How should the code be changed?

Current open space standards appear to be focused on the preservation of open space to support neighborhood recreation facilities. The current requirement for 10 percent open space of developable area should be refined to require 10 percent continuous open space or 15 percent open space throughout a site to encourage the preservation of undeveloped, *natural* land within a development, permit applicants should be required to implement additional conservation measures.

Of the 10 percent contiguous open space or 15 percent open space throughout a site, the City should require that at least 50 percent[4] contain existing native shrubs or trees.

In addition to this requirement, permit applicant should implement one or both of the following measures to protect or restore *natural* open space:

- Protect trees as open space; preferably large tract of mature trees adjacent to undeveloped areas, sensitive areas, or fish and wildlife habitat corridors and/or

- If the development of the property resulted in loss of forest cover, reforest the property with a variety of native tree species, preferably conifers.

Trails within the sensitive area buffers should be encouraged as a component of education where tree removal in buffers and other ecological disturbances due to trail construction can be avoided, minimized, and mitigated. Typically trails should be in the outer 25 percent of buffers but under certain parameters and mitigation measures may be allowed in the inner buffer.

The adjustments to the subdivision open space regulatory requirement would be designed to complement the fish and wildlife habitat corridor requirements, should the City decide to pursue both recommendations. These corridors would not only benefit wildlife and protect/enhance vegetation, but also improve the quality of the environment for people in the surrounding area.

These recommended changes and additions would apply to DMC 14.64.240 (Open space standards—Residential).

[4] See footnote 5.

An additional strategy could be to provide open space credit for open stormwater management features that are vegetated, resemble natural wetlands or ponds (including shallow side slopes and serpentine edges), and that provide public access through use of trails, boardwalks, and/or overlooks. Such facilities would need to be designed to minimize or eliminate maintenance requirements (for example, providing oversized sediment storage or pre-settling element so as to eliminate need for sediment removal, or keeping all control structures outside of naturalized areas to provide maintenance access). The City could consider greater allowances for such facilities within buffers associated with low functioning wetlands, especially within Management Groups 2B, 2C and 3.

Which watershed processes would the recommendation benefit?

Open space performs a multitude of functions within a watershed that benefit not only the functional processes of the watershed, but also the plants, wildlife, and people that live in proximity to the open space.

Open space ameliorates the local climate by reflecting and retaining less solar heat and by removing particulates from the air, particularly in association with stands of trees. Open space also offers opportunities for stormwater detention and flow attenuation, water quality improvements, groundwater recharge, soil retention, nutrient cycling, noise screening, and habitat for plants and wildlife. In addition to these watershed processes, which directly and indirectly benefit people, open space could be used by people as a source of food (e.g., community gardens) and also provide aesthetic value and recreational opportunities.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups in Duvall.

SA-7 Action – Improve Tree Protection for Geologic Hazards

Increase protection of geologic hazards through implementation of tree protection standards.

What does the Duvall Municipal Code require now?

DMC 14.42.420 (Geologically hazardous areas—General standards) regulates landslide hazard areas and erosion hazard areas, which comprise geologically hazardous areas (seismic hazard areas are not addressed in this review). The code states that site alterations must be directed away from portions of parcels that are subject to, or at risk from, geological hazards and their associated buffer. Only land that is partially located with the hazard area or buffer, as opposed to completely within, may be subdivided provided that several criteria are met (DMC 14.42.420.C).

DMC 14.42.420.E, F. G. H, I, J; DMC 14.42.430.A; and DMC 14.42.440.A and B place limitations or restrictions on allowable activities within geologically hazardous areas. In addition to these regulations, DMC 1442.430.C establishes landslide hazard

area buffer widths from the top-of-slope and toe-of-slope and also allows for reductions of up to 10 feet. In erosion hazard areas, buffers only apply to areas with severe surface erosion (DMC 14.42.440.C) and buffer areas are the same as those designated for landslide hazard areas (DMC 14.42.430.C).

How should the code be changed?

Apply tree protection standards in combination with existing geologic hazard regulations to strengthen protections.

Tree protections standards that help preserve large, mature tracts of trees located adjacent to geologic hazard areas would help maintain vegetative cover and mechanical stability of slopes (by means of the root matrix) in the vicinity of these hazardous area (e.g., top-of-slope or toe-of-slope). Preserving stands of trees and associated vegetation will also protect hazardous areas by restricting development in close proximity to geologic hazard areas.

In addition, reductions of landslide hazard area buffers should be discouraged. While the reduced buffer distance of 10 feet is relatively small, these buffers are established to protect slope stability, property, and life and therefore, should not be reduced unless it can be demonstrated that the reduced buffer does not impact slope stability. If reductions are granted within Management Groups 1 and 2A, the amount of reduced landslide hazard buffer area could be required elsewhere within the development to retain trees, increase habitat corridors, or provide increased stream or wetland buffer areas. Within Management Groups 2B, 2C, and 3, landslide hazard area buffer reductions could be approved without a requirement for compensation of reduced area.

These recommended additions would apply to multiple subsections of DMC 14.42.400-14.42.460.

Which watershed processes would the recommendation benefit?

Landslides and erosion have the potential to disrupt or degrade watershed processes, impacting water quality, water quantity, and habitat. Increased protection of landslide- and erosion-prone sensitive areas, stemming from the combination of habitat corridor regulations and tree protection standards, could minimize impacts to ecological functions within a watershed.

Strengthened geologically hazardous areas regulations could reduce impacts from erosion which can elevate sediment loads conveyed to wetlands and streams, impairing water quality and negatively affecting fish habitat. Stronger regulations also retain vegetation on landslide-prone slopes, which helps maintain slope stability. The loss of terrestrial habitat associated landslides disrupts wildlife corridors and foraging and breeding habitat.

Where would this apply in Duvall?

These recommendations should apply to all subbasin management groups in Duvall.

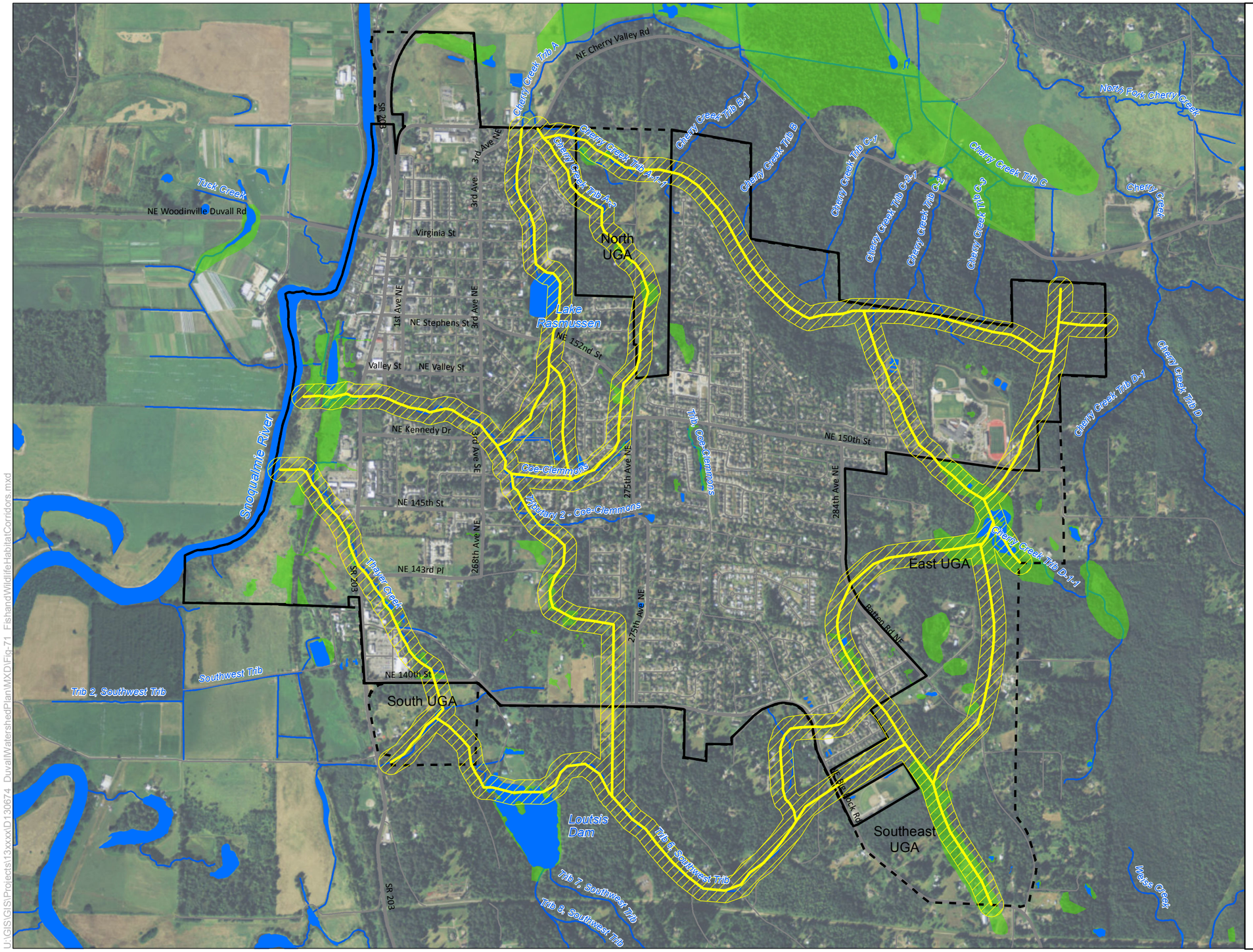
7.3 Outcomes of Watershed Approach

Integrating a watershed approach with DMC 14.42 will both strengthen the protection of relatively intact hydrologic processes within the city and foster a synergistic regulatory relationship between wetlands, Fish and Wildlife Habitat Conservation Area, geologic hazard areas, frequently flooded areas, and critical aquifer recharge areas. Increased restrictions for high conservation value subbasin management groups will protect, restore, and conserve hydrologic processes, which also support other ecological processes such as water quality and habitat functions. The overlap of sensitive areas regulations promotes the conservation of wetlands, Fish and Wildlife Habitat Conservation Area, and geologic hazards, and their associated buffers, not only sustaining site specific ecological processes, but those of the watershed.

Duvall Watershed Plan . 130674

Figure 7-1

Fish and Wildlife Habitat Corridors



Legend

- City Limits
- Urban Growth Area
- Fish & Wildlife Habitat Corridors
- Water Body
- Stream
- Wetlands

0 2,000 Feet

N

SOURCE: King County, 2014

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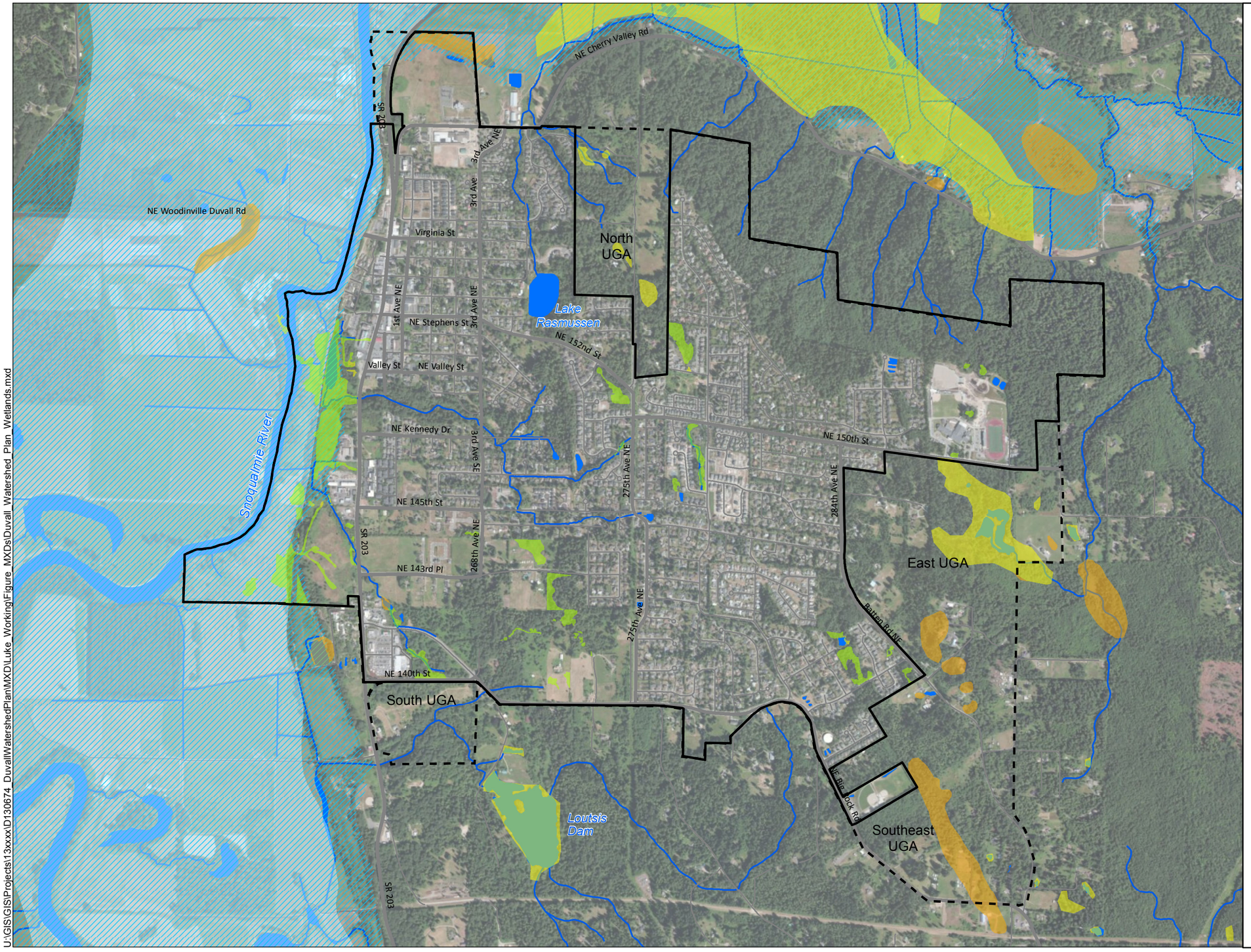
Duvall Watershed Plan . 130674

Figure 7-2

Wetlands



Legend

- City Limits
- Urban Growth Area
- Floodplain
- Floodway
- Water Body

Wetland Boundary Confidence Level

- High
- Medium
- Low

0 2,000 Feet

N

SOURCE: King County, 2013, 2014

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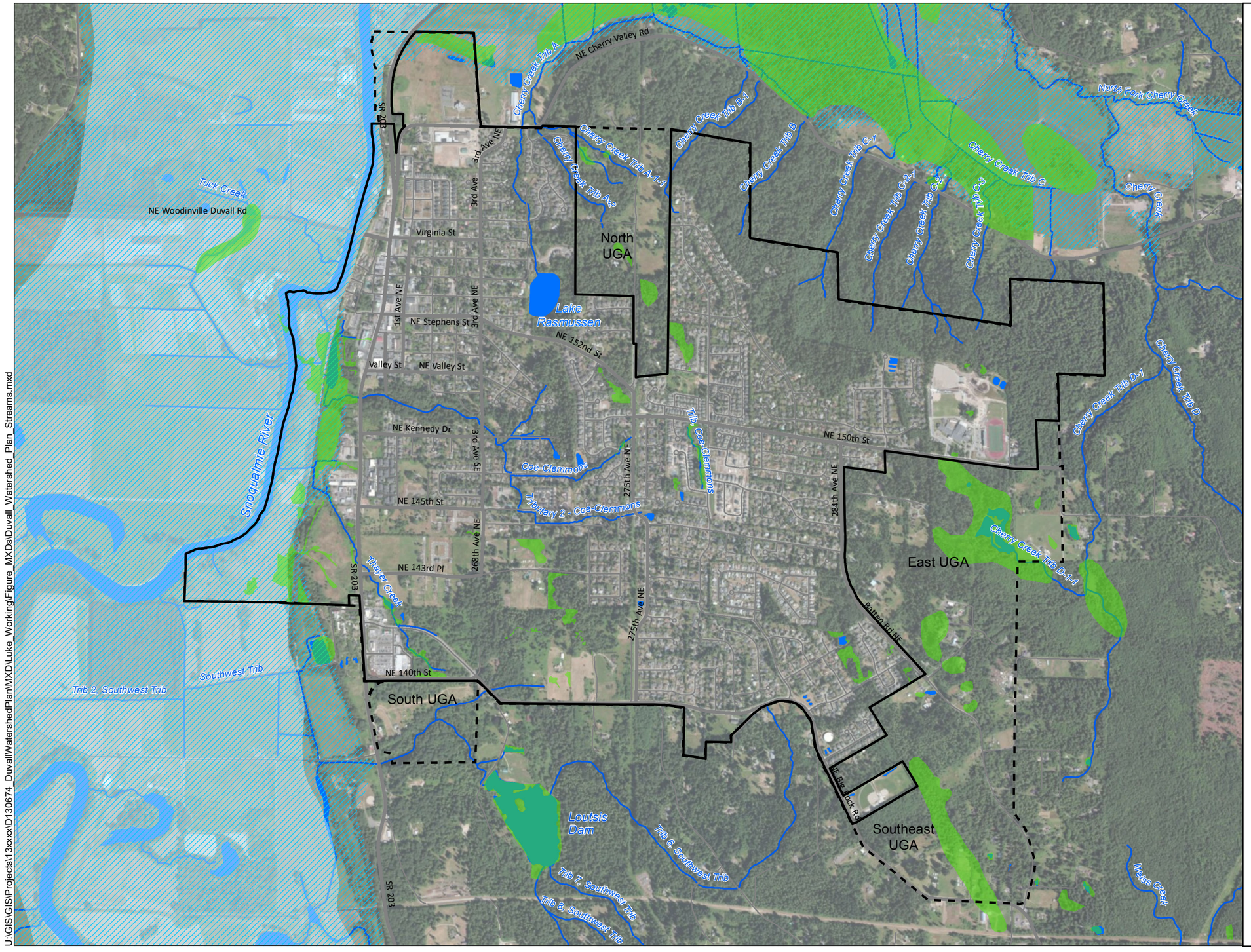
Duvall Watershed Plan . 130674

Figure 7-3

Streams



Legend

- City Limits
- Urban Growth Area
- Wetlands
- Floodplain
- Floodway
- Water Body

0 2,000 Feet

N

SOURCE: King County, 2013, 2014

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CHAPTER 8. LAND USE STRATEGIES FOR URBAN GROWTH AREAS

8.1 Urban Growth Area Land Use Strategies Overview

Objectives

A substantial portion of foreseeable future development is likely to occur in urban growth areas (UGAs) located to the north, east, and south of Duvall's current city limits. This chapter presents information on environmental constraints for these areas, as well as recommendations on where future development is appropriate based on watershed analysis results. The purpose of this chapter is to provide environmental information that will be assessed in the Duvall Comprehensive Plan Environmental Impact Statement (EIS). The EIS will evaluate UGA alternatives and associated ecological benefits and impacts, with recommendations developed as part of the Comprehensive Plan update that is currently underway. The Duvall Comprehensive Plan is a policy document that establishes goals and policies for the City's population and employment growth over the next 20 years. Based on the information provided here, the City can craft goals, policies, and Comprehensive Plan land use designations for its UGAs in a manner that is consistent with the watershed analysis results.

This chapter evaluates the City's UGAs as five separate areas and provides a description of existing conditions based on key watershed characteristics. Land use recommendations are provided based on the folio sheets in Chapter 4 for the applicable Project Assessment Units (PAUs). Actions for revising the Duvall Municipal Code identified in Chapters 5, 6, and 7 would benefit watershed processes in the UGAs and would apply to the UGAs upon annexation.

Areas Studied

This chapter presents information on existing UGAs and UGA reserves associated with the City, as well as additional areas that the City has considered as potential alternative UGAs. Potential alternative areas were identified based on proximity to existing City infrastructure, potential development capacity, and environmental constraints. Five areas are assessed in this chapter:

- North UGA (Section 8.2) – Extends across 88 acres adjacent to single-family residential areas in the northern portion of Duvall.

- East UGA Reserve (Section 8.3) – Extends across 200 acres to the east of Duvall, south of NE 150th Street and east of 248th Avenue NE.
- Southeast UGA Reserve (Section 8.4) – Extends across 126 acres to the southeast of Duvall, between NE Big Rock Road and Batten Road NE.
- South of City – Eastern Portion (Section 8.5) – Extends across 116 acres to the south of NE Big Rock Road and east of the existing Puget Sound Energy utility corridor; this area is not currently a UGA or UGA reserve.
- South of City – Western Portion (Section 8.6) – Extends across 71 acres to the south of Big Rock Road and west of the existing Puget Sound Energy utility corridor; this area is not currently a UGA or UGA reserve.

