Users Guide for the Puget Sound Watershed Characterization

Version 1. Draft – June 10th , 2013

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Department of Commerce
Innovation is in our nature.

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List of terms and acronyms used in this document

Analysis Area: The geographic extent of an assessment. It can range in scale depending on the size of a jurisdiction (city vs. county) and the type of landforms being considered (e.g., coastal terrace vs. large river basin). The methods and assessment models of the Characterization are not limited to a single scale but they do require source data that are both suitably detailed and sufficiently comprehensive across the analysis area.

Assessment Models: Methods that provide a quantitative analysis of abiotic and biotic components outlined in the conceptual model. This includes processes for water flow and water quality (sediment, metals, pathogens, nutrients), and terrestrial, freshwater, and marine/nearshore habitats. The models generate quantitative indices of relative condition for each Assessment Unit relative to all others, but they do not provide the actual rate or quantity of the presence or movement of water, sediment, pathogens or organisms.

Assessment Unit (AU): Each analysis area is divided into many smaller “Assessment Units” for comparison of model results. All source data and model results are homogenized within each AU; their size determines the minimum spatial scale over which the Characterization results are meaningful. Using available source data, AU’s are ranked from most important to least important, and most impaired to least impaired, for each process. The size and number of these units depends on the size of the analysis area, the landform types, available source data, and the planning issues a jurisdiction may be addressing.

Assessing Watershed Processes: The application of abiotic and biotic methods for analyzing watershed processes and environments presented in the conceptual model. In this document, ‘assessment’, ‘watershed assessment’, or ‘assessment of processes’ have the same meaning.

Characterization: The integration of multiple assessments, following an explicit conceptual model, that describes landscape conditions from the basin to sub-basin scale.

Conceptual Model: A simplified representation of a complex system that emphasizes the interrelationship of the major elements rather than the details of each element. For the Characterization, its conceptual model qualitatively describes the biotic/abiotic elements that are judged to drive and control physical and chemical processes, and the structure and functions of three biological environments (freshwater, terrestrial and marine) across multiple scales. Conceptual models are useful complements to (but not substitutes for) more detailed quantitative models.

Function: Role(s) provided by the local structures of the landscape at the site or reach scale, such as wildlife habitat, salmon spawning habitat, flow attenuation, flood storage, groundwater recharge, etc**.**

Impervious Surfaces: Constructed surfaces, such as pavement for transportation, buildings, roofs, and sidewalks, that effectively prevent or retard the movement of water vertically through the underlying soil and geologic deposits. The percentage of impervious surfaces in an assessment unit is the largest single determinant of that AU's degree of degradation.

Landscape Group: A group of AU's within the analysis area that each have similar environmental characteristics, such as precipitation, landform, and/or geology. In the current version of the Characterization models, landscape groups are identified strictly on geographical position (coastal, lowland, and mountain, plus a subset of lowland analysis units that drain to one of four large lakes). In the models that assess AU "importance," the assessment units are compared only to others within the same landscape group and not to assessment units in a different landscape group.

Method(s): The quantitative analysis of an individual watershed process. The methods applied for analyzing each process are presented in the appendices.

Multi-Scale Framework: An analytical hierarchy of abiotic and biotic assessments, information, and data across multiple scales within a watershed. The framework acts as decision-support tool to help interpret and apply Characterization results to planning and permitting decisions. The Characterization's "analysis framework" is an example of a multi-scale framework; it is based on a conceptual model that generally describes the freshwater, terrestrial and marine environments in Puget Sound and a set of analysis steps and questions to help integrate watershed information.

N-SPECT: The "Nonpoint-Source Pollution and Erosion Comparison Tool," developed and supported by the National Oceanographic and Atmospheric Administration (NOAA). N-SPECT is GIS-based model that uses pollutant export coefficients to quantify the relationship between land use/land cover and pollutant amounts. It is most useful in planning-level assessments such as the Characterization, providing estimates of the change in pollutant amount in response to a change in land use/land cover (see also http://www.csc.noaa.gov/digitalcoast/tools/nspect).

Process: Physical and chemical fluxes of water, sediment, nutrients, and organic material across large land areas (e.g., watersheds or drift cells) that form and maintain the landscape and the **structure** and **function** of their ecosystems over multiple scales. The movement of water, sediment, metals, pathogens, and nutrients constitute the processes addressed in Volume 1 of the Characterization).