8.2 North UGA

The North UGA extends to the north of the corner of NE 152nd Street and 275th Avenue NE, and is surrounded by City jurisdiction to the west, south, and east. Annexation of the North UGA is more imminent than any other UGA around Duvall, and could occur in as soon as 2 to 3 years (Thomas, 2014).

Existing Conditions

The North UGA extends across approximately 88 acres occurring along 275th Avenue NE. The existing road access to the North UGA is from 275th, which extends north from its intersection with NE 152nd Street before dead-ending at the UGA northern boundary. Existing land use is rural residential development, with 8 single-family residences located on relatively large (5+ acre) lots. There are also several undeveloped, vacant lots.

Key information on existing watershed conditions within the North UGA is presented in Table 8-1. In order to determine potential environmental constraints from sensitive areas, Table 8-1 identifies the presence of wetlands, streams, and potential landslide and erosion hazards and the buffers associated with these sensitive areas as currently required by the Duvall Municipal Code. Two scenarios were assumed for calculating buffers, a minimum buffer scenario and a standard buffer scenario. See Figure 8-1 for the location of sensitive areas, sensitive area buffers (under both buffer scenarios), impervious surface, and forest cover in the North UGA.

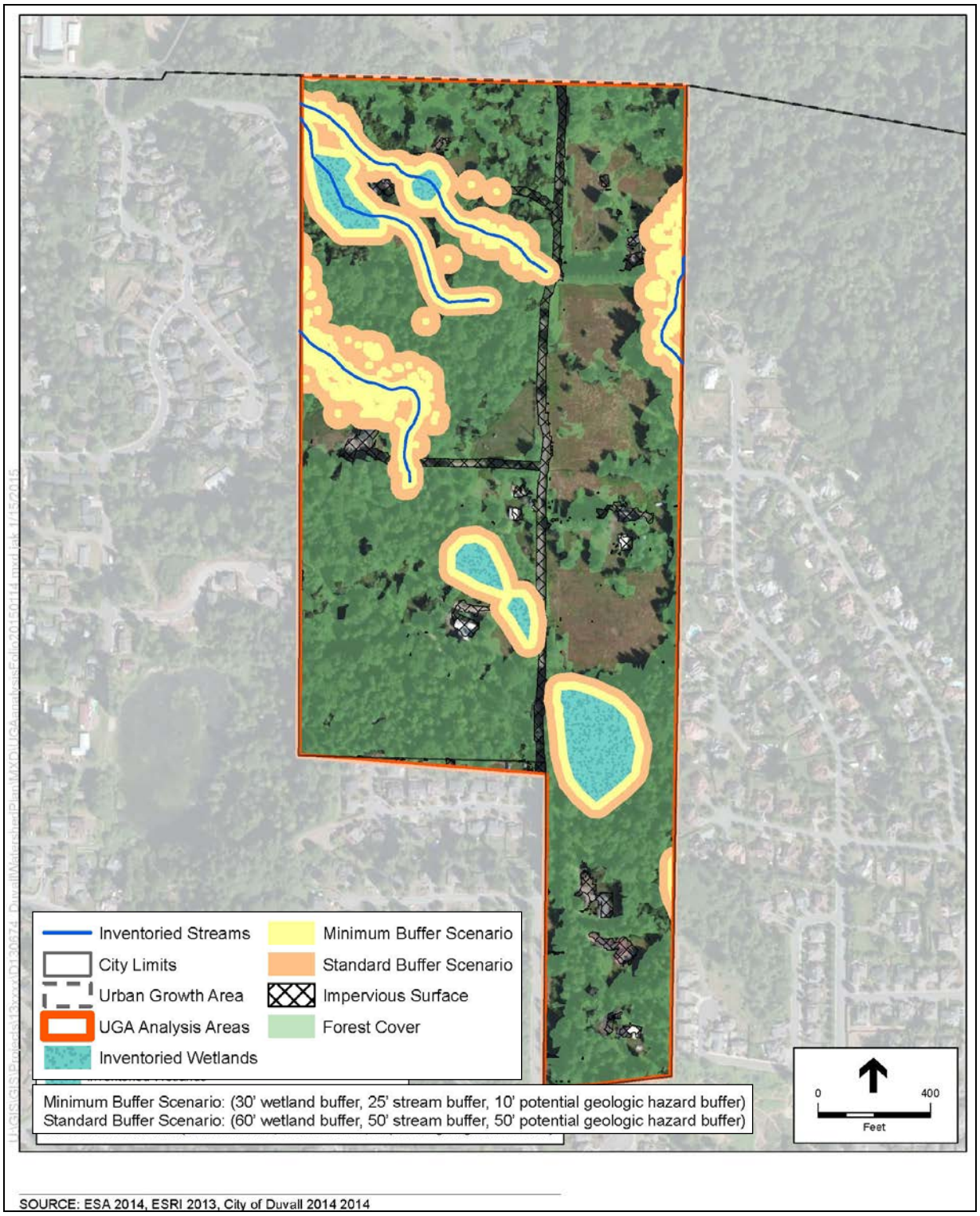
Table 8-1. Summary of North UGA Watershed Conditions

Subbasins	PAU C3 Cherry Creek A – 64.6 acres (73% of total area)	PAU C4 Cherry Creek B – 23.3 acres (27% of total area)
Subbasin Management Group	Group 2C Lowest Conservation	Group 2B Moderate Conservation
Forest Cover	69% of total area (including large majority of mapped wetlands and riparian corridors)	
Impervious Surface Cover	5% of total area (limited to existing roads and rural residential development)	
Mapped Sensitive Areas		
Wetlands	3 acres (4% of total area)	
Streams	Multiple tributary channels of Cherry Creek A subbasin (northwest portion of UGA) Segment of Cherry Creek B subbasin tributary along northeast edge of subbasin	
Potential Landslide / Erosion Hazards*	1 acre (1% of total area)	
Total area within Sensitive Areas and Associated Buffers**	Minimum Buffer Scenario as Allowed by City Code (30' wetland buffer; 25' stream buffer, 10' landslide / erosion hazard buffer)	Standard Buffer Scenario as Required by City Code (60' wetland buffer; 50' stream buffer, 50' landslide / erosion hazard buffer)
	12 acres (13% of total area)	21 acres (24% of total area)

*Identified for planning purposes only; slopes greater than 30% located within 150 feet of inventoried streams were identified as potential landslide/erosion hazards and buffered per requirements of Duvall Municipal Code 14.42.

**Minimum and standard buffer assumptions are based on existing sensitive areas buffer requirements of Duvall Municipal Code 14.42.

Figure 8-1. Sensitive Areas Buffers, Impervious Surfaces, and Forest Cover in the North UGA



Land Use Recommendations

The following are land use recommendations for the North UGA based on the watershed assessment results for PAU C3 (Cherry Creek A) and PAU C4 (Cherry Creek B):

- Apply standard buffer requirements to the existing riparian corridor and wetlands, especially those along tributary streams and Lake Rasmussen.
- Require use of LID approaches for water quality and water flow, especially those encouraging infiltration, as new development occurs in North UGA.
- Limit runoff from developed areas with increased pollutant loads discharging into Lake Rasmussen.
- Limit tree loss within contiguous forested areas in and around the streams located in the northwest portion of the North UGA and along the fish and wildlife habitat corridors identified in Figure 7-1.
- Require a master plan as part of the annexation process that identifies the most sensitive areas that should be set aside in a native growth protection area tract.
- Road design should avoid crossing streams, habitat corridors, and potential hazards. Roadway expansion and new roads should incorporate green infrastructure standards.

8.3 East UGA Reserve

Existing Conditions

The East UGA Reserve extends across approximately 200 acres to the east of Duvall, south of NE 150th Street and east of 248th Avenue NE. Existing land use is rural residential, with single-family residences occurring on relatively large (5+ acre) lots. There are also several undeveloped, vacant lots.

Key information on existing watershed conditions within the East UGA Reserve is presented in Table 8-2. In order to determine potential environmental constraints from sensitive areas, Table 8-2 identifies the presence of wetlands, streams, and potential landslide and erosion hazards and the buffers associated with these sensitive areas as currently required by the Duvall Municipal Code. Two scenarios were assumed for calculating buffers, a minimum buffer scenario and a standard buffer scenario. See Figure 8-2 for the location of sensitive areas, sensitive area buffers (under both buffer scenarios), impervious surface, and forest cover in the East UGA Reserve.

Table 8-2. Summary of East UGA Reserve Watershed Conditions

Subbasins	PAU C6 Cherry Creek D – 122 acres (60% of total area)	PAU W3 Upper Weiss Creek – 54 acres (26% of total area)
	PAU C5 Cherry Creek C – 17 acres (9% of total area)	PAU D7 Unnamed Southern Trib - Upper – 10 acres (4% of total area)
Subbasin Management Group	Predominantly Group 2A Highest Conservation (Cherry Creek D and Cherry Creek C) and Group 2B Moderate Conservation (Upper Weiss Creek); remaining area is in Group 2C Low Conservation	
Forest Cover	49% of total area (including large majority of extensive mapped wetland complex)	
Impervious Surface Cover	9% of total area (predominantly rural residential development and associated drives)	
Mapped Sensitive Areas		
Wetlands	43 acres (21% of total area)	
Streams	North segment of upper Cherry Creek D extends into wetland complex (wetlands are headwaters for Cherry Creek D).	
Potential Landslide / Erosion Hazards*	0 acre (0% of total area)	
Total area within Sensitive Areas and Associated Buffers**	Minimum Buffer Scenario as Allowed by City Code (30' wetland buffer; 25' stream buffer, 10' landslide / erosion hazard buffer)	Standard Buffer Scenario as Required by City Code (60' wetland buffer; 50' stream buffer, 50' landslide / erosion hazard buffer)
	41 acres (20% of total area)	49 acres (24% of total area)

*Identified for planning purposes only; slopes greater than 30% located within 150 feet of inventoried streams were identified as potential landslide/erosion hazards and buffered per requirements of Duvall Municipal Code 14.42.

**Minimum and standard buffer scenarios determined from existing sensitive areas buffer requirements of Duvall Municipal Code 14.42.

Figure 8-2. Sensitive Areas Buffers, Impervious Surfaces, and Forest Cover in East UGA Reserve

Land Use Recommendations

The following are land use recommendations for the East UGA Reserve based on the watershed assessment results for PAU C6 (Cherry Creek D) and PAU W3 (Upper Weiss Creek), which take up the large majority of the East UGA Reserve area:

- Limit future development throughout Cherry Creek D subbasin by working with King County to remove the area from the UGA Reserve. If adjustments to the UGA reserve boundaries are not feasible, create a new Comprehensive Plan designation that allows only low-intensity development. Prior to annexation, require a master plan that places the large forested wetland complex (with substantial buffers) in a conservation easement.

- Protect forested habitat corridors, including downstream flow pathways from wetland complex to Cherry Creek Tributary D streams and to Weiss Creek and along the fish and wildlife habitat corridors identified in Figure 7-1.

- Require use of LID approaches for water flow and water quality wherever development occurs in Upper Weiss Creek subbasin.

- For Upper Weiss Creek subbasin, avoid development near wetland complex and incorporate green infrastructure standards for expanded or new roadways and encourage onsite LID approaches.

8.4 Southeast UGA Reserve

Existing Conditions

The Southeast UGA Reserve extends across approximately 126 acres to the southeast of Duvall, between NE Big Rock Road and Batten Road NE. Existing land use is rural residential, with single-family residences on relatively large (5+ acre) lots. There are also several undeveloped, vacant lots.

Key information on existing watershed conditions within the Southeast UGA Reserve is presented in Table 8-3. In order to determine potential environmental constraints from sensitive areas, Table 8-3 identifies the presence of wetlands, streams, and potential landslide and erosion hazards and the buffers associated with these sensitive areas as currently required by the Duvall Municipal Code. Two scenarios were assumed for calculating buffers, a minimum buffer scenario and a standard buffer scenario. See Figure 8-3 for the location of sensitive areas, sensitive area buffers (under both buffer scenarios), impervious surface, and forest cover in the Southeast UGA Reserve.

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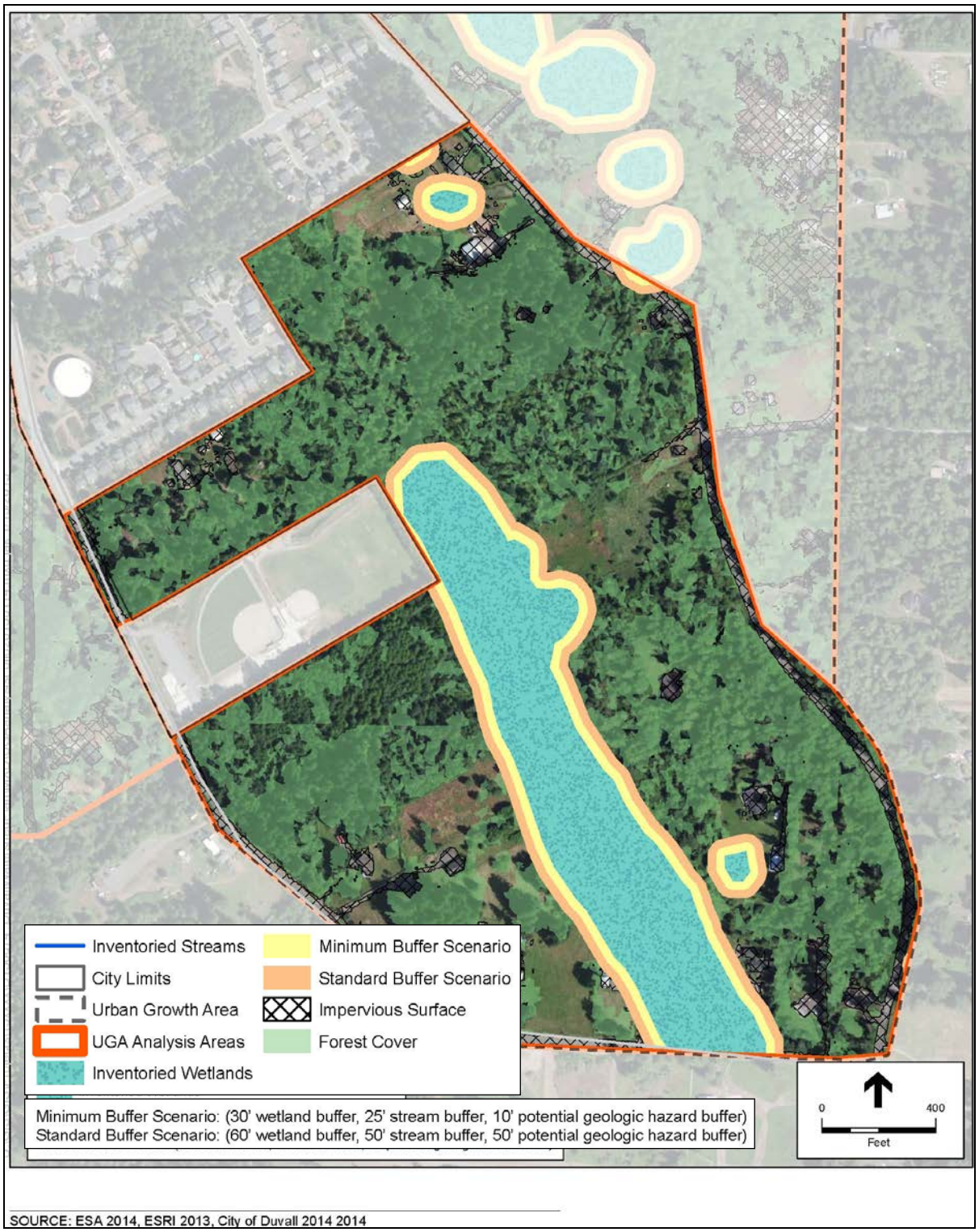
Table 8-3. Summary of Southeast UGA Reserve Watershed Conditions

Subbasins	PAU W3 Upper Weiss Creek – 103 acres (81% of total area)	PAU W1 Lower Weiss Creek – 14 acres (11% of total area)	PAU D7 Unnamed S. Tributary – Upper – 10 acres (8% of total area)
Subbasin Management Group	Predominantly Group 2B Moderate Conservation (Upper Weiss Creek); remaining areas Group 2A Highest Conservation and Group 2C Lowest Conservation.		
Forest Cover	45% of total area (including large majority of extensive mapped wetland)		
Impervious Surface Cover	8% of total area (predominantly rural residential development and associated drives)		
Mapped Sensitive Areas			
Wetlands	16 acres (13% of total area)		
Streams	Wetland complex is at headwaters for Weiss Creek – no mapped stream channels		
Potential Landslide / Erosion Hazards*	0 acre (0% of total area)		
Total area within Sensitive Areas and Associated Buffers**	Minimum Buffer Scenario as Allowed by City Code (30' wetland buffer; 25' stream buffer, 10' landslide / erosion hazard buffer)	Standard Buffer Scenario as Required by City Code (60' wetland buffer; 50' stream buffer, 50' landslide / erosion hazard buffer)	
	20 acres (16% of total area)	25 acres (20% of total area)	

*Identified for planning purposes only; slopes greater than 30% located within 150 feet of inventoried streams were identified as potential landslide/erosion hazards and buffered per requirements of Duvall Municipal Code 14.42.

**Minimum and standard buffer assumptions are based on existing sensitive areas buffer requirements of Duvall Municipal Code 14.42.

Figure 8-3. Sensitive Areas Buffers, Impervious Surfaces, and Forest Cover in Southeast UGA Reserve



SOURCE: ESA 2014, ESRI 2013, City of Duvall 2014 2014

Land Use Recommendations

The following are land use recommendations for the Southeast UGA Reserve based on the watershed assessment results for PAU W3 (Upper Weiss Creek), which takes up the large majority of the area:

- Limit future development to areas along Big Rock Road and Batten Road, well away from forested depressional wetland complex.
- Require use of LID approaches for water flow and water quality wherever development occurs. Roadway expansion and new roads should incorporate green infrastructure standards.
- Maintain forested habitat corridors in all directions, including downstream flow pathways from wetland complex to Weiss Creek and along the fish and wildlife habitat corridors identified in Figure 7-1.
- Require a master plan as part of the annexation process that identifies the most sensitive areas that should be set aside in a native growth protection area tract. This master plan could be done in conjunction with the East UGA Reserve.

8.5 South of City Limits – Eastern Portion

Existing Conditions

This eastern area south of city limits extends across approximately 116 acres to the south of NE Big Rock Road and east of the existing Puget Sound Energy utility corridor; this area is not currently part of the City's UGA or UGA Reserve. Existing land use is rural residential, with single-family residences located on relatively large (5+ acre) lots. There are also several undeveloped, vacant lots.

Key information on existing watershed conditions within the South of City Limits – Eastern Portion is presented in Table 8-4. In order to determine potential environmental constraints from sensitive areas, Table 8-4 identifies the presence of wetlands, streams, and potential landslide and erosion hazards and the buffers associated with these sensitive areas as currently required by the Duvall Municipal Code. Two scenarios were assumed for calculating buffers, a minimum buffer scenario and a standard buffer scenario. See Figure 8-4 for the location of sensitive areas, sensitive area buffers (under both buffer scenarios), impervious surface, and forest cover in the South of City Limits - Eastern Portion.