Scale: The typical geographical extent of interest. The range of scales (and the terminology we adopt) in this document includes “basins” (>100 mi2); “sub-basins,” “valley segments,” and “drift cells” (commonly, 1 to 100 mi2); “reaches” and “waterbodies” (100 acres to 1 mi2); and individual “stream segments” and “sites” (normally, <100 acres).

Structure: Features of the landscape at the site scale created and maintained by the controlling **processes**, for example stream channel shape, floodplain, slope wetlands, estuaries, etc.

Watershed Management Matrix: A matrix that combines the categorical results of the models for importance and degradation for any single process in a particular AU to identify the most suitable management strategy (described by the terms protection, restoration, conservation, or development) for that process within that area.

Water Resource Inventory Area (WRIA): Administrative watershed boundaries designated by the State of Washington’s natural resource agencies.

Acronyms:

AU – Assessment Unit (see above)

GIS – Geographic Information Systems

SSHIAP – Salmon and Steelhead Habitat Inventory and Assessment Program

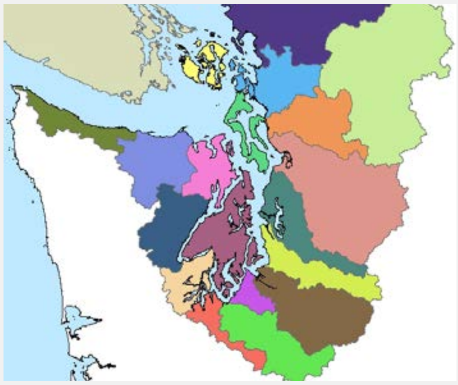
WRIA – Water Resource Inventory Area: the major watershed areas of Washington State, of which 19 drain into Puget Sound and the Strait of Juan de Fuca

1. Introduction

The Puget Sound Watershed Characterization Project is a decision support tool that provides information for regional, county and watershed based planning. It is comprised of a set of spatially explicit water and habitat assessments that compare areas within a watershed in terms of their relative value for protection or restoration. The assessments cover water resources (both water flow and water quality) and fish and wildlife habitats in terrestrial, freshwater and marine nearshore areas over the entire drainage area of Puget Sound. This document is a companion to Volume 1 , Volume 2, and the **Puget Sound Watershed Characterization Website** . It is intended to help users integrate and apply the assessment information in a systematic, consistent manner across multiple scales within an analytical watershed framework in order to achieve ecologically based land use and management decisions. Additionally, it acts as a navigation guide to the Watershed Characterization website.

Throughout this guide when we speak of the Puget Sound landscape, region, or basin, we are referring to the same geographic area (the 19 uniquely colored “water resource inventory areas” [WRIA’s] on the map).

When we refer to the Puget Sound “ecosystem,” we include the biological community along with the physical environment, not including marine waters seaward of nearshore areas.



This document is not intended as a replacement for the technical documents that describe the details of the Characterization history and methodology. The technical documents that describe the details of the individual assessments that make up the Characterization are available separately, they are:

Puget Sound Watershed Characterization - Volume 1: The Water Resource Assessments (Water Flow and Water Quality)

Puget Sound Watershed Characterization - Volume 2: A Coarse-scale Assessment of the Relative Value of Small Drainage Areas and Marine Shorelines for the Conservation of Fish and Wildlife Habitats in Puget Sound Basin