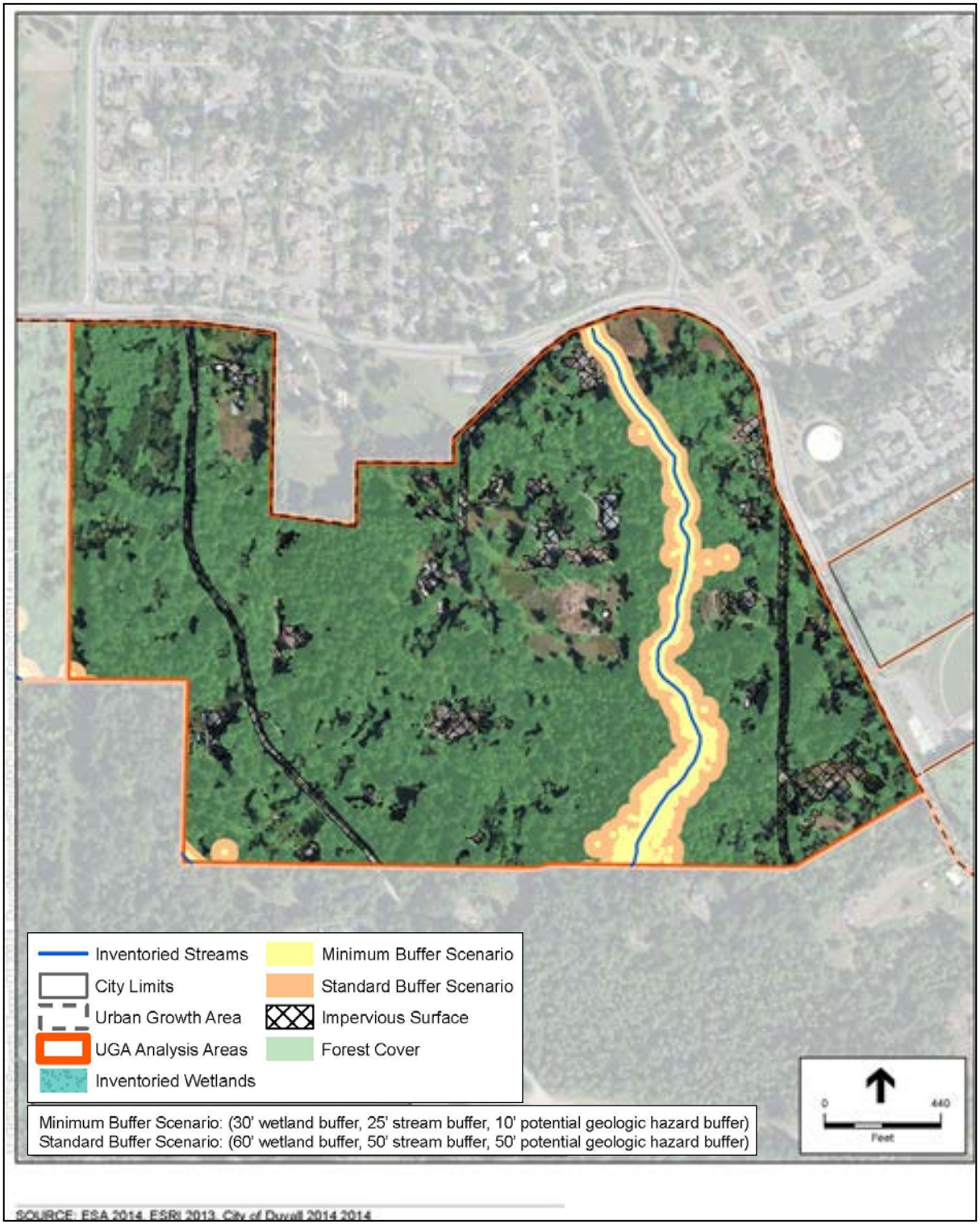
Table 8-4. Summary of Watershed Conditions in the Area South of City Limits – Eastern Portion

Subbasins	PAU D7 Unnamed S. Tributary – Upper – 111 acres (96% of total area)	PAU W1 Lower Weiss Creek – 0.9 acres (>1% of total area)	PAU D1 Unnamed S. Tributary – Lower – 4.2 acres (4% of total area)
Subbasin Management Group	Predominantly Group 2C Lowest Conservation (Unnamed Southern Tributary – Upper subbasin)		
Forest Cover	71% of total area (extensive forest cover includes all areas along Unnamed Tributary stream reach)		
Impervious Surface Cover	7% of total area (predominantly rural residential development and associated drives)		
Mapped Sensitive Areas			
Wetlands	0 acre (0% of total area)		
Streams	Unnamed Southern Tributary stream channel flows across the eastern portion of the area		
Potential Landslide / Erosion Hazards*	1 acre (1% of total area)		
Total area within Sensitive Areas and Associated Buffers**	Minimum Buffer Scenario as Allowed by City Code (30' wetland buffer; 25' stream buffer, 10' landslide / erosion hazard buffer)	Standard Buffer Scenario as Required by City Code (60' wetland buffer; 50' stream buffer, 50' landslide / erosion hazard buffer)	
	4 acres (4% of total area)	9 acres (8% of total area)	

*Identified for planning purposes only; slopes greater than 30% located within 150 feet of inventoried streams were identified as potential landslide/erosion hazards and buffered per requirements of Duvall Municipal Code 14.42.

**Minimum and standard buffer assumptions are based on existing sensitive areas buffer requirements of Duvall Municipal Code 14.42.

Figure 8-4. Sensitive Areas Buffers, Impervious Surfaces, and Forest Cover in the South of City Limits – Eastern Portion



Land Use Recommendations

The following are land use recommendations for the South of City Limits – Eastern Portion based on the watershed assessment results for PAU D7 (Unnamed Southern Tributary – Upper), which takes up the large majority of this potential UGA area:

- Require use of LID approaches for water flow and water quality, especially those encouraging infiltration, as new development occurs.
- Road design should avoid crossing streams, habitat corridors, and potential hazards. Roadway expansion and new roads should incorporate green infrastructure standards.
- Require a master plan as part of the annexation process that sets aside the predominantly forested segment of the unnamed tributary stream (with substantial buffers) in a native growth protection area tract. This master plan can be done in conjunction with the South of City Limits - Western Portion.

8.6 South of City Limits – Western Portion

Existing Conditions

This area extends across approximately 71 acres to the south of Big Rock Road and west of the existing Puget Sound Energy utility corridor; this area is not currently part of the City's UGA or UGA Reserve. Existing land use is rural residential, with single-family residences located on relatively large (5+ acre) lots. There are also several undeveloped, vacant lots.

The area includes the northern portion of the Loutsis Pond, which is an impoundment of the unnamed stream flowing through the Unnamed Southern Tributary subbasins. The pond is located at the southwestern edge of this potential UGA area. Key information on existing watershed conditions within the South of City Limits – Western Portion area is presented in Table 8-5. In order to determine potential environmental constraints from sensitive areas, Table 8-5 identifies the presence of wetlands, streams, and potential landslide and erosion hazards and the buffers associated with these sensitive areas as currently required by the Duvall Municipal Code. Two scenarios were assumed for calculating buffers, a minimum buffer scenario and a standard buffer scenario. See Figure 8-5 for the location of sensitive areas, sensitive area buffers (under both buffer scenarios), impervious surface, and forest cover in the South of City Limits - Western Portion.

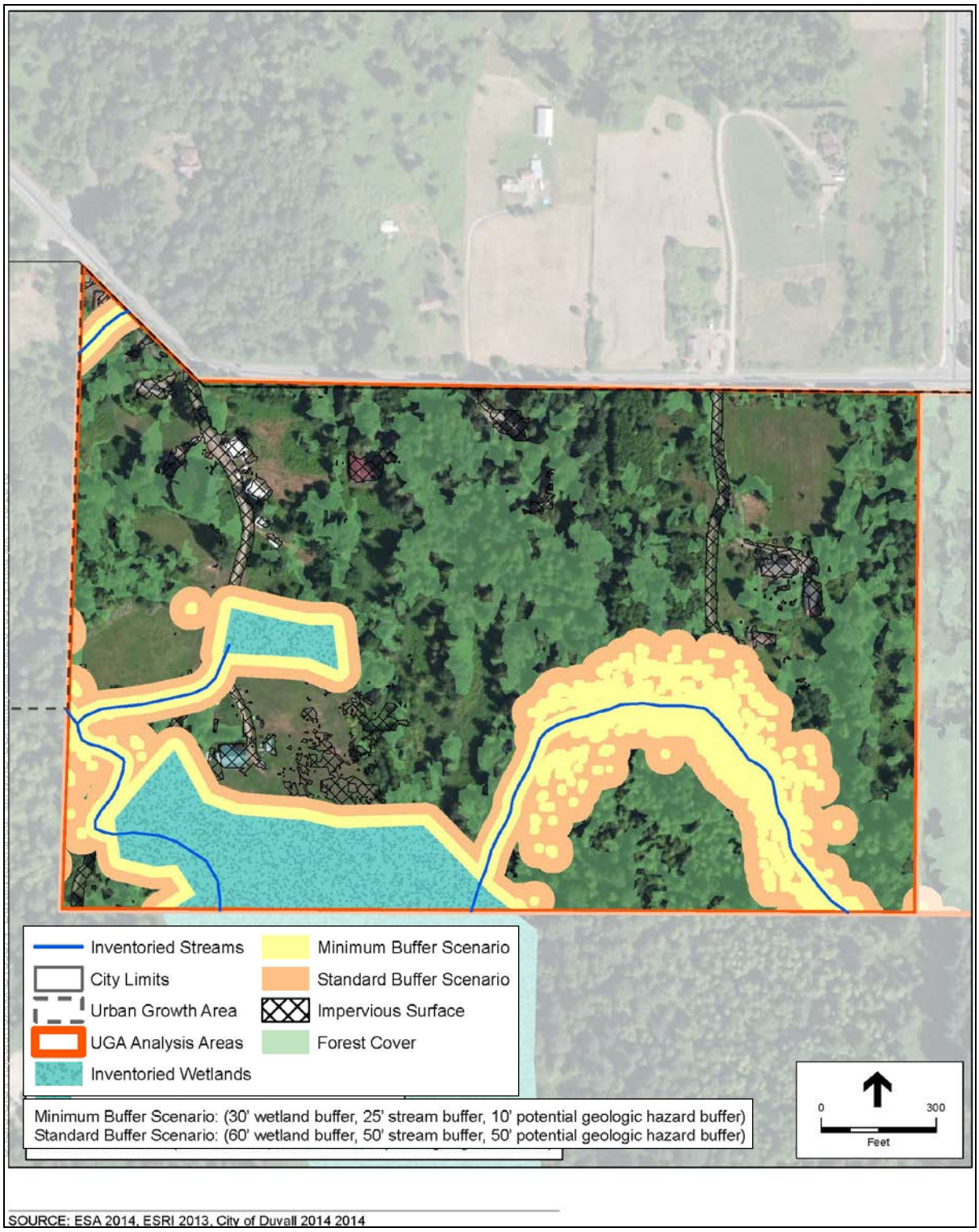
Table 8-5. Summary of Watershed Conditions in the Area South of City Limits – Western Portion

Subbasins	PAU D1 Unnamed S Tributary - Lower – 55 acres (78% of total area)	PAU D7 Unnamed S Tributary - Upper – 16 acres (22% of total area)
Subbasin Management Group	Group 2C Lowest Conservation	
Forest Cover	44% of total area (dispersed throughout area)	
Impervious Surface Cover	6% of total area (predominantly rural residential development and associated driveways)	
Mapped Sensitive Areas		
Wetlands	6 acres (8% of total area; includes Loutsis Pond)	
Streams	Unnamed Southern Tributary stream segments, including segment flowing through Loutsis Pond	
Potential Landslide / Erosion Hazards*	1 acre (2% of total area)	
Total area within Sensitive Areas and Associated Buffers**	Minimum Buffer Scenario as Allowed by City Code (30' wetland buffer; 25' stream buffer, 10' landslide / erosion hazard buffer)	Standard Buffer Scenario as Required by City Code (60' wetland buffer; 50' stream buffer, 50' landslide / erosion hazard buffer)
	14 acres (20% of total area)	22 acres (31% of total area)

*Identified for planning purposes only; slopes greater than 30% located within 150 feet of inventoried streams were identified as potential landslide/erosion hazards and buffered per requirements of Duvall Municipal Code 14.42.

**Minimum and standard buffer assumptions are based on existing sensitive areas buffer requirements of Duvall Municipal Code 14.42.

Figure 8-5. Sensitive Areas Buffers, Impervious Surfaces, and Forest Cover in South of City Limits – Western Portion



Land Use Recommendations

The following are land use recommendations for the South of City Limits – Western Portion based on the watershed assessment results for PAU D1 (Unnamed Southern Tributary – Lower) and PAU D7 (Unnamed S Tributary - Upper):

- Apply standard buffer requirements to the existing riparian forest along stream channels and surrounding Loutsis Dam pond.
- Require use of LID approaches for water quality and water flow, especially those encouraging infiltration, as new development occurs. Roadway expansion and new roads should incorporate green infrastructure standards.
- Require a master plan as part of the annexation process that sets aside the contiguous forested area along the streams and Loutsis Pond located in the southern portion of this potential UGA area in a native growth protection area tract. This master plan can be done in conjunction with the South of City Limits - Eastern Portion.
- Require a limnology study of the lake to determine baseline ecological conditions at the time of annexation and for future comparison ecological conditions that may be altered by subsequent development.

8.7 Outcomes of Watershed-based Planning for Urban Growth Areas

Applying a watershed approach to annexations and future developments will strengthen the protection of relatively intact hydrologic processes and support other ecological processes such as water quality and habitat functions. Evaluating developments at a subbasin scale will ensure that the most sensitive features of the subbasin are protected. Where almost any type of urban development is not appropriate, removing subbasins from a city's UGA or applying a Comprehensive Plan land use designation that allows only low land-use intensities will ensure long-term protection of intact watershed processes.

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Chapter 8 Land Use Strategies for Urban Growth Areas

Thomas, Lara. 2014. Planning Director, City of Duvall, Planning Department, Duvall, WA. Personal communication with Aaron Booy, ESA regarding timing of North Urban Growth Area annexation, October 14, 2014.

APPENDIX A

DUVALL DAYS SURVEY RESULTS MEMORANDUM

Appendix A

5309 Shilshole Avenue NW
Suite 200
Seattle, WA 98107
206.789.9658 phone
206.789.9684 fax
www.esassoc.com

memorandum

date June 17, 2015

to Lara Thomas, City of Duvall
Watershed Advisory Group

from Reema Shakra and Casey Rogers, ESA

subject City of Duvall Watershed Planning - Duvall Days Survey Results

On Saturday May 31, 2014, a survey was conducted at the watershed booth during the Duvall Days Festival, in Duvall, WA. The booth was hosted by the City of Duvall Department of Planning and Community Development, City of Duvall Public Works Department, Environmental Science Associates (ESA), Sound Salmon Solutions, Mountains to Sound Greenway, and Stewardship Partners. The purpose of the survey was to identify:

- Concerns Duvall community members have regarding the health of their watershed;
- Regulatory and voluntary approaches community members think the City should pursue to protect or improve the health of their watershed; and
- Actions that community members are already taking to preserve watershed functions and values.

The survey was also a tool to inform Duvall community members about approaches to protect or restore watershed processes. The survey was conducted electronically via Survey Monkey using an iPad and as hard copy handouts (see attachment 1). After the Duvall Days Festival, the survey was made available on the City's website, at the Watershed Open House on March 18, 2015, and at the Duvall Earth Day Celebration event on April 25, 2015. The survey consisted of 7 questions and solicited a total of 63 respondents. The majority of the respondents were residents (86 percent).

Key findings of the survey are identified as follows:

- In response to question #3, which asked people to indicate their level of concern for watershed issues, loss of fish and wildlife habitat, forest habitat and river and stream water quality were ranked as the highest concern.
- In response to question #4, which asked people to identify activities they have done to protect their watershed, more than 50 percent indicated that they had planted native landscaping, picked up and disposed pet waste, planted trees and washed their cars at car washes.
- In response to question #5, which asked people to identify actions they would like to see implemented, all actions listed were almost evenly selected, with planting trees ranked as the most popular action.
- In response to question #6, which asked people to select City actions that should be done, 67 percent (39 respondents) indicated that they would like the City to provide additional incentives for developers to build housing units with smaller footprints (cottages, townhouses, condos).

The survey results should not be construed as representing a broad range of opinions held by Duvall community members because of the limited number of respondents compared to the total population and the approach used to solicit participation. These results simply provide an overview of a select group of individuals' attitude towards the Duvall watershed. See attachment for more detailed survey results.

Attachments:

1. Survey Handout
2. Survey Results, Tabulated (question #7 contains personal information and is not included)

DUVALL WATERSHED CHARACTERIZATION PROJECT SURVEY

(Survey Intended For Duvall Residents Only)

1. What is your affiliation(s) in the community?

- ☐ Duvall Resident
- ☐ Business Owner
- ☐ Student
- ☐ Non-profit Group
- ☐ Riverview School District Faculty/Staff
- ☐ Other _____

2. Please tell us your zip code (as it applies to the affiliation listed above) _____

3. Please indicate your level of concern for each of these issues

	Not Concerned	Somewhat Concerned	Concerned	Very Concerned	N/A
Flooding and erosion in our rivers and streams	○	○	○	○	○
Water quality in our rivers and streams	○	○	○	○	○
Loss of fish and wildlife habitat and natural areas	○	○	○	○	○
Loss of forest habitat	○	○	○	○	○
Loss of agricultural lands	○	○	○	○	○

4. In the past two years which of the following have you (or someone in your household) done to protect your watershed (check all that apply)?

- ☐ Installed rain garden
- ☐ Installed rain barrel
- ☐ Planted stream bank vegetation
- ☐ Planted native landscaping
- ☐ Planted trees
- ☐ Serviced septic tanks every 3-5 years
- ☐ Washed car on grass
- ☐ Washed car at car wash
- ☐ Picked up and properly disposed of pet waste

5. What actions would you want to see implemented in your area (check all that apply)?

- ☐ Conserve land for public use
- ☐ Conserve land for natural vegetation and habitat
- ☐ Install rain gardens
- ☐ Install rain barrels
- ☐ Replace impervious surface with pervious pavers
- ☐ Plant river and stream bank vegetation
- ☐ Plant native landscaping
- ☐ Plant trees
- ☐ Educational stormwater signage

(Survey Continued on Back)

6. **What regulations or voluntary programs would you like the City to implement (check all that apply)?**

☐ Additional limits on impervious surfaces in City code

☐ Create narrower public streets with less pavement

☐ Conduct additional educational workshops on best practices for managing stormwater

☐ Provide additional incentives for developers to build housing units with smaller footprints (cottages townhouses, condos)

☐ Increase restrictions on tree removal in City code

7. **Would you be interested in hearing more about the Watershed Land Use Planning Grant?**

☐ Yes

☐ No

If yes, please provide your email address below.

_____

City of Duvall
Small Town. Real Life.

DEPARTMENT OF ECOLOGY
State of Washington

Department of Commerce
Innovation is in our nature.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

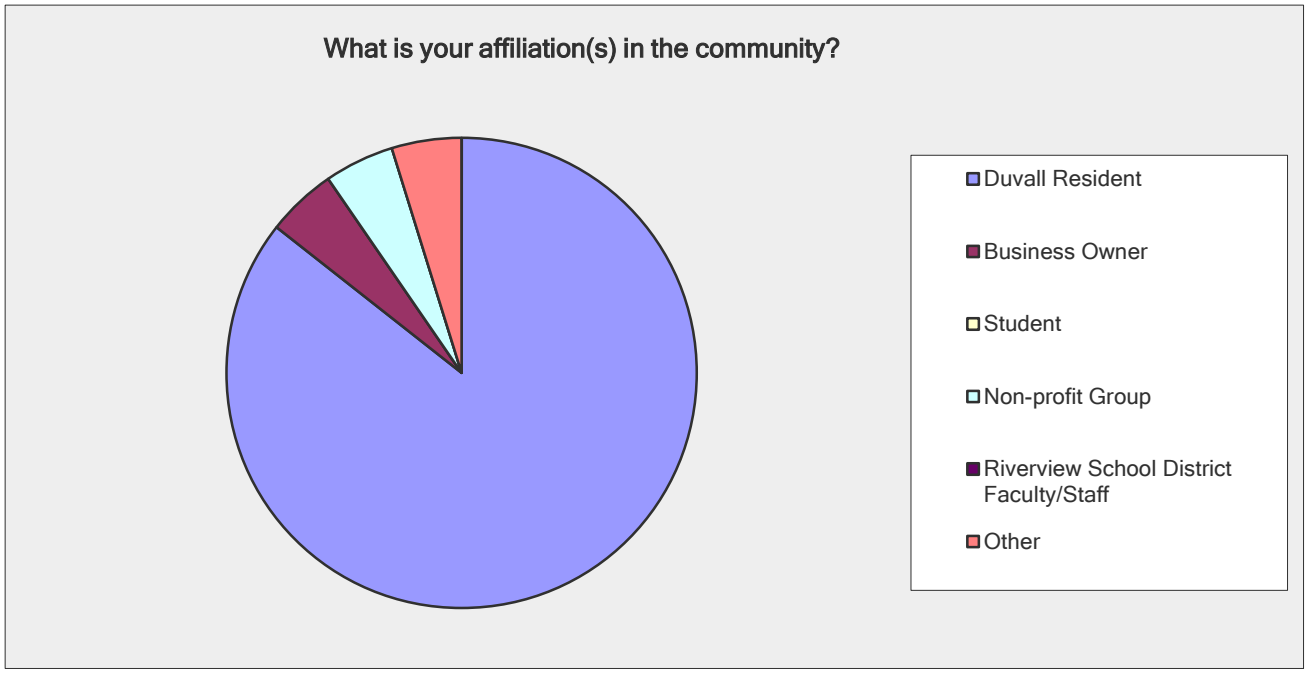
ESA

For More Information Contact Lara Thomas (425) 788 -2779

Duvall Watershed Characterization Project

1. What is your affiliation(s) in the community?

Answer Options	Response Percent	Response Count
Duvall Resident	85.7%	54
Business Owner	4.8%	3
Student	0.0%	0
Non-profit Group	4.8%	3
Riverview School District Faculty/Staff	0.0%	0
Other	4.8%	3
	answered question	63
	skipped question	0



Duvall Watershed Characterization Project

2. Please tell us your zip code (as it applies to the affiliation listed above)

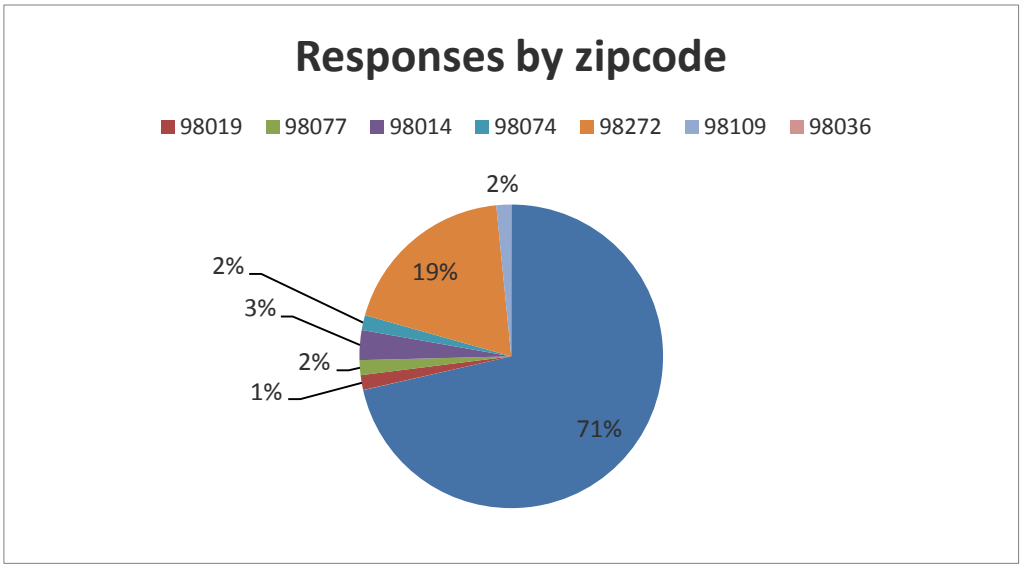
Answer Options	Response Count
	63
answered question	63
skipped question	0

Number	Response Date	Response Text	Categories
1	Jun 11, 2015 6:35 PM	98019	
2	Jun 11, 2015 6:34 PM	98019	
3	Jun 11, 2015 6:34 PM	98019	
4	Jun 11, 2015 6:31 PM	98019	
5	Jun 11, 2015 6:28 PM	98019	
6	May 1, 2015 3:41 AM	98019	
7	Apr 30, 2015 8:48 PM	98019	
8	Apr 30, 2015 4:55 AM	98019	
9	Apr 30, 2015 1:14 AM	98019	
10	Apr 29, 2015 10:25 PM	98019	
11	Apr 29, 2015 10:11 PM	98019	
12	Apr 29, 2015 9:39 PM	98019	
13	Apr 29, 2015 9:12 PM	98019	
14	Apr 29, 2015 8:50 PM	98019	
15	Apr 29, 2015 8:15 PM	98019	
16	Apr 29, 2015 8:14 PM	98019	
17	Apr 29, 2015 8:11 PM	98019	
18	Apr 29, 2015 7:55 PM	98019	
19	Apr 29, 2015 7:53 PM	98019	
20	Apr 29, 2015 7:30 PM	98019	
21	Apr 29, 2015 7:29 PM	98019	
22	Apr 29, 2015 7:12 PM	98019	
23	Apr 29, 2015 7:10 PM	98019	
24	Apr 29, 2015 5:35 PM	98019	
25	Apr 28, 2015 4:46 PM	98019	
26	Apr 16, 2015 1:03 AM	98019	
27	Apr 15, 2015 2:28 AM	98019	
28	Mar 19, 2015 3:23 AM	98077	
29	Mar 19, 2015 2:21 AM	98019	
30	Jun 4, 2014 6:09 PM	98109	
31	Jun 4, 2014 6:09 PM	98109	
32	Jun 4, 2014 6:08 PM	98109	
33	Jun 4, 2014 6:07 PM	98109	
34	Jun 4, 2014 6:06 PM	98109	
35	Jun 4, 2014 6:05 PM	98109	
36	Jun 4, 2014 6:04 PM	98109	
37	Jun 4, 2014 6:04 PM	98109	
38	Jun 4, 2014 6:02 PM	98109	
39	Jun 4, 2014 6:01 PM	98109	

Attachment 2
Watershed Planning - Duvall Days Survey Results
June 17, 2015

Number	Response Date	Response Text	Categories
40	Jun 4, 2014 6:00 PM	98109	
41	Jun 4, 2014 5:59 PM	98109	
42	May 31, 2014 8:08 PM	98019	
43	May 31, 2014 8:01 PM	98019	
44	May 31, 2014 7:56 PM	98019	
45	May 31, 2014 7:53 PM	98019	
46	May 31, 2014 7:14 PM	98019	
47	May 31, 2014 7:02 PM	98019	
48	May 31, 2014 6:55 PM	98036	
49	May 31, 2014 6:39 PM	98019	
50	May 31, 2014 6:26 PM	98019	
51	May 31, 2014 6:15 PM	98019	
52	May 31, 2014 6:12 PM	98019	
53	May 31, 2014 6:09 PM	98019	
54	May 31, 2014 6:06 PM	98014	
55	May 31, 2014 6:04 PM	98019	
56	May 31, 2014 6:02 PM	98272	
57	May 31, 2014 5:57 PM	98019	
58	May 31, 2014 5:40 PM	98019	
59	May 31, 2014 5:15 PM	98074	
60	May 31, 2014 5:12 PM	98074	
61	May 31, 2014 5:06 PM	98019	
62	May 31, 2014 4:51 PM	98019	
63	May 31, 2014 4:35 PM	98019	

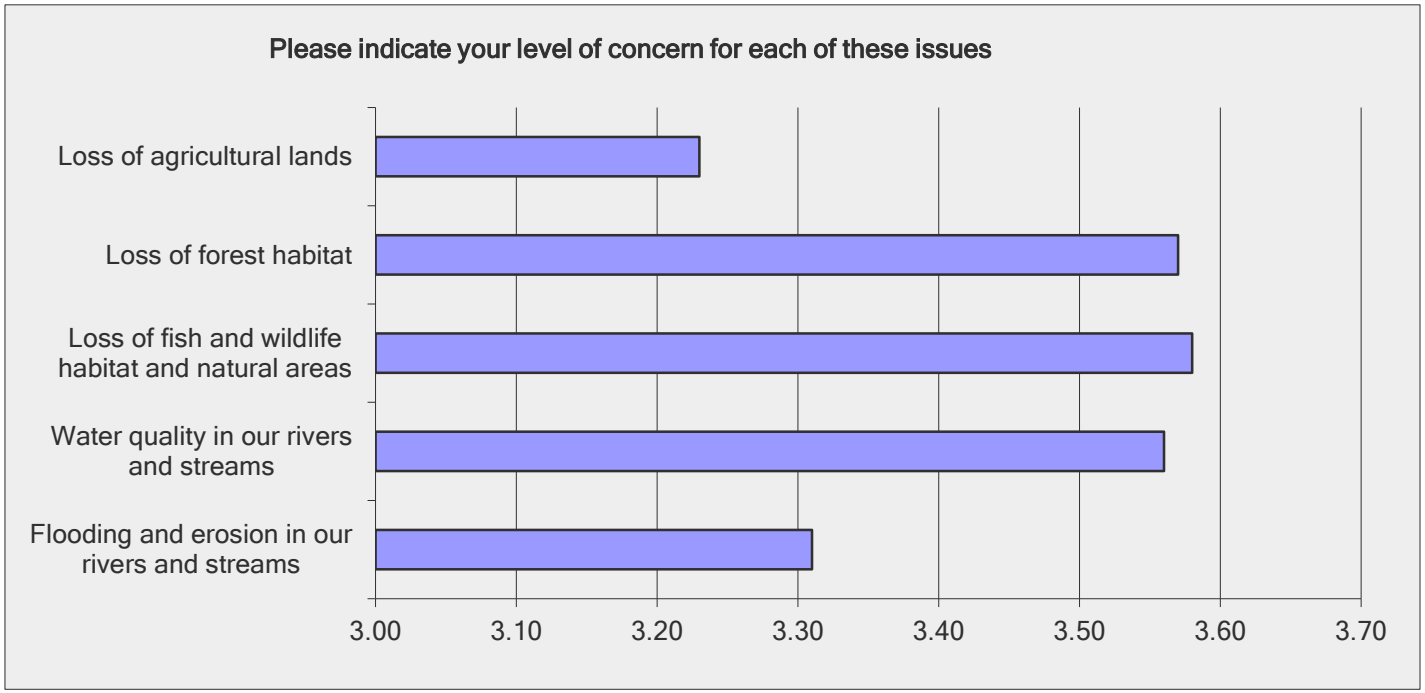
Zipcode	Count	Percent
98019	45	71.43%
98077	1	1.59%
98014	1	1.59%
98074	2	3.17%
98272	1	1.59%
98109	12	19.05%
98036	1	1.59%
Total	**63**	**100.00%**



Duvall Watershed Characterization Project

3. Please indicate your level of concern for each of these issues

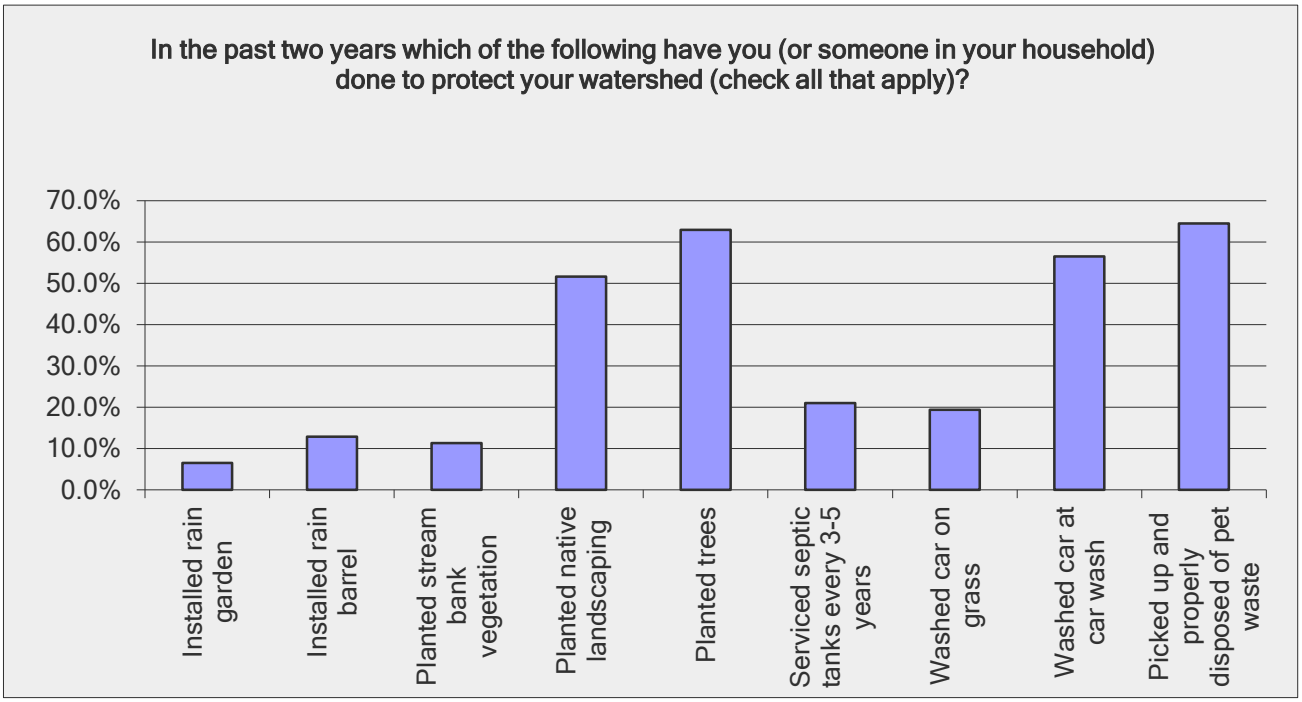
Answer Options	Not Concerned	Somewhat Concerned	Concerned	Very Concerned	N/A	Rating Average	Response Count
Flooding and erosion in our rivers and streams	2	8	21	31	0	3.31	62
Water quality in our rivers and streams	2	5	12	44	0	3.56	63
Loss of fish and wildlife habitat and natural areas	2	5	10	45	0	3.58	62
Loss of forest habitat	4	2	11	46	0	3.57	63
Loss of agricultural lands	4	8	20	30	0	3.23	62
						answered question	63
						skipped question	0



Duvall Watershed Characterization Project

4. In the past two years which of the following have you (or someone in your household) done to protect your watershed (check all that apply)?

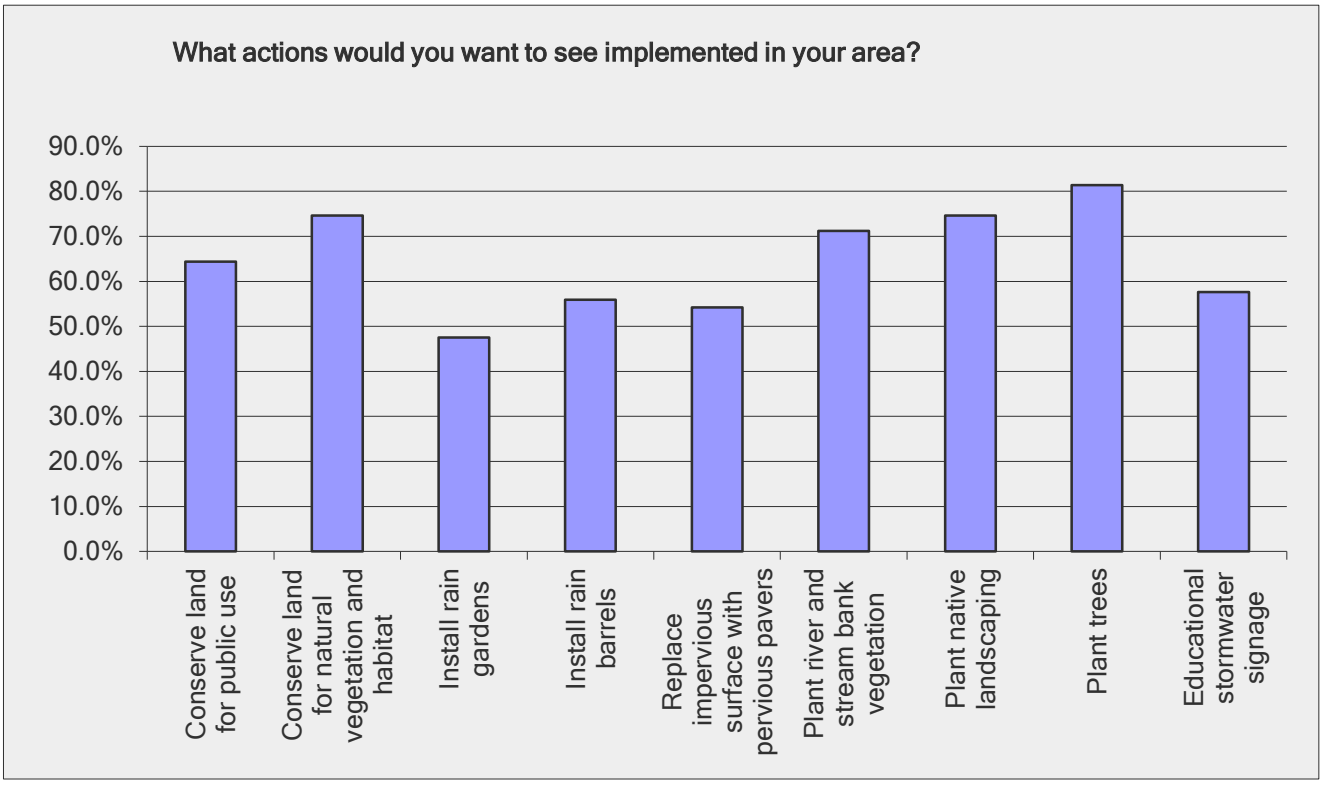
Answer Options	Response Percent	Response Count
Installed rain garden	6.5%	4
Installed rain barrel	12.9%	8
Planted stream bank vegetation	11.3%	7
Planted native landscaping	51.6%	32
Planted trees	62.9%	39
Serviced septic tanks every 3-5 years	21.0%	13
Washed car on grass	19.4%	12
Washed car at car wash	56.5%	35
Picked up and properly disposed of pet waste	64.5%	40
	answered question	62
	skipped question	1



Duvall Watershed Characterization Project

5. What actions would you want to see implemented in your area?

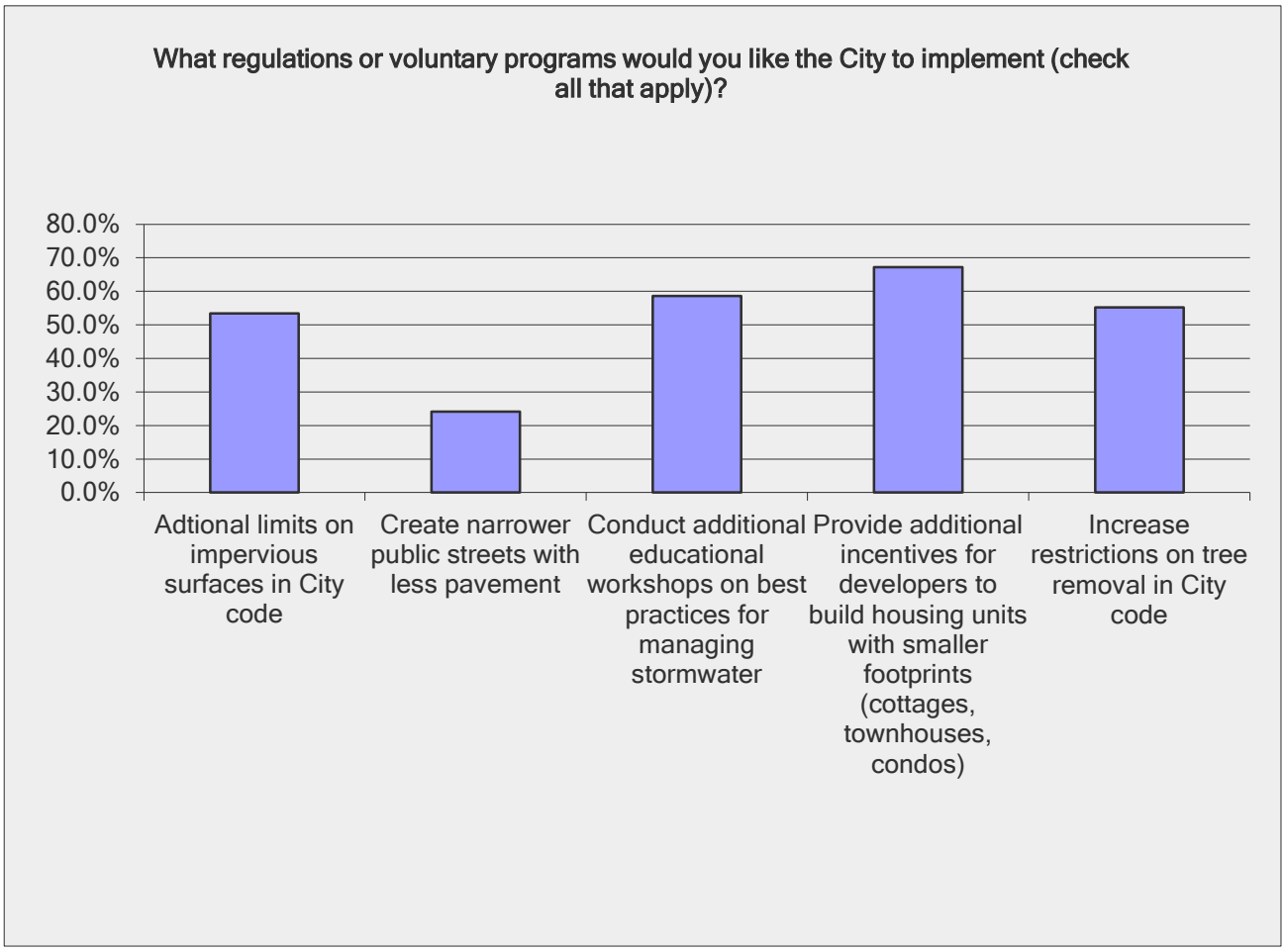
Answer Options	Response Percent	Response Count
Conserve land for public use	64.4%	38
Conserve land for natural vegetation and habitat	74.6%	44
Install rain gardens	47.5%	28
Install rain barrels	55.9%	33
Replace impervious surface with pervious pavers	54.2%	32
Plant river and stream bank vegetation	71.2%	42
Plant native landscaping	74.6%	44
Plant trees	81.4%	48
Educational stormwater signage	57.6%	34
	answered question	59
	skipped question	4



Duvall Watershed Characterization Project

6. What regulations or voluntary programs would you like the City to implement (check all that apply)?

Answer Options	Response Percent	Response Count
Adtional limits on impervious surfaces in City code	53.4%	31
Create narrower public streets with less pavement	24.1%	14
Conduct additional educational workshops on best	58.6%	34
Provide additional incentives for developers to build	67.2%	39
Increase restrictions on tree removal in City code	55.2%	32
answered question		58
skipped question		5



Duvall Watershed Characterization Project

7. Would you be interested in hearing more about the Watershed Characterization Project? If yes, please provide your email address below.