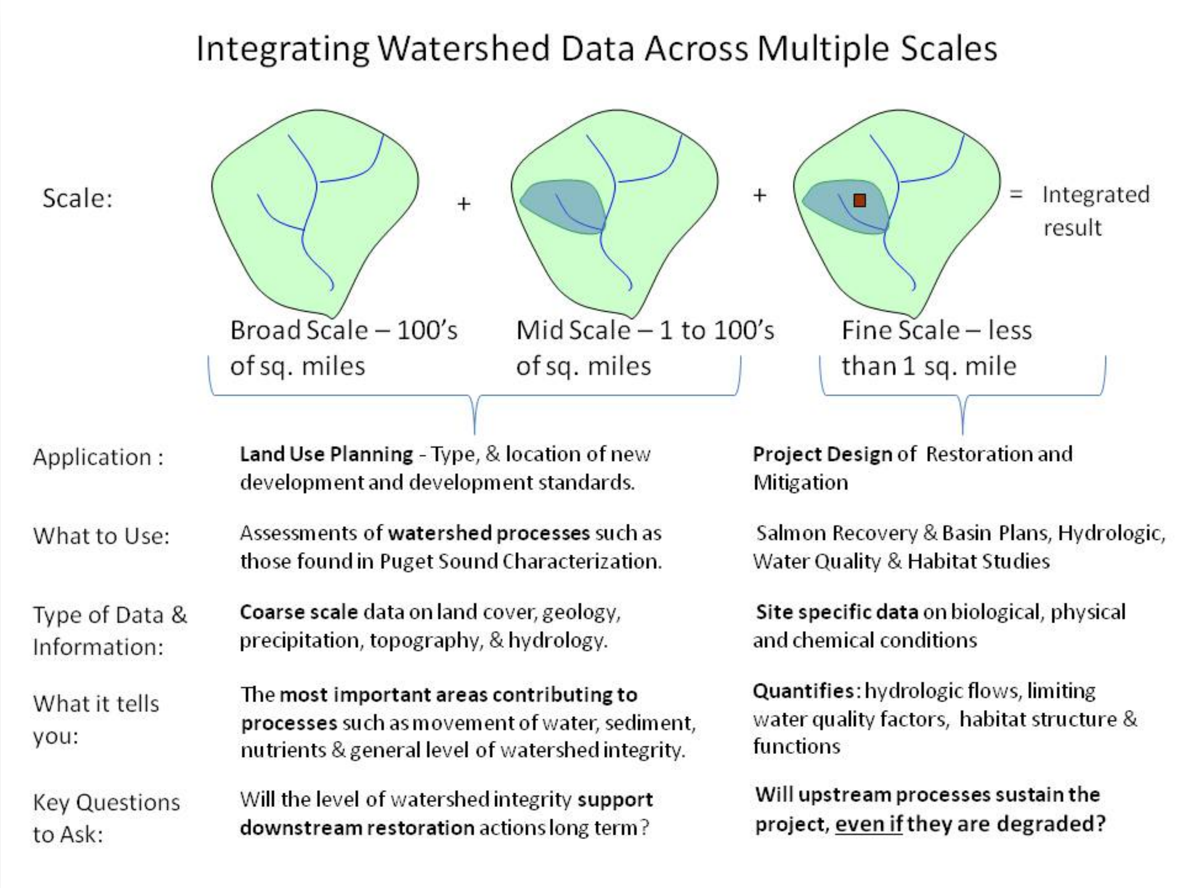
The Puget Sound Watershed Characterization is intended for use by city, county and Tribal government planners, watershed managers and decision-makers, state agencies and resource managers, and other regional decision-making bodies. It provides readily accessible, watershed-based information that can be used to help answer three fundamental questions:

1. ***Where on the landscape*** should management efforts be focused first, be they actions for planning (e.g., protection) or mitigation (e.g., restoration)?
2. ***Why specific areas on the landscape*** may be more important to maintaining watershed processes and functions?
3. ***What types of activities and actions*** are most appropriate to that place, be they restoration, protection, conservation, or development?

Multi-Scale Framework: An analytical hierarchy of abiotic and biotic assessments, information, and data across multiple scales (see Figure 1) within a watershed. The framework acts as decision-support tool to help interpret and apply Characterization results to planning and permitting decisions. The Characterization's "analysis framework" is an example of a multi-scale framework; it is based on a conceptual model (Figure 6) that generally describes the freshwater, terrestrial and marine environments in Puget Sound and a set of analysis steps and questions (figure 15) to help integrate watershed information. Over time, the framework analysis steps and questions will be added to and expanded from experience with actual planning applications.

By answering these three questions within the context of a watershed, using information from multiple scales (Figure 1 below) that integrate the basic understanding of the workings of the freshwater, terrestrial and marine nearshore environments in Puget Sound, planners can make more ecologically based decisions involving planning. This includes shoreline master plans , comprehensive plans (including critical area regulations), subarea and stormwater plans, and helping to establish the basis for a variety of mitigation and resource management programs such as in-lieu fee, transfer of development rights, ecosystem services and others. Over time, factoring an understanding of the watershed processes, structures and functions into these decisions related to regional planning should result in more effective, more successful restoration and protection actions and ultimately increase the overall health of Puget Sound.