Answer Options	Response Count
	23
answered question	23
skipped question	40

Number	Response Date	Response Text	Categories
1	6/11/2015 6:34:00 PM	No	
2	6/11/2015 6:34:00 PM	Yes: Larry Bergerow	
3	Apr 29, 2015 10:11 PM	signup15@bluehorses.com	
4	4/29/2015 7:55:00 PM	tallen@Microsoft.com	
5	3/19/2015 3:23:00 AM	Kochkyle.w@gmail.com	
6	3/19/2015 2:21:00 AM	RobertHess@msm.com	
7	6/4/2014 6:06:00 PM	happytrailswa@gmail.com	
8	6/4/2014 6:05:00 PM	ireanar@Hotmail.com	
9	6/4/2014 6:04:00 PM	mikewolman@gmail.com	
10	6/4/2014 6:04:00 PM	andreamck@outlook.com	
11	6/4/2014 6:02:00 PM	ajshaw35@hotmail.com	
12	6/4/2014 6:00:00 PM	sprice712@hotmail.com	
13	6/4/2014 5:59:00 PM	sean.pohlarn@gmail.com	
14	May 31, 2014 8:08 PM	Deborah.oaks@yahoo.com	
15	May 31, 2014 7:02 PM	Pgarvey2000@yahoo.com	
16	May 31, 2014 6:55 PM	Jennifer.mckeown@mtsgreenway.org	
17	May 31, 2014 6:39 PM	Cindy.sewell@gmail.com	
18	May 31, 2014 6:06 PM	Shopper5757@gmail.com	
19	May 31, 2014 5:57 PM	Willsmith888@hotmail.com	
20	May 31, 2014 5:40 PM	Eastsidetbird@hotmail.com	
21	May 31, 2014 5:15 PM	Joe.pennock@duvallwa.gov	
22	May 31, 2014 5:06 PM	Sldenison@yahoo.com	
23	May 31, 2014 4:35 PM	Jason.walker@duvallwa.gov	

APPENDIX B. DATA SOURCES, METHODS AND DETAILED ANALYSIS RESULTS

This appendix presents underlying data layers, information sources, and assessment methods used to complete the watershed analysis and provides detailed watershed analysis results. Methods are based on an assessment approach established by the Ecology Puget Sound Watershed Characterization (Stanley et al. 2011)[1]. The Puget Sound Characterization is a regional-scale model that highlights the most important areas to protect and restore, and those more suitable for development. The characterization developed for Duvall builds on Ecology's characterization model, but was down-scaled to make the results more specific to Duvall. As is true for the Duvall project, Ecology's characterization model was funded by an Environmental Protection Agency grant and developed as a collaboration between Ecology, the Puget Sound Partnership, and Washington Department of Fish and Wildlife.

B.1 Spatial Data Sources

A number of key spatial datasets were used for this analysis (see Appendix D). Water Flow and Water Quality were assessed using Puget Sound Watershed Characterization data. Examples of data used in this effort include precipitation, wetland and floodplain extents, land use/land cover, soils (including areas mapped with high permeability), impervious surface cover and road density.

Data sources providing more detailed, higher resolution data (primarily from City and King County sources) were used to refine the Ecology model results. These data enable quantitative assessment of:

- Percent impervious (total impervious area) by subbasin
- Areas of depressional wetlands and other surface storage features (including integration of City stormwater infrastructure data)
- Percent forest cover by subbasin
- Linear feet of aquatic habitat, including:
    - Salmonid presence
    - Potential salmonid presence (intrinsic potential) from Washington Department of Fish and Wildlife models
- Infiltration capacity, as measured by soil types

Additional data sources were acquired from City staff, including from the Planning and Public Works departments, for use in qualitative evaluation of the watershed

[1] See http://www.ecy.wa.gov/puget_sound/characterization/ for more information on the Ecology Puget Sound Watershed Characterization.

B.2 Project Assessment Unit (PAU) Delineation

Ecology identified three Assessment Units (AUs) within the study area (see Chapter 1, Figure 1-1). These AUs were delineated using the data from the WDFW Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP) in partnership with the Northwest Indian Fisheries Commission.

To better represent variability at the study area, the City divided the three AUs into 17 project assessment units (PAUs) using a combination of high resolution LiDAR digital elevation model, hydrology, and stormwater infrastructure maps. In some cases, the boundary of the Ecology AU was adjusted to match the more detailed topographic and drainage information. PAUs range from 98 to 1,273 acres (average size is 385 acres) and generally correspond to 1st order streams and specific landscape positions (Table B-1).

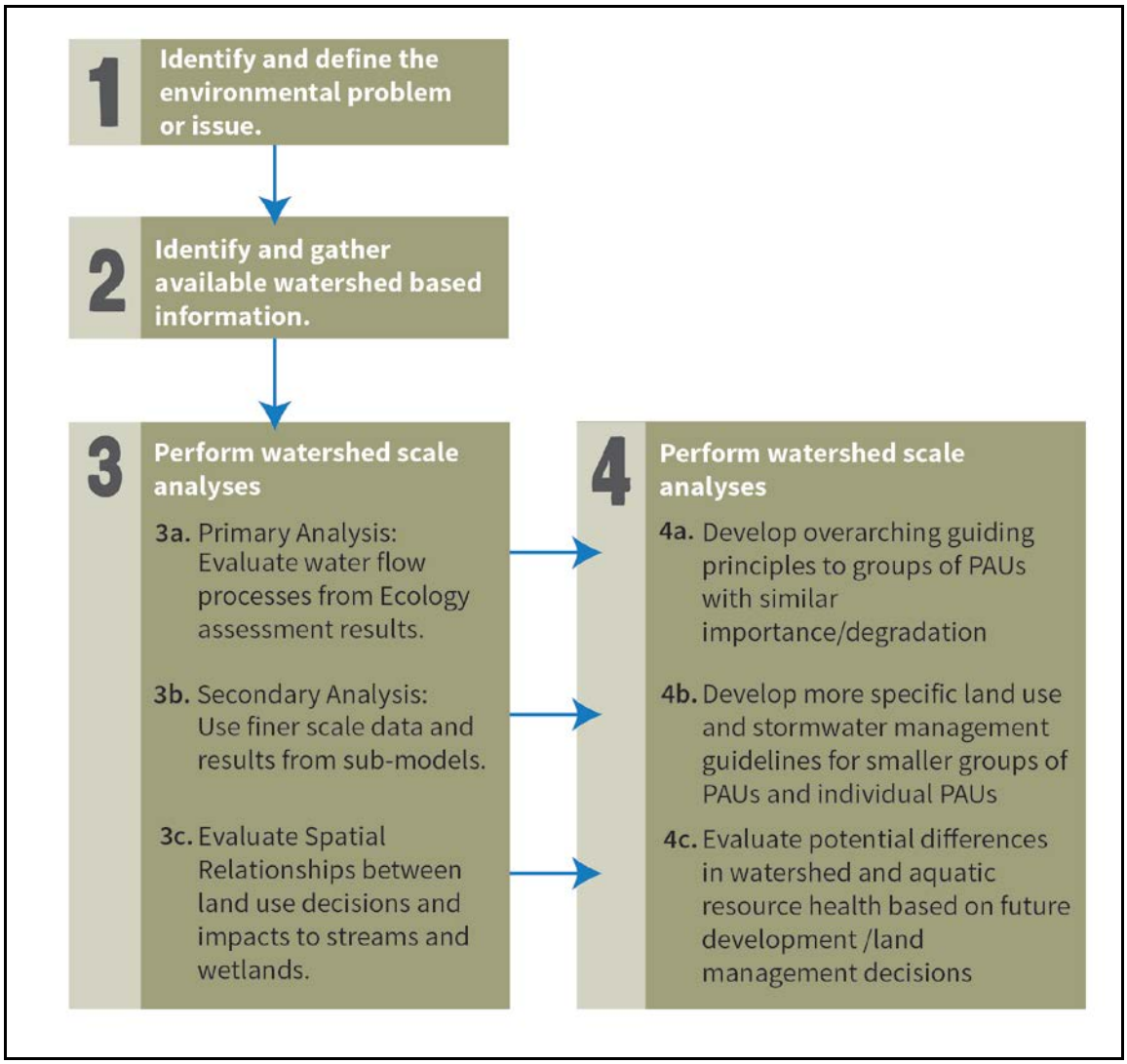
Table B-1. Project Assessment Unit (PAU) summary table

PAU Name	PAU Number	Area (acres)	Within City		Within UGA	
			Acres	% of Subbasin	Acres	% of Subbasin
Cherry Creek Basin						
Cherry Creek Floodplain	C2	865	8	1%	5	1%
Cherry Creek A	C3	264	146	55%	64	24%
Cherry Creek B	C4	158	72	46%	23	15%
Cherry Creek C	C5	457	272	59%	20	4%
Cherry Creek D – East	C1	288	1	< 1%	5	2%
Cherry Creek D – West	C6	166	0.3	< 1%	129	77%
Duvall Tributaries Basin						
Old Town	D2	146	129	88%	10	7%
Coe-Clemons – Lower	D6	98	98	100%	0	0%
Coe-Clemons – Upper	D5	273	273	100%	0	0%
Thayer	D4	235	215	92%	5	2%
Coe-Clemons / Thayer Floodplain	D3	663	84	13%	0	0%
Unnamed Southern Tributary - Lower	D1	373	156	42%	35	9%
Unnamed Southern Tributary – South	D8	158	0	0%	0	0%
Unnamed Southern Tributary - Upper	D7	327	117	36%	19	6%
Weiss Creek Basin						
Weiss Creek – Upper	W3	207	7	4%	156	75%
Weiss Creek – Middle	W2	587	0	0%	0	0%
Weiss Creek – Lower	W1	1273	0	0%	0	0%

B.3 Methods Overview

The goal of the Duvall watershed analysis is to evaluate the importance of watershed processes and the level to which these watershed processes are intact within the study area in order to inform land use planning decisions (Stanley et al. 2011) (Figure B-1).

Figure B-1. Framework for using Watershed Analysis across multiple scales to inform land use and stormwater management decisions (from Stanley et al. 2011)



The Puget Sound Watershed Characterization model was developed to be applied at larger spatial scales; therefore, the assessment was re-run for Duvall's PAUs. In this project, results of the regional characterization, normalized to the Duvall study area, were used to evaluate watershed processes (including water flow, water quality,

and habitat processes) at a local scale. This is the primary analysis, detailed in Section B.4. Additional analysis using finer scale data was completed to augment primary analysis. This is the secondary analysis, detailed in Section B.5. Finally, results from both primary and secondary analysis were used along with local information about land and infrastructure management and development policies and priorities for the City (tertiary analysis).

Analysis was performed at these three spatial scales (Step 3 in Figure B-1). Using a variety of spatial scales allows the City to make general and more specific land use, stormwater and sensitive areas management strategies.

B.4 Primary Analysis

Primary analysis is the evaluation of water flow (hydrologic) processes at the PAU scale relying on Ecology's Puget Sound Characterization model, re-normalized for the 17 PAUs within the Duvall study area. Relative importance and degradation of water flow processes are assigned, and PAUs with similar importance and degradation levels are organized into general subbasin management groups.

Methods

Seventeen PAUs delineated for the study area were provided to Ecology as a geographic information system (GIS) shapefile, allowing the Puget Sound Characterization water flow model to be re-run specific to Duvall's landscape setting. The model evaluates the importance and level of degradation of water flow processes based on GIS data of key landscape elements that influence the movement of water through the watershed. Raw importance and degradation scores from model runs were normalized relative to the study area, allowing for more variation in results.

The Water Flow assessment component of the model was used for this study. Water Flow assessment includes watershed characterization results for key water flow processes – delivery, surface storage, recharge, and discharge (Table B-2). The assessment evaluates the relative importance and degradation within each PAU and provides an overall result which combines all processes and results for each individual process (Figure B-2). Under Ecology's standard approach to using the Water Flow assessment, the combined results can then be used to determine the overall management objective for each PAU.

Table B-2. Flow Variables

Process	**Importance Score** – an assessment of relative importance based on pre-developed conditions	**Degradation Score** – an assessment of relative process alteration based on existing conditions
Delivery	Precipitation Rain on snow areas (N/A in Duvall)	Impervious Surface Forest Loss
Surface Storage	Depressional wetlands Low gradient floodplain	Loss of wetlands and floodplains (urban/rural development)
Recharge	High permeability deposits Low permeability deposits	Development (impervious surface) over high/low permeability deposits
Discharge	Geology, soils, topography Slope wetlands near streams	Road density Groundwater well density

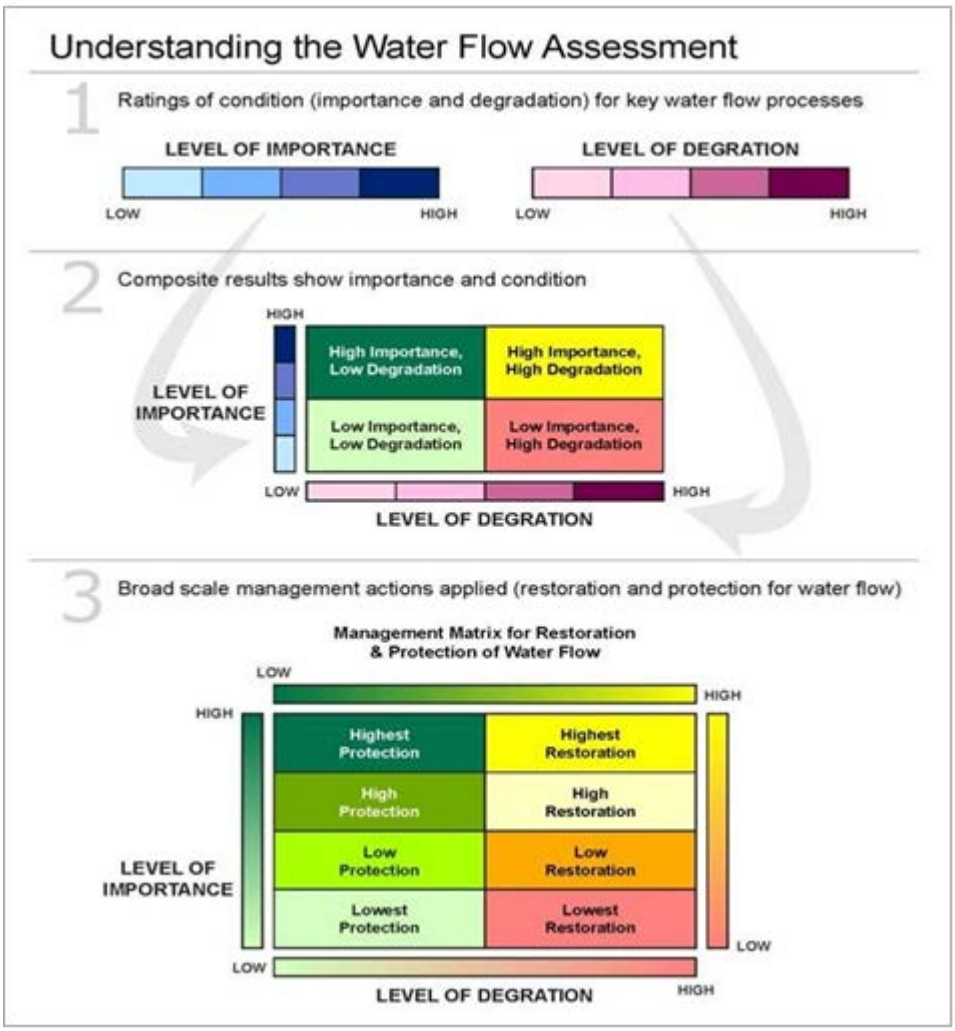
The Water Flow process is characterized by precipitation delivered (primarily as rain in Duvall) and the physical features that control its surface and subsurface movement within a subbasin. Features describing the process of water flow and used in the assessment include land cover, storage areas (i.e., wetlands and floodplains), areas of higher permeability and recharge, and areas that discharge groundwater.

Water Flow importance results are based on underlying, pre-development physical conditions.

Water Flow degradation results identify the amount of change to land cover indicators that maintain or are indicative of water flow processes. For example, degradation to water flow delivery processes is represented by features such as percent impervious cover and percent of forest cover loss that control how quickly precipitation moves to downstream areas. Other indicators for water flow process degradation include alteration to storage areas and the number of groundwater extraction wells.

The approach identified each PAU's relative importance and degradation for water flow processes. Composite results (combining importance and degradation) indicate, at a coarse scale, areas that should be targeted for restoration (highest to lowest priority) or protection (highest to lowest priority).

Figure B-2. Water Flow assessment method, from Stanley et al. (2013)



Results

PAU results from Ecology were presented with each subbasin assigned to one of eight standard Ecology Watershed Characterization management categories:

1) highest protection (for highest importance / low degradation PAUs);
2) high protection (for moderate high importance / low degradation PAUs);
3) low protection (for moderate importance / low degradation PAUs);
4) lowest protection (for low importance / low degradation PAUs);
5) highest restoration (for highest importance, high degradation PAUs),
6) high restoration (for moderate high importance, high degradation PAUs),
7) low restoration (for moderate importance, high degradation PAUs); and
8) lowest restoration (for low importance, high degradation PAUs).

Results are derived by binning an equal number of PAUs into each category; this is the standard approach for categorizing results under Ecology's Puget Sound Watershed Characterization model. The binning allows for rapid differentiation of water flow importance and degradation scores into these eight distinct management categories. Results are provided for all water flow submodels, as well as overall water flow results, in Table B-3.

The City worked with the project Advisory Group and Ecology to look beyond the binned management categories for each PAU. Raw scores of relative importance and degradation for each PAU were reviewed (Table B-4). Both the overall water flow importance and degradation scores provide a normalized value between 0.0 and 1.0 for each PAU. For the overall water flow importance model, a score of 1.0 indicates the PAU within the study area with highest relative importance for water flow processes. Likewise, a score of 1.0 for the degradation model indicates the PAU with the highest relative level of degradation.

Table B-3. Water Flow Submodel Results for all Study Area Project Assessment Units (PAUs)

PAU Name	PAU Number	Submodel Results - Management Categories (as well as Importance & Degradation Scores)				Overall Water Flow - Management Categories (as well as Importance & Degradation Scores)
		Delivery	Surface Storage	Recharge	Discharge	
Cherry Creek Basin						
Cherry Creek Floodplain	C2	Highest Restoration (Highest Importance & Mod High Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Highest Protection (Highest Importance & Low Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Highest Restoration (Highest Importance & Highest Degradation)
Cherry Creek A	C3	High Restoration (Mod High Importance & Mod High Degradation)	Low Protection (Moderate Importance & Low Degradation)	Low Restoration (Moderate Importance & Mod High Degradation)	Lowest Protection (Low Importance & Low Degradation)	Lowest Protection (Low Importance & Moderate Degradation)
Cherry Creek B	C4	High Protection (Mod High Importance & Moderate Degradation)	Lowest Protection (Low Importance & Low Degradation)	High Restoration (Mod High Importance & Mod High Degradation)	High Protection (Mod High Importance & Low Degradation)	Low Protection (Moderate Importance & Moderate Degradation)
Cherry Creek C	C5	Highest Protection (Highest Importance & Moderate Degradation)	Low Restoration (Moderate Importance & Mod High Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Lowest Protection (Low Importance & Moderate Degradation)	Low Protection (Moderate Importance & Moderate Degradation)
Cherry Creek D – East	C1	Highest Protection (Highest Importance & Moderate Degradation)	High Protection (Mod High Importance & Low Degradation)	Highest Protection (Highest Importance & Low Degradation)	Low Protection (Moderate Importance & Moderate Degradation)	Highest Protection (Highest Importance & Low Degradation)
Cherry Creek D – West	C6	Highest Protection (High Importance & Low Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Low Protection (Moderate Importance & Moderate Degradation)	High Protection (Mod High Importance & Low Degradation)	Highest Protection (Highest Importance & Low Degradation)
Duvall Tributaries Basin						
Old Town	D2	Low Restoration (Moderate Importance & Highest Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Highest Restoration (Highest Importance & Highest Degradation)
Coe-Clemons – Lower	D6	Low Restoration (Moderate Importance & Highest Degradation)	Low Protection (Moderate Importance & Low Degradation)	High Restoration (Mod High Importance & Highest Degradation)	Lowest Restoration (Low Importance & Mod High Degradation)	Lowest Restoration (Low Importance & Highest Degradation)
Coe-Clemons – Upper	D5	High Restoration (Mod High Importance & Highest Degradation)	Lowest Protection (Low Importance & Low Degradation)	Lowest Restoration (Low Importance & Highest Degradation)	Lowest Protection (Low Importance & Moderate Degradation)	Lowest Restoration (Low Importance & Highest Degradation)
Thayer	D4	Lowest Restoration (Low Importance &	Lowest Restoration (Low Importance & Mod	Low Restoration (Moderate Importance &	Highest Restoration (Highest Importance &	High Restoration (Mod High Importance &

PAU Name	PAU Number	Submodel Results - Management Categories (as well as Importance & Degradation Scores)				Overall Water Flow - Management Categories (as well as Importance & Degradation Scores)
		Delivery	Surface Storage	Recharge	Discharge	
		Highest Degradation)	High Degradation)	Highest Degradation)	Highest Degradation)	Highest Degradation)
Coe-Clemons / Thayer Floodplain	D3	Lowest Protection (Low Importance & Moderate Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Highest Protection (Highest Importance & Low Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Highest Restoration (Highest Importance & Mod High Degradation)
Unnamed Southern Tributary - Lower	D1	Lowest Restoration (Low Importance & Highest Degradation)	High Restoration (Mod High Importance & Mod High Degradation)	Lowest Restoration (Low Importance & Highest Degradation)	Highest Restoration (Highest Importance & Mod High Degradation)	High Restoration (Mod High Importance & Mod High Degradation)
Unnamed Southern Tributary – South	D8	Lowest Protection (Low Importance & Low Degradation)	Low Protection (Moderate Importance & Low Degradation)	Lowest Protection (Low Importance & Low Degradation)	Low Protection (Moderate Importance & Low Degradation)	Lowest Protection (Low Importance & Low Degradation)
Unnamed Southern Tributary - Upper	D7	Low Restoration (Moderate Importance & Mod High Degradation)	Lowest Protection (Low Importance & Low Degradation)	Low Restoration (Moderate Importance & Mod High Degradation)	Low Restoration (Moderate Importance & Mod High Degradation)	Low Restoration (Moderate Importance & Mod High Degradation)
Weiss Creek Basin						
Weiss Creek – Upper	W3	Low Restoration (Moderate Importance & Mod High Degradation)	Highest Restoration (Highest Importance & Highest Degradation)	Lowest Protection (Low Importance & Moderate Degradation)	Low Restoration (Moderate Importance & Highest Degradation)	High Restoration (Mod High Importance & Mod High Degradation)
Weiss Creek – Middle	W2	Highest Protection (High Importance & Low Degradation)	High Protection (Mod High Importance & Low Degradation)	High Protection (Mod High Importance & Low Degradation)	High Restoration (Mod High Importance & Mod High Degradation)	High Protection (Mod High Importance & Moderate Degradation)
Weiss Creek – Lower	W1	High Protection (Mod High Importance & Low Degradation)	High Restoration (Mod High Importance & Mod High Degradation)	High Protection (Mod High Importance & Low Degradation)	High Protection (Mod High Importance & Moderate Degradation)	Low Protection (Moderate Importance & Low Degradation)

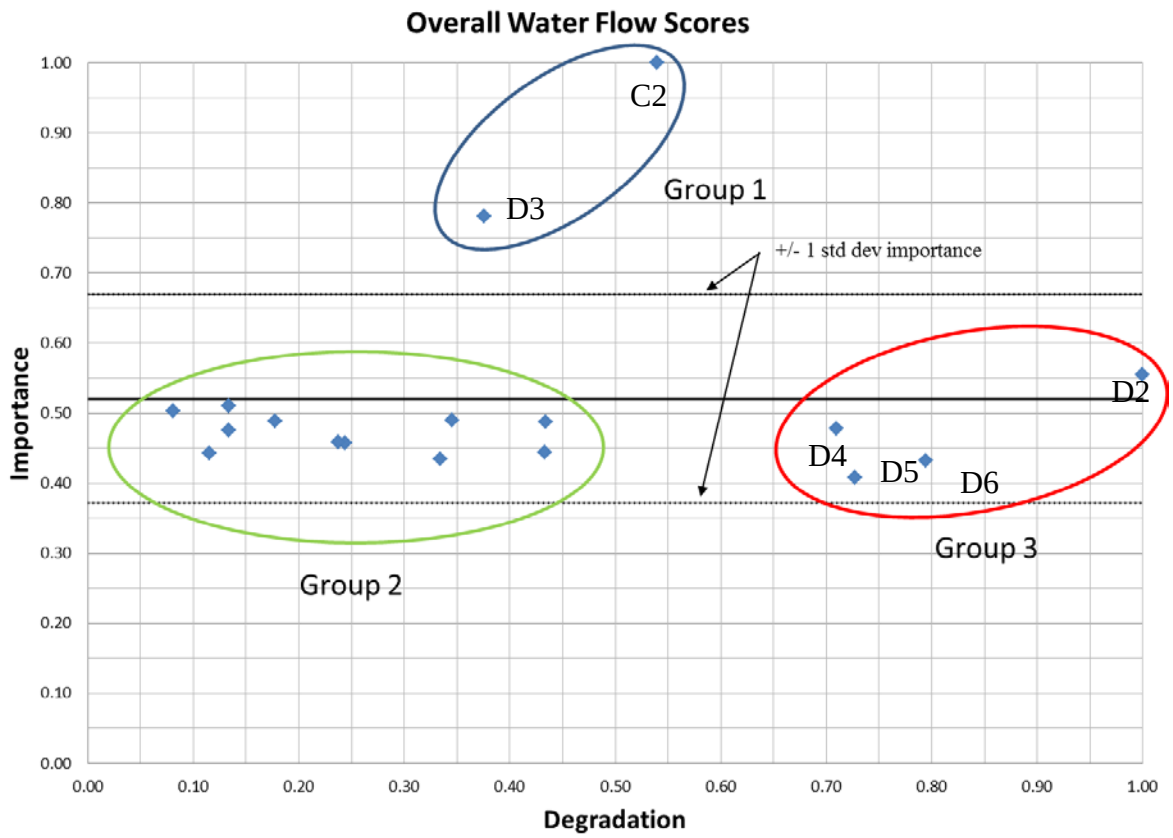
Table B-4. Primary analysis results from the Water Flow assessment.

PAU Name	PAU #	% Forest Cover	% Impervious Surface	Overall Water Flow Importance Score (Low – High)	Overall Water Flow Degradation Score (Low – High)
Group 1 Subbasins – *overall water flow importance scores greater than 0.6 (and more than 20% higher than Groups 2 and 3 scores for importance)*					
Cherry Creek Floodplain	C2	5%	3%	1.00	0.54
Coe-Clemons / Thayer Floodplain	D3	7%	3%	0.78	0.38
Group 2 Subbasins – *overall water flow importance scores between 0.4 and 0.6, with overall water flow degradation scores below 0.5*					
Cherry Creek A	C3	44%	24%	0.43	0.33
Cherry Creek B	C4	62%	15%	0.46	0.24
Cherry Creek C	C5	71%	11%	0.46	0.24
Cherry Creek D – East	C1	56%	4%	0.50	0.08
Cherry Creek D – West	C6	55%	6%	0.51	0.13
Unnamed Southern Tributary – Lower	D1	40%	17%	0.49	0.43
Unnamed Southern Tributary – South	D8	70%	7%	0.44	0.12
Unnamed Southern Tributary – Upper	D7	54%	18%	0.44	0.43
Weiss Creek – Upper	W3	42%	11%	0.49	0.35
Weiss Creek – Middle	W2	54%	8%	0.49	0.18
Weiss Creek – Lower	W1	63%	7%	0.48	0.13
Group 3 Subbasins – *overall water flow degradation scores above 0.7 (and more than 15% higher than Groups 1 and 2 scores for degradation)*					
Old Town	D2	11%	43%	0.55	1.00
Coe-Clemons – Lower	D6	27%	43%	0.43	0.79
Coe-Clemons – Upper	D5	26%	43%	0.41	0.73
Thayer	D4	24%	29%	0.48	0.71

Review of normalized scores revealed differences between PAUs that were not apparent from Ecology's binned standard management categories. For example, the overall water flow restoration and protection management categories identified three PAUs that were assigned the highest priority for protection: Cherry Creek Floodplain, Coe-Clemons /Thayer Floodplain, and Old Town. While these three subbasins do have the highest scores for water flow importance (1.0, 0.78 and 0.55, respectively) and are all relatively degraded, a closer look reveals that normalized scores for Old Town are much closer to scores for the other most urbanized PAUs within the study area.

By plotting these scores, three distinct groups became apparent for the 17 PAUs (Figure B-3, also see Chapter 2, Figure 2-4). Scores for each of these groupings were examined to identify primary management strategies appropriate for each.

Figure B-3. Plotted PAU results for process importance and degradation from Ecology's overall water flow model (primary analysis results); PAU numbers are shown for Groups 1 and 3 only



Management Groups

Group 1: PAUs C2 and D3

PAUs C2 and D3 were grouped together because they had overall importance scores significantly higher than the other PAUs within the study area and only have moderate levels of degradation. The general management theme for Group 1 areas is "Protect/Restore" due to intact water flow processes in these PAUs. PAUs C2 and D3 are located within the Snoqualmie River/Cherry Creek Floodplains and generally have low levels of urban/suburban development.

Group 2: PAUs W1, D1, C1, C3, C4, C5, D7, D8, C6, W3

The PAUs in Group 2 generally have little variation in overall importance scores. Importance scores are similar to the PAUs in Group 3; however, all of these PAUs exhibit low to moderate levels of degradation when compared to Group 3 PAUs. "Develop / Conserve" is the management theme for Group 2 areas, and as development occurs in these less degraded areas, intact processes should be maintained.

Group 3: PAUs D2, D4, D5, and D6

The overall scores for these PAUs are at or below average for water flow importance and indicate the highest degradation levels for Duvall. These PAUs are generally located in the historic downtown areas of Duvall with a management theme of "Urban Development."

B.5 Secondary Analysis

At completion of the primary analysis, eleven out of seventeen PAUs were sorted into Group 2. These eleven PAUs include most of the city and urban growth area/urban growth area reserve, covering an area with substantial differences in existing land use and land cover types. To provide a more useful characterization for guiding land use decisions, Group 2 PAUs were further evaluated for finer scale understanding of watershed processes importance and degradation, and further subdivided into more useful management groups.

Methods

The Advisory Group identified four additional indicators of ecological processes for evaluation and finer resolution data that could be used for a secondary analysis of watershed importance:

- Sediment Export Potential Model from Ecology's Water Quality Assessment
- Modified Storage

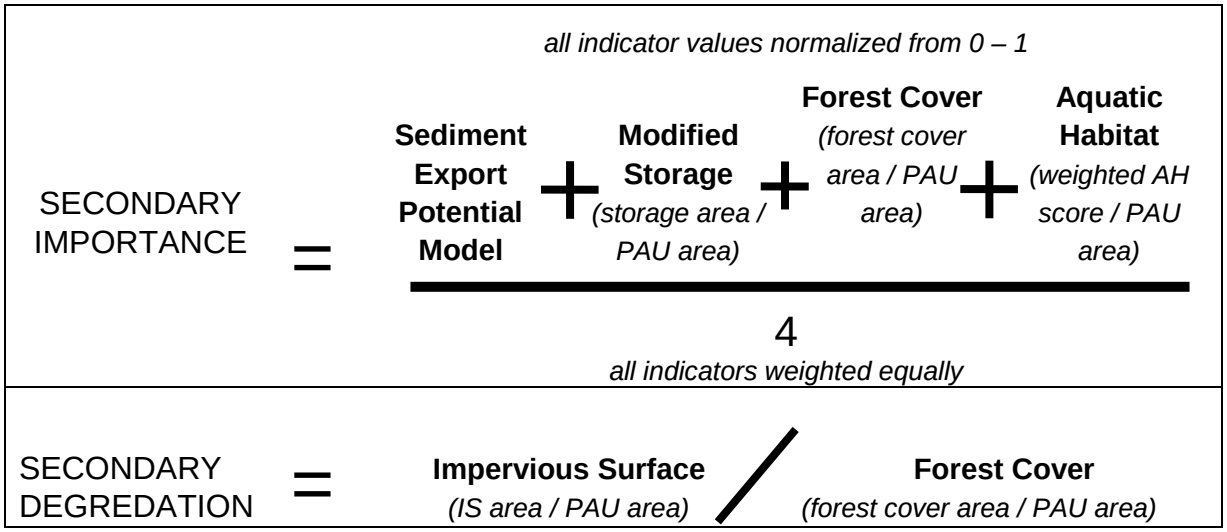
- Forest Cover
- Aquatic Habitat

For each of the four additional measures of importance, PAU scores were normalized and weighted equally to determine one value for importance (Figure B-4).

Additionally, total impervious area was compared to total forest cover (within each PAU), with the ratio developed as a secondary (and higher resolution) measure of degradation to watershed processes.

Results of this analysis were used to further refine recommendations for land use management and resource protection within Group 2 (Develop / Conserve) PAUs that balance economic development goals with conservation of watershed processes. Secondary analyses were performed on Group 2 PAUs only. More detail on methods for analyzing the measures is provided below.

Figure B-4. Indicators and method used for secondary watershed analysis (evaluation of Group 2 PAU importance and degradation)



Ecology's Sediment Export Potential Model

Erosion in the ravines and sedimentation in the lower stream reaches is a problem throughout and surrounding Duvall. The Ecology Sediment Export Potential model (part of the Water Quality Assessment) analyzed natural sources and sinks of sediment by looking at three processes based on attributes of the watershed: surface erosion, mass wasting, and stream channel erosion (Stanley et al. 2011). The results of the Ecology Sediment Export Potential model were calculated for each PAU in Group 2 and normalized within the study area (see Figure B-5). Scores for

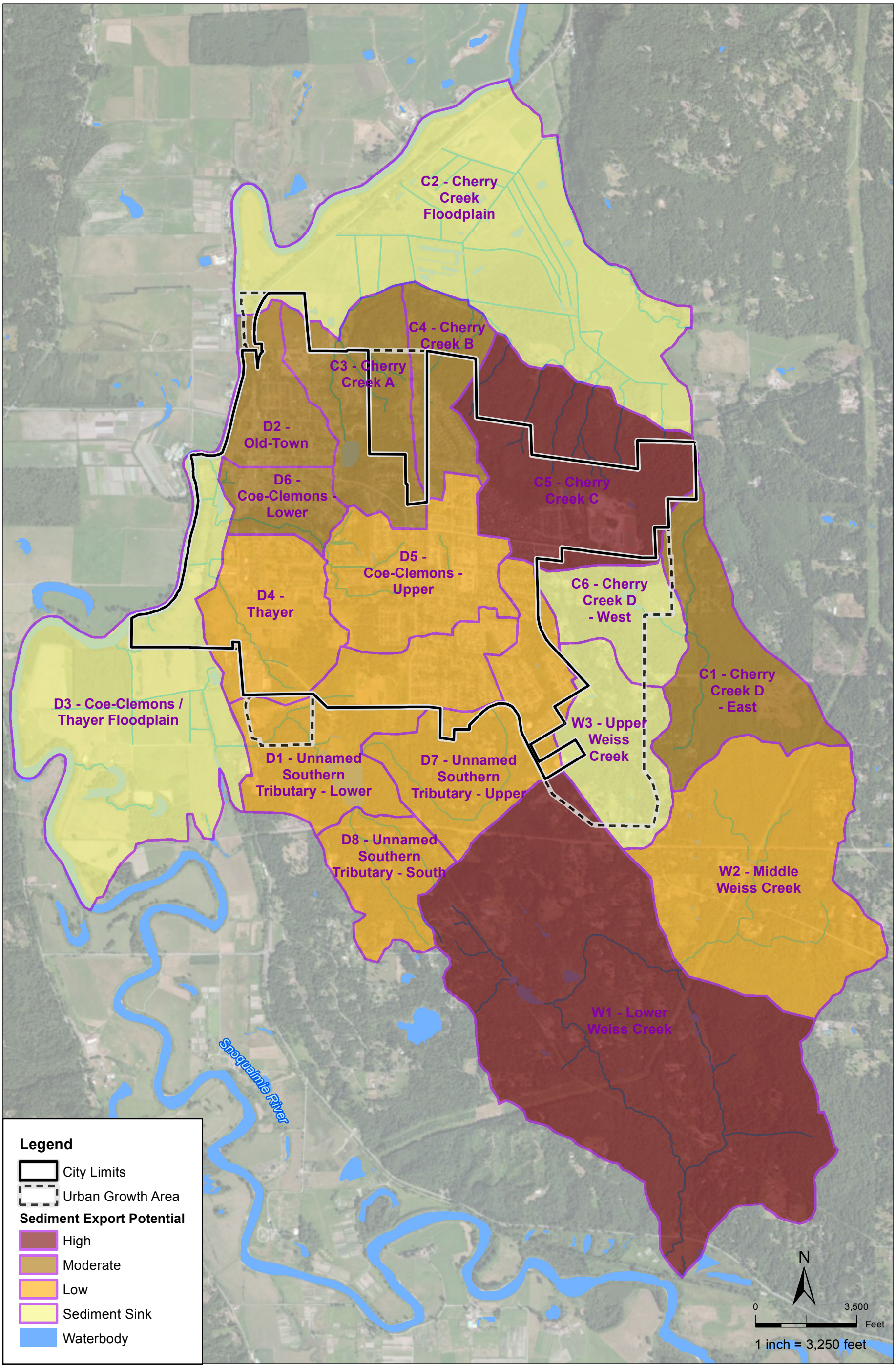
sediment export potential were assigned rankings:

- High: 0.6 – 1.0
- Moderate: 0.4 – 0.6
- Low: 0.15 – 0.4
- Sediment Sink: 0.0 – 0.15 (PAUs where there the model shows more sediment sinks then sediment sources)

This ranking system differs from the standard ranks within Ecology's water flow assessment model, and was developed to capture the patterns of the PAU results for the study area.

High sediment export potential scores represent a naturally high potential for the PAU to deliver sediment, indicating a high risk of surface erosion, landslides or slope failures, or channel erosion. Areas with high sediment export potential also play an important role in assessing the potential for other materials (including phosphorus and metals) to move through the landscape to downstream aquatic resources (Stanley et al. 2011).

PAUs in Group 2 with high scores for sediment export potential were given a higher priority for implementation of stormwater management strategies to reduce the risk associated with erosion and sedimentation. For those areas with low sediment export potential, including PAUs where sediment sinks are modeled as more extensive then sediment sources, protection of areas that provide sinks (primarily wetlands and floodplains) is prioritized, especially when downstream areas could be prone to erosion if upstream sinks were lost.