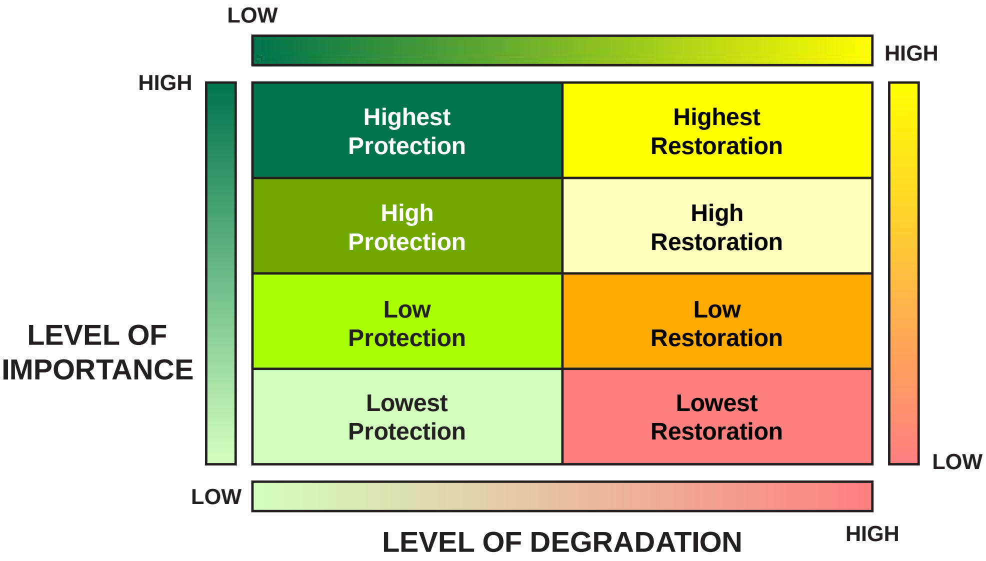
Figure 1. Integration of data across multiple scales



Integrating Watershed Data Across Multiple Scales

Application :	**Land Use Planning** - Type, & location of new development and development standards.	**Project Design** of Restoration and Mitigation
What to Use:	Assessments of **watershed processes** such as those found in Puget Sound Characterization.	Salmon Recovery & Basin Plans, Hydrologic, Water Quality & Habitat Studies
Type of Data & Information:	**Coarse scale** data on land cover, geology, precipitation, topography, & hydrology.	**Site specific data** on biological, physical and chemical conditions
What it tells you:	The **most important areas contributing to processes** such as movement of water, sediment, nutrients & general level of watershed integrity.	**Quantifies:** hydrologic flows, limiting water quality factors, habitat structure & functions
Key Questions to Ask:	Will the level of watershed integrity **support downstream restoration** actions long term?	**Will upstream processes sustain the project, even if they are degraded?**

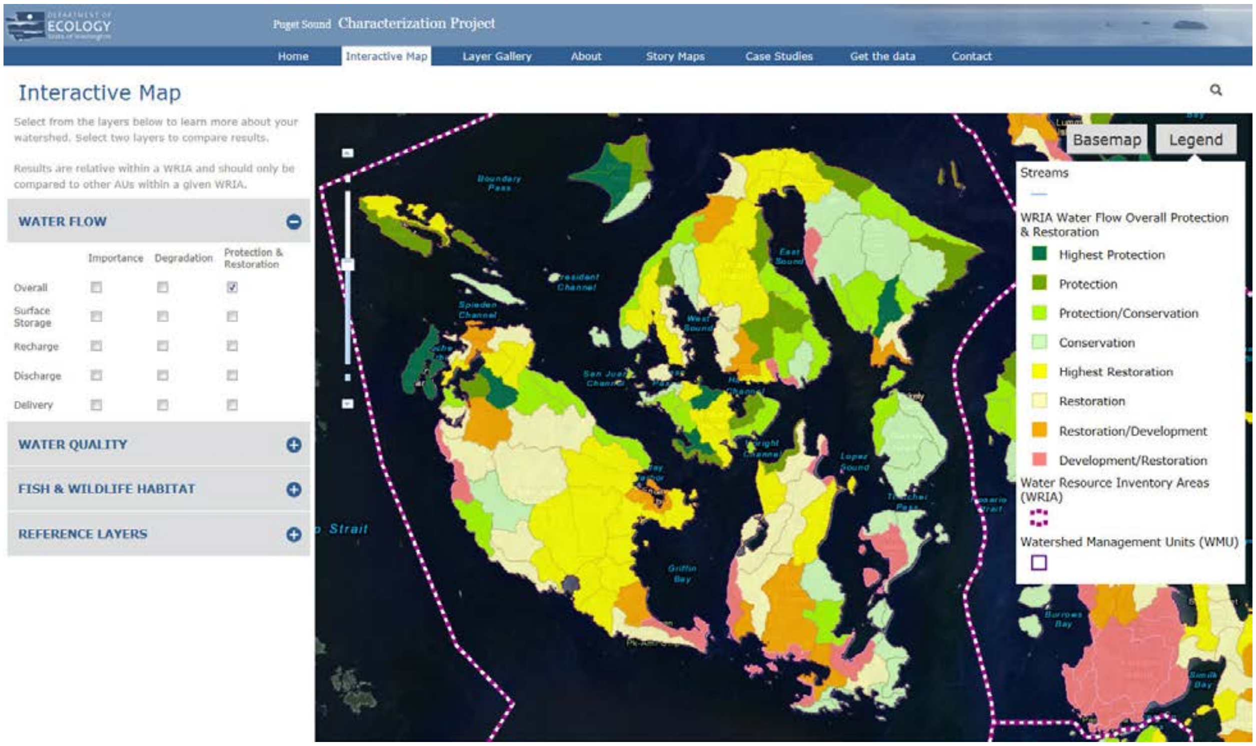
Figure 2. Management matrix for restoration and protection of water flow processes