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

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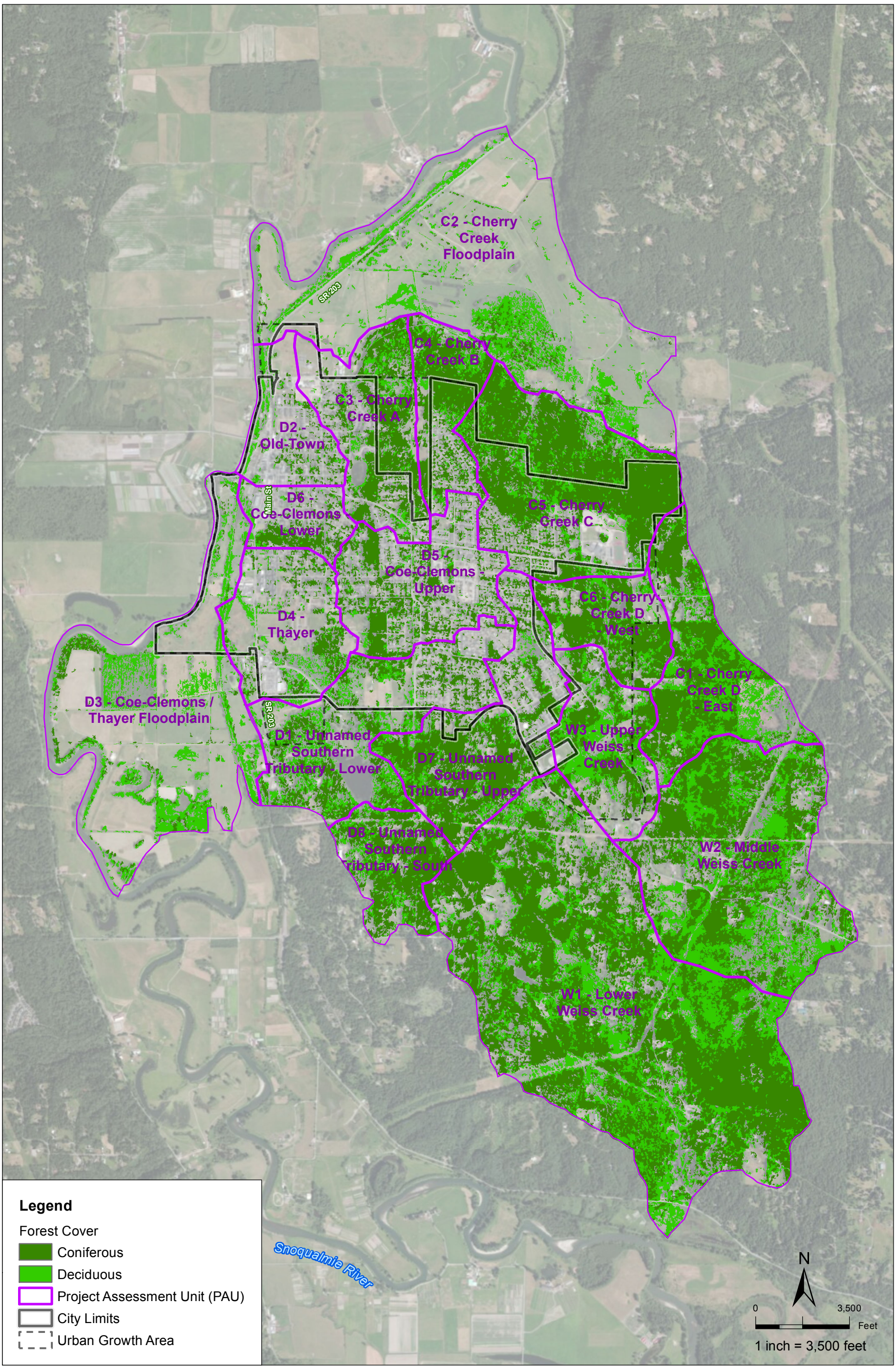
Figure B-5
Export Potential of Sediment

Modified Storage

Primary analysis of surface water storage processes yielded storage scores that were uniform and near zero for all PAUs in Group 2. More variability was expected based on field observations and knowledge of the study area, indicating a need for additional analysis using local data. A more detailed storage data layer was created for this project using National Resources Conservation Service hydric soils maps, City and County wetland data layers, infrared data, aerial photos, field reconnaissance, and City stormwater detention pond data (see Chapter 2, Figure 2-2). The density of storage features was calculated for each PAU (area of storage features / area of PAU) and the scores were normalized within Group 2.

Forest Cover

Although not a watershed process, the Advisory Group agreed that upland habitat conditions were an important indicator of watershed health. Upland habitat land cover data is not available for the study area; therefore, forest cover was used as a proxy. Forest cover is also an indicator of water flow and water quality process integrity. Forest cover was defined using land cover classifications, infrared imagery and ortho-imagery in GIS. The density of forest cover in each PAU was calculated and the scores were normalized for PAUs in Group 2 (see Figure B-6).



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

Figure B-6
Forest Cover

Aquatic Habitat

Aquatic habitat was evaluated using Washington Department of Fish and Wildlife for coho salmon distribution and data from WDFW's freshwater habitat assessment model to determine a weighted aquatic habitat score for each PAU. Their model scores streams based on their intrinsic potential (IP) to support salmonids (as opposed to actual documented fish presence). For any given stream segment, IP is broadly based on stream gradient, channel width and contributing basin. For Duvall, salmon distribution and IP data were both focused on coho salmon (see Figure B-7). These datasets were chosen because they were the most extensive aquatic datasets for the small Duvall subbasin streams.

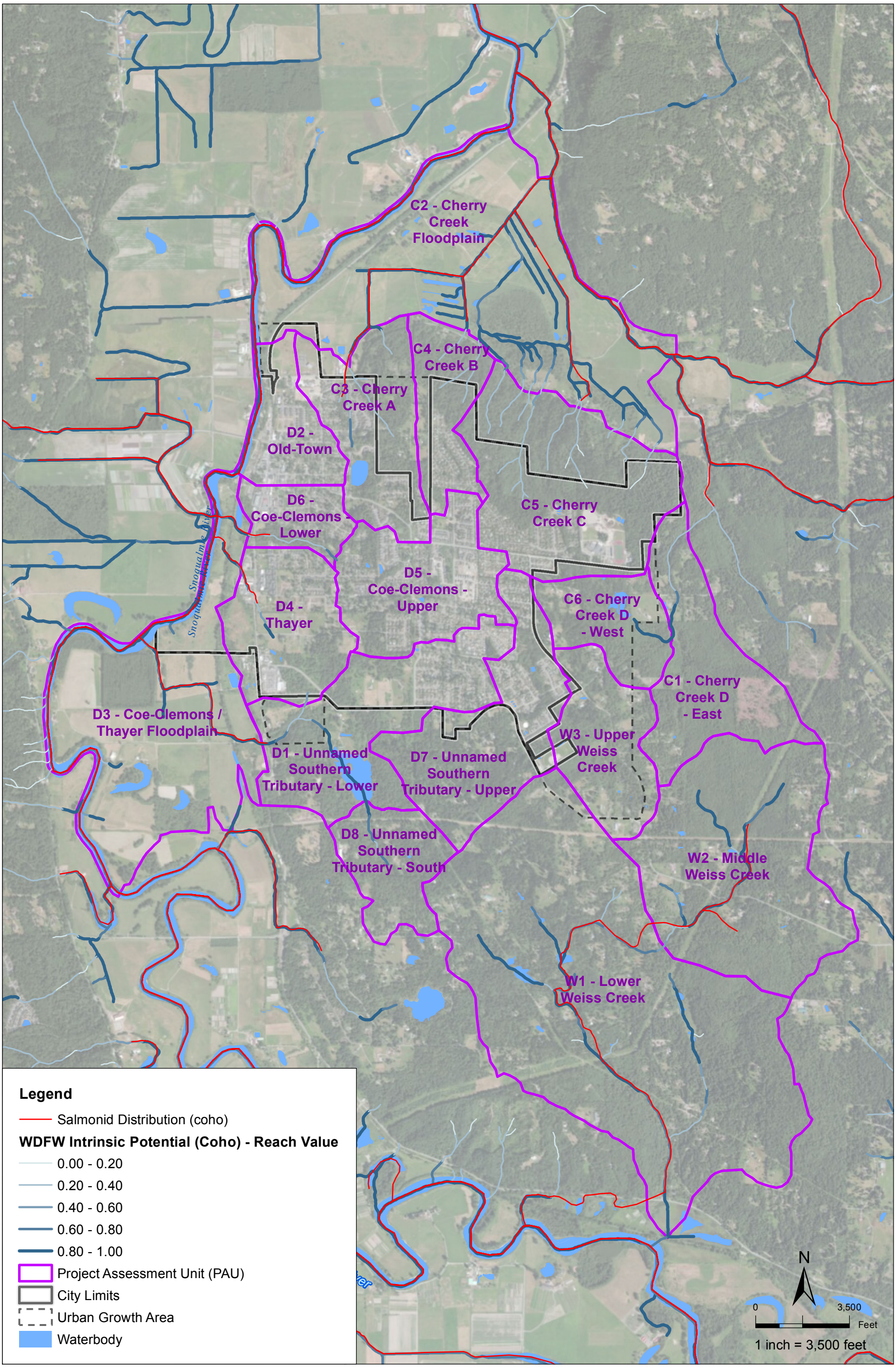
Secondary importance scores were developed based on a calculation of weighted aquatic habitat (linear feet) using the values (0.0 – 1.0) from the IP layer. For each reach, weighted aquatic habitat was calculated based on presence of coho:

- Coho present: weighted aquatic habitat = reach_IP X 1.0
- No coho present: weighted aquatic habitat = reach_IP X 0.5

Through this calculation, the IP value for stream segments with actual coho presence were weighted fully, whereas the IP value for stream segments without known coho presence were discounted by 50 percent. Weighted aquatic habitat scores were then calculated as a per acre value and normalized by PAU.

Refined Degradation Score

Additional analysis was completed to determine a refined measure for level of degradation. Using the same approach as described above for forest cover, high resolution aerial photography was used to identify impervious surface cover (see Figure B-8). The refined degradation score was determined as the ratio of total impervious surface cover to forest cover for each subbasin.



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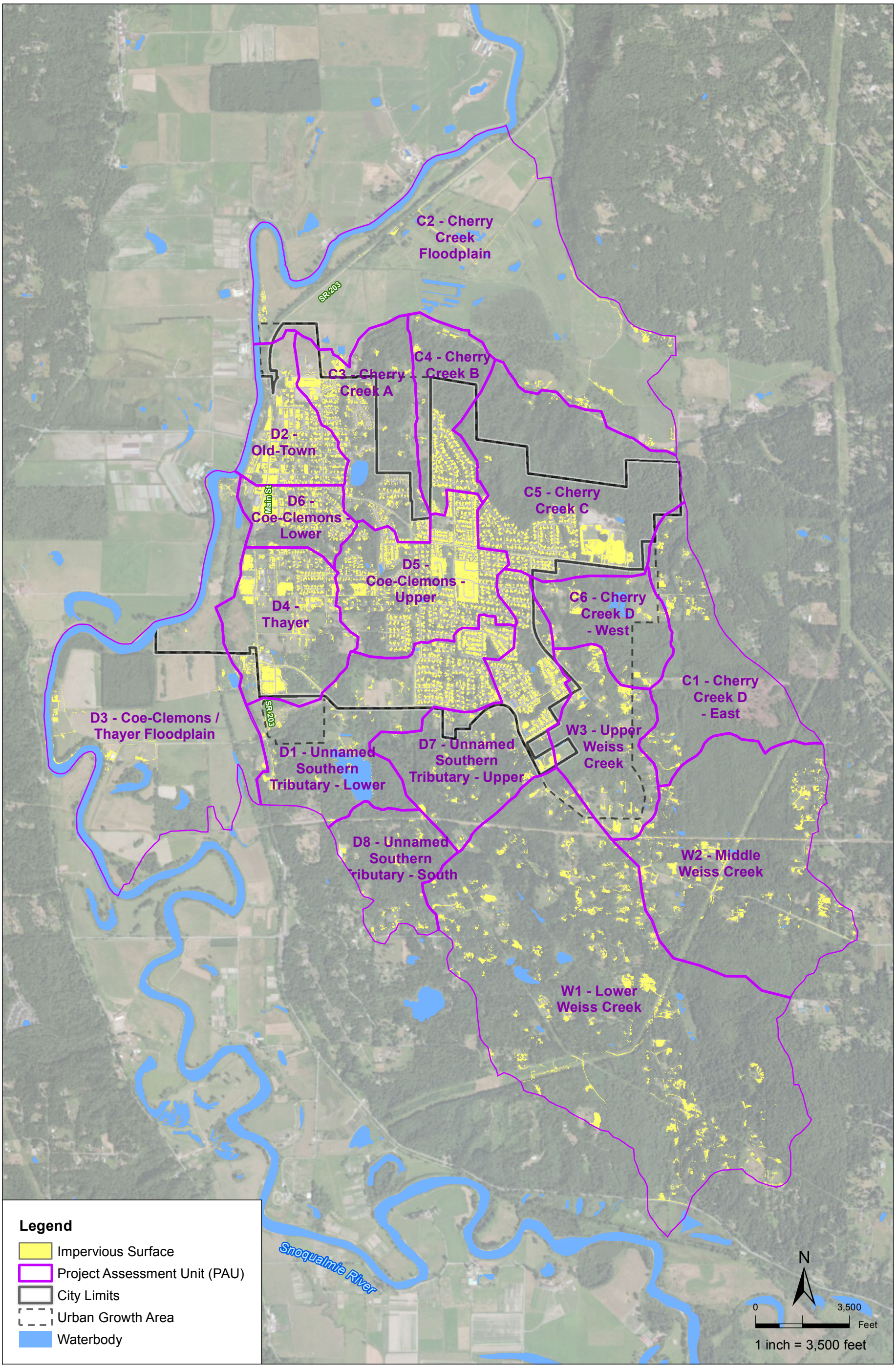
SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

Figure B-7
Coho Distribution and WDFW Intrinsic Potential for Coho



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SOURCE: BHC Consultants, 2013; USDA NAIP, 2013, King County, 2014

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Figure B-8
Impervious Surface

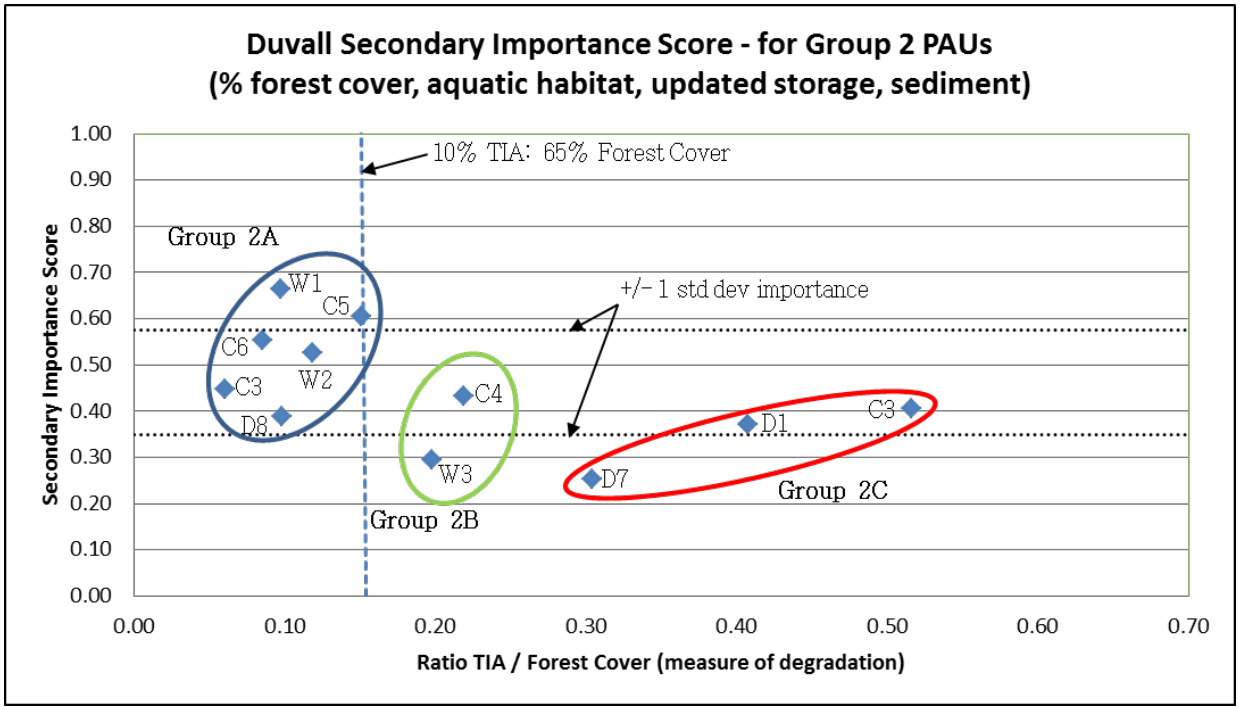
Results

The results of each secondary analysis data set were rolled into one value (Secondary Importance Score) and plotted against the secondary measure for level of degradation (Table B-5, Figure B-9). The scores are normalized to a scale of 0 to 1, where 1 is the highest possible score (see Figure B-4 for summary of secondary score calculations).

Table B-5. Secondary analysis results (all scores presented below are normalized from 0.0 – 1.0)

PAU Name	PAU #	Sediment Export Potential	Wetland Density	% Forest Cover	Aquatic Habitat	Secondary Importance Score	Secondary Degradation (Ratio of Impervious Area : Forest Cover)
Sub-Group 2A: Highest Conservation *Note: All scores for degradation at or lower than 0.15*							
Cherry Creek D - East	C1	Moderate 0.49	0.14	1.00	0.24	**0.45**	**0.06**
Cherry Creek C	C5	High 1.0	0.03	0.97	0.44	**0.61**	**0.15**
Cherry Creek D - West	C6	Sediment Sink 0.12	1.00	0.91	0.32	**0.55**	**0.08**
Lower Weiss Creek	W1	High 0.67	0.06	0.99	1.00	**0.66**	**0.10**
Middle Weiss Creek	W2	Low 0.39	0.03	0.89	0.89	**0.53**	**0.12**
Unnamed Southern Tributary - South	D8	0Low 0.37	0.02	0.95	0.33	**0.39**	**0.10**
Sub-Group 2B: Moderate Conservation *Note: All scores for degradation between 0.2 and 0.25*							
Cherry Creek B	C4	Moderate 0.51	0.07	0.88	0.34	**0.43**	**0.22**
Upper Weiss Creek	W3	Sediment Sink 0.07	0.50	0.75	0.00	**0.30**	**0.20**
Sub-Group 2C: Lowest Conservation *Note: All scores for degradation at or above 0.3*							
Unnamed Southern Tributary - Lower	D1	Low 0.37	0.23	0.54	0.45	**0.37**	**0.41**
Cherry Creek A	C3	Moderate 0.45	0.11	0.62	0.54	**0.41**	**0.52**
Unnamed Southern Tributary - Upper	D7	Low 0.31	0.03	0.79	0.00	**0.25**	**0.30**

Figure B-9. Plotted secondary analysis results for Group 2 PAUs



Based on analysis results, three sub-management groups were identified within Group 2 (see Chapter 2, Figure 2-5). These sub-management groups still have an overarching prioritization for development and conservation to protect remaining watershed functions; however, with results from the secondary analysis, more specific land use and stormwater management decisions can be made.

Sub-Group 2A: Highest Conservation

- PAUs W1, W2, D8, C1, C5, and C6
- Secondary scores for these six PAUs are above average for importance and indicate lower levels of relative degradation.

Sub-Group 2B: Moderate Conservation

- PAUs C4 and W3
- Secondary scores for these PAUs are average for importance and indicate lower to moderate levels of relative degradation.

Sub-Group 2C: Lowest Conservation

- PAUs D1, C3, D7
- Secondary scores for these PAUs are average for importance and indicate higher levels of relative degradation.

Once management groups were defined for groups and sub-groups, results of the characterization, along with local knowledge, were used to develop more specific management recommendations for individual PAUs. Details of the management recommendations are provided on the subbasin folio sheets in Chapter 4. On each of the subbasin folio sheets, analysis results are provided along with management priorities for each watershed process, land use opportunities and constraints, and preliminary management priorities and objectives for the subbasin.

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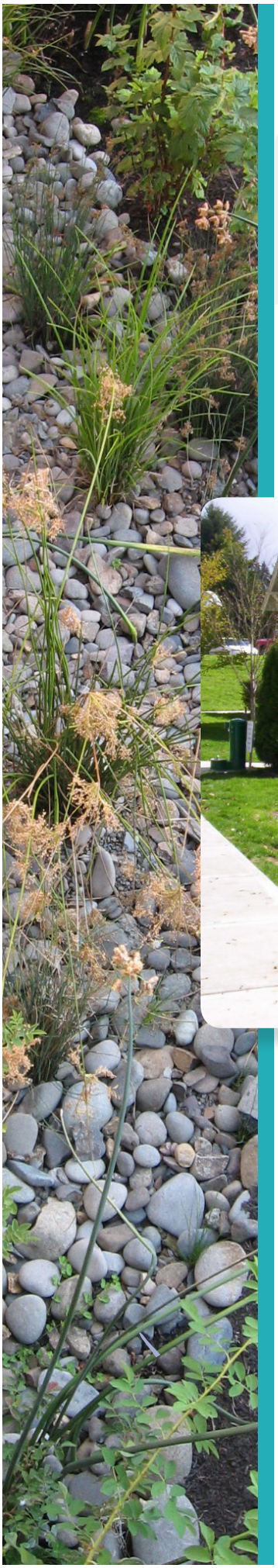
APPENDIX C

LOW IMPACT DEVELOPMENT MANUAL FOR RESIDENTIAL PROJECTS

Appendix C

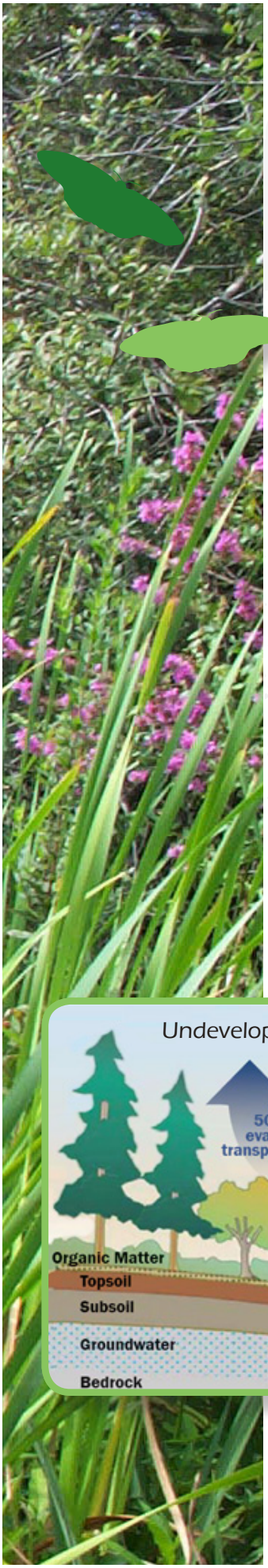


City of Duvall
Washington

Homeowner's Guide to Low Impact Development Best Management Practices

A Guide to Design, Installation, and Maintenance

March 2015



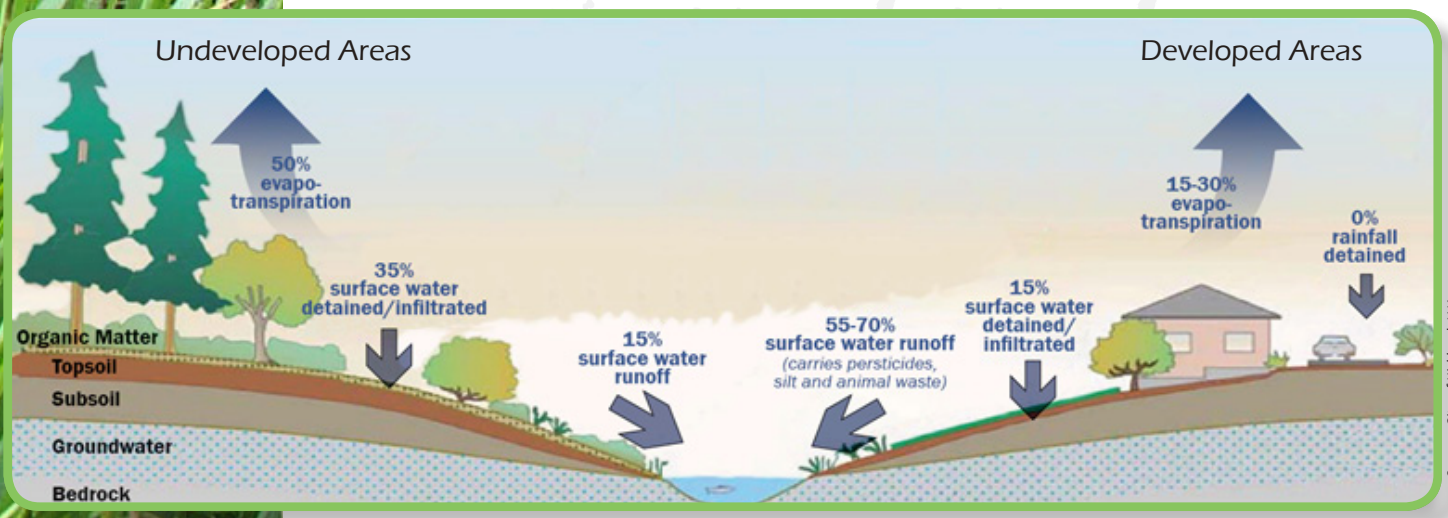
What is Low Impact Development?

Low Impact Development (LID) refers to stormwater and land use management practices that mimic natural hydrologic processes by promoting infiltration, evapotranspiration, water storage and filtration, and conservation of natural landscape features and vegetation. LID Best Management Practices (BMPs) manage and treat stormwater runoff close to its source to moderate the runoff volume reaching streams, prevent erosion, recharge groundwater aquifers, and maintain the health of stream, wetlands and other waterbodies.

Using LID BMPs on residential lots reduces the amount of precipitation running off as stormwater and improves water quality, which allows public stormwater facilities to work more effectively to protect streams and wetlands.

Why use Low Impact Development BMPs?

In developed areas like Duvall, hard (impervious) surfaces such as buildings, parking lots, and streets replace areas that historically stored and infiltrated precipitation. Precipitation runs off of impervious surfaces as storm water, gets collected in stormwater pipes, and is conveyed to detention facilities or discharged directly to a stream. Unless this stormwater is properly managed, it contributes to high flow rates in streams during storms. High flow rates increase flooding and destabilize stream banks, threatening homes, roads, utilities, and other important infrastructure. High flows also damage stream habitat, making conditions less suitable for fish spawning, rearing and migration. Additionally, stormwater runoff can pick up pollutants from impervious surfaces and carry them directly to the stream, degrading water quality.



Source: City of Kirkland, WA

Integrating LID BMPs into developed areas restores some of the natural hydrologic functions resulting in better water quality, reduced flooding, and reduced stream erosion.

Low Impact Development on Your Property

This booklet is organized into three basic steps intended to provide guidance for the use of LID BMPs on a residential lot.

1. **Assess your property**
2. **Select an LID BMP**
3. **Design, install, and maintain your LID BMP**

1) Assess Your Property

Site planning is an integral part of implementing LID BMPs. To identify the approrpiate BMPs for your property, it is important to assess natural characteristics and built infrastructure. The first step is to draw a map of the existing features on your property. Common site characteristics to consider are described in the table below.

PROPERTY ASSESSMENT

Characterize Soils	Identify locations where soils may be contaminated by past activities such as oil or lead paint. Areas with contaminated soils are not suitable for LID BMPs. Identify locations with high groundwater. Avoid areas where winter ponding occurs.
Locate Existing Trees	Locate mature trees. Consult an arborist if the LID BMP will be located within the drip line of an existing tree to determine if the LID BMP will destabilize or otherwise adversely affect the health of the tree.
Streams and Wetlands	Construction near streams and wetlands may require additional considerations and permits. Consult a natural resource scientist if you think you will need to do work within or adjacent to a stream or wetland.
Identify Stormwater Flow Patterns and Impervious Areas	Draw a diagram of flow directions. Identify locations where surface runoff leaves your property.
Map Setbacks	LID BMPs should be at least 10 feet from structures and 5 feet from property lines where the adjacent property is down slope.
Locate Utilities	Locate existing utilities such as electric, water, sewer, and gas lines that run underground. Call 811 to have utilities located with spray paint on your site.

2) Select an LID BMP

Once you have completed your property assessment, follow the flow diagram to determine which LID BMPs are suitable on your property.

Is your property located in a steep slope hazard area?

Yes → LID BMPs
- Amended Soils
- Native Plants
- Cistern/Rain Barrel

No → Is the infiltration rate at least 0.5 inch per hour?* (infiltration test on next page)

No → LID BMPs
- Amended Soils
- Native Plants
- Cistern/Rain Barrel
- Rain Garden
- Dispersion

Yes → LID BMPs
- Amended Soils
- Native Plants
- Cistern/Rain Barrel
- Rain Garden
- Dispersion
- Pervious Pavement/Pavers
- Gravel Trench

Click here for a Landslide and Erosion Hazard Area Map to determine whether your home is in a hazard area:

http://www.duvallwa.gov/DocumentCenter/View/110

* If you do not measure the infiltration rate, assume soil will not infiltrate 0.5 inch/hour.

SOIL INFILTRATION TEST

The next step to selecting appropriate LID BMPs is to determine your soil infiltration rate. You can measure the soil infiltration rate using an Open Pit Infiltration Test.

Steps for an Open Pit Infiltration Test:

1. Dig a hole to the depth where the bottom of the LID BMP will be located. This can be done by hand using a shovel, auger or post-hole digger. Ideally this should be done when groundwater levels may be high (such as spring).

2. Fill the hole with water to a height of about six inches from the bottom of the hole or to one-half the maximum depth of the proposed facility (whichever is greater),
   and record the exact time.

3. Check the water level at regular intervals (at least 4 times) until all the water has infiltrated. Record the distance the water has dropped from the top edge of the hole for each time interval.

4. Calculate time interval, drop in water level and infiltration rate for each interval. The infiltration rate for the hole is the average
   of all individual infiltration rates.

$$\text{Infiltration rate} = \frac{\text{drop in water level}}{\text{time interval}} \times \text{time conversion}$$

$$\textit{for example:} \quad \frac{0.6\text{ in}}{20\text{ min}} \times \frac{60\text{ min}}{\text{hr}} = 1.8\text{ in/hr}$$

5. Repeat this process two more times, for a total of three rounds of testing. These tests should be performed as close together as possible to assess the soils ability to infiltrate while saturated.

STEP 1. Dig a hole

STEP 2. Fill the hole with water

STEP 3. Record the water level at regular time intervals

Robert Emanuel

LID BMP Options for Residential Development

Once you have determined which LID BMPs are suitable for your property, select the LID BMP(s) that best meet your personal aesthetic, budget, and environmental stewardship goals.

LID BMP	Description	Photo
Amended Soils	Amending soil restores the health and function of disturbed soils. Amending soils reduces the amount of runoff from landscaped areas. Two common materials for amending soil are: 1) Native topsoils, stockpiled and reapplied (amendment with some imported topsoil may be necessary) 2) Imported topsoil (Pacific Topsoils, Topsoils Northwest, or other approved source)	 *ESA*
Native Plants	Native plants intercept and transpire precipitation. They are adapted to the northwest climate thus often reduce the need for summer irrigation and use of fertilizer, pesticides, and herbicides. Some common and useful native plants for Duvall include vine maple, Pacific Dogwood, bitter cherry, oceanspray, tall Oregon Grape, bald hip rose and snowberry. Extensive plant lists are available in the Rain Garden Handbook for Western WA.	 *King County*
Cistern/Rain Barrel	Rain barrels and cisterns collect runoff and store it for re-use. They reduce peak runoff rates and can be used to offset summer irrigation needs. *Capacity - limited.	 *SPU*
Rain Garden	Rain gardens store and filter runoff from adjacent developed surface areas; this improves water quality and also reduces peak runoff rates.	 *ESA*

LID BMP	Description	Photo
Dispersion	Dispersing runoff from roofs or adjacent impervious areas; improves water quality and reduces peak runoff rates. *Cost effective if you have a small impervious area and a large greenspace that infiltrates.	 *Clark County*
Pervious Pavement / Pavers	Pervious pavements and pavers allow precipitation to soak into the ground. This improves water quality and reduces peak runoff rates. *Appropriate where infiltration rates are high enough that ponding does not occur.	 *SPU*
Gravel Trench	Gravel trenches allow precipitation to soak into the ground. This improves water quality and reduces peak runoff rates. *Appropriate where infiltration rates are high enough that ponding does not occur.	 *SPU*

3) Design, install, and maintain your LID BMP

Specific detailed information about proper design, installation and maintenance of the LID BMPs recommended in this booklet can be found in the attached fact sheets or the Rain Garden Handbook. The Rain Garden Handbook for Western Washington can be obtained from the Department of Ecology's website at: https://fortress.wa.gov/ecy/publications/publications/1310027.pdf. The fact sheets are also available online or for pick up at city hall.

Additional Resources

King County's Native Plant Guide Website– includes lookup tools, customizable plant lists, sample landscaping plans and more resources to "create your own native plant landscape". Available at: https://green2.kingcounty.gov/gonative/Index.aspx.

12,000 Rain Gardens in the Puget Sound – a collaboration between Stewardship Partners and WSU to provide free rain garden education workshops to homeowners, as well as other resources. Available at: http://www.12000raingardens.org/.

RainWise Program Website – Seattle Public Utilities resources for managing rainwater at your home. Available at: http://www.seattle.gov/util/MyServices/DrainageSewer/Projects/GreenStormwaterInfrastructure/RainWise/index.htm.

For more information please contact:
City of Duvall
14525 Main Street NE
Duvall, WA 98019
425.788.3434

The City of Duvall is committed to Low Impact Development.

APPENDIX D

GIS DATA SOURCES LIST

Appendix D

Appendix D - GIS Data Sources List

August 2015

Theme	Sub-theme	Data	Description	Date	Source	Resolution	Link
THEME 1 - Puget Sound Watershed Characterization Data Layers (Ecology) ***The City coordinated with Ecology to rerun the assessment for the project's study area using the same framework and data as used for the watershed-scale assessment***	*The Puget Sound Characterization is a set of water and habitat assessments that compare areas within a watershed for restoration and protection value. It is a coarse-scale decision-support tool that provides information for regional, county, and watershed-based planning. The information it provides will allow local and regional governments to base their decisions regarding land use on a systematic analytic framework that prioritizes specific geographic areas on the landscape as focus areas for protection, restoration, and conservation of our region's natural resources, and that also identifies areas that are likely suitable for more development.* ***- See Ecology Watershed Characterization Layer Gallery (https://fortress.wa.gov/ecy/coastalatlas/wc/LayerGallery.html) for more information***						http://www.ecy.wa.gov/puget_sound/characterization/index.html
	Watershed Scale - Water Flow	Delivery, Discharge, Recharge and Surface Storage submodels		2010	Ecology		http://www.ecy.wa.gov/services/gis/data/pugetsound/characterization.htm
		See Ecology Watershed Characterization Layer Gallery (https://fortress.wa.gov/ecy/coastalatlas/wc/LayerGallery.html) for more information	Water flow assessment includes watershed characterization results for key water flow processes – including delivery, surface storage, recharge, and discharge. Results presented for water flow improtance, degredation, and restoration / protection prioritization				
	Watershed Scale - Water Quality	Sediment, Phosphorus, Metals, Nitrogen, Pathogen		2012	Ecology		http://www.ecy.wa.gov/services/gis/data/pugetsound/characterization.htm
		Land Use/Land Cover (NOAA C-CAP)	The Coastal Change Analysis Program (C-CAO) is a nationally standardized database of land cover information (developed using remotely sensed imagery) for the coastal regions of the US.		NOAA-CCAP		
		Sub-Basin Analysis Units (NIFC SSHIAP)	Hydrography data from the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP).		NIFC SHIAP		
		2-year, 24-hour storm event precipitation (OCS Prism Model)	Precipitation data from the Parameter-elevation Regressions on Independent Slopes Model (PRISM).		PRISM		
		Digital Elevation Model (USGS)	Elevation data.		USGS		
		K-Factor Grid (NRCS SSURGO)	Soil erodability (K-factor) data from the Natural Resource Conservation Service (NRCS)		NRCS		
		Hydrologic Soil Groups (NRCS SSURGO)	From the Natural Resource Conservation Service (NRCS): classification of soils into groups (A, B, C, and D) based upon their water infiltration rate.		NRCS		
	Watershed Scale - Fish & Wildlife Habitat			2011	Ecology		http://www.ecy.wa.gov/services/gis/data/pugetsound/characterization.htm
		Ecoregional Assessments (WDFW et al.)	Priority areas for preserving biodiversity, developed from wildlife occurrence records and a classification of habitat types.		WDFW		
		Priority Habitats and Species (WDFW)	Database of species and habitat locations, drawn for multiple agency databases.		WDFW		
		Land Use/Land Cover	Derived from satellite-collected data (various sources)		NOAA-CCAP		
		Road density	Road density and traffic intensity data		WSDOT		
THEME 2 - Finer Scale Data (Locally Available from City and King County Sources) ***The City used these existing data layers when completing secondary subbasin assessment as part of the project***	Aerial Photography	King County aerial ortho-photography	City currently aquiring from County	2012	King County Air Photo co-op		Acquired by City from King County
	Topography	King County LiDAR / Digital Elevation Model	Elevation and hillshade - City currently aquiring from County	2012	King County		Acquired by City from King County
	Impervious Surface	CountyImpervious/Impacted Surface Interpretation; incorp building footprint (2012)	Determine % impervious at sub-basin scale also effective impervious	2012	King County	12" spatial	Acquired by City from King County
	Forest Cover	Forest Cover		2007	King County	1m spatial	
	Road Density	Transportation Network	# of miles of roads per basin	2013	King County		
	Precipitation	TBD - PRISM/USGS rain gauge data and interpolate					
	City / County Sensitive Areas Inventories	Wetlands, Streams, and Geologic Hazard Inventories		2006	Duvall / King County		http://www.duvallwa.gov/appsformspubs/Duvall%20wetlands.pdf ; King County Erosion Hazards: http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=erode ; King County Wetlands: http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=sao_wetland
	% Soil Hydro Classes (A,B,C,D)	Soil Hydrologic Classes	soil hydrologic classes (A,B,C,D)				
	Geologic Units	Geologic Units	Geologic Map of Carnation 7.5 min Quadrangle, King County, Washington	2010	WDNR		
	Slope	LiDAR Derived Slope Classes				1m spatial	
	Road Crossings/Density/Length	Transportation Network	# of road crossings	2013	King County		
	Stormwater Infrastructure						
		Piped and Open Drainage System	Stormwater geodatabase	2012	Duvall		
		Detention Ponds	Stormwater geodatabase	2012	Duvall		
		Drainage data for Unicorporated King County	KIng County stormwater GIS data	2012	King County		
	Buffer Intactness/Riparian Condition	TBD - coordinating with King County and other agencies on data source for this					
	Sensitive Area Connectivity	Priority Habitats and Species (WDFW)		2013	WDFW		
		Wildlife Habitat Network	The Wildlife Habitat Network was designed to link high quality streams and open space lands and to minimize habitat fragmentation.	1996	King County		http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=wildnet96
	Fish Presence	Fish Distribution		2011	WDFW		
		Fish Distribution	Mapped Chinook Distribution in King County	2001	King County		http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=chinbuff
	Land Use / Land Cover	King County Assessors Data		2012	King County		http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=parcel
		Landsat Landcover		2007	King County		
	Basin Condition	Environmental Condition of Basins	Environmental Condition Value for each King County Basin; Environmental conditons of Drainage Basins. Used as a tool to regulate land use according the 2005 King County Critical Areas Ordinance.	2005	King County		http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=basin_condition#Description
THEME 3 - Other Information ***The City used these layers to understand implications of the project's assessment***	Regulatory Data - Overlays	City Comprehensive Plan/Zoning	City of Duvall designations	2010	Duvall		http://www.duvallwa.gov/appsformspubs/2010_FINAL_Zoning.pdf
		King County Comprehensive Plan	King County Comprehensive Plan Lan	2013	King County		http://www5.kingcounty.gov/sdc/Metadata.aspx?Layer=complu
		City SMP		2013	Duvall		http://www.duvallwa.gov/departments/planning/SMP_Update/2011_Feb/Duvall%20Public%20Participation%20Plan.pdf
							http://www.duvallwa.gov/appsformspubs/Duvall%20wetlands.pdf
	Input from Technical Group	Digitized locations based on expert knowledge of area			Duvall and project experts		
	Existing BMPs						