Highest Protection	Highest Restoration
High Protection	High Restoration
Low Protection	Low Restoration
Lowest Protection	Lowest Restoration

The main products of the Characterization are color-coded maps that show the *relative* value of small watersheds and marine shorelines throughout the Puget Sound Basin. In general the relative value of small watersheds and marine shorelines for protection, restoration or conservation is determined by assessing the potential importance of the area to ecological processes or values (e.g., water delivery, sediment delivery, habitat/species conservation) and weighing that against the degree to which these fundamental process or values have been interrupted or degraded.

Figure 3. Interactive mapping application



Interactive Map

Select from the layers below to learn more about your watershed. Select two layers to compare results.

Results are relative within a WRIA and should only be compared to other AUs within a given WRIA.

WATER FLOW

	Importance	Degradation	Protection & Restoration
Overall	☐	☐	☑
Surface Storage	☐	☐	☐
Recharge	☐	☐	☐
Discharge	☐	☐	☐
Delivery	☐	☐	☐

WATER QUALITY

FISH & WILDLIFE HABITAT

REFERENCE LAYERS

Streams

WRIA Water Flow Overall Protection & Restoration

- 🟩 Highest Protection
- 🟩 Protection
- 🟩 Protection/Conservation
- 🟩 Conservation
- 🟨 Highest Restoration
- 🟨 Restoration
- 🟧 Restoration/Development
- 🟥 Development/Restoration

Water Resource Inventory Areas (WRIA)

Watershed Management Units (WMU)

The Watershed Characterization is Comprised of a Number of Assessments

Water Flow Assessment:

The water-flow model integrates two distinct submodels, one for "importance" and one for "degradation," that are both applied to every Assessment Unit (AU) across the Puget Sound region. A third submodel is applied only to those AU's whose water-flow processes are affected by upstream dams. The model evaluates the following groups of processes, the results of which can be combined to assess overall water flow processes or evaluated individually.

- Delivery – The Delivery process group assesses those physical features that control how precipitation is delivered to the landscape. This includes the quantity of precipitation, area of forest cover and rain on snow zones. Changes to these controls are also evaluated including percent of forest and impervious cover.
- Surface storage- The Surface Storage process group assesses those features that control the movement of water at the surface, including depressional wetlands and floodplains. Changes to storage are assessed based on the type of adjoining development and the changes to areas that decrease the capacity to store water.
- Recharge - The Recharge process group assesses areas that control the infiltration and percolation of precipitation into groundwater. The model calculates the decrease in recharge based on the intensity of development.
- Discharge - The Discharge process group assesses areas that control the movement of groundwater back to the surface, including the area of slope wetlands and floodplains with permeable deposits. Changes to discharge controls are evaluated based on road density, number of water wells and type of adjacent development.
- Loss – The Loss process group assesses areas that control the loss of water to the atmosphere or to another assessment unit via surface or groundwater. The loss process is only evaluated by the degradation submodel.

Water Quality Assessment:

There are five water quality models, each of which has an export potential submodel and a degradation submodel.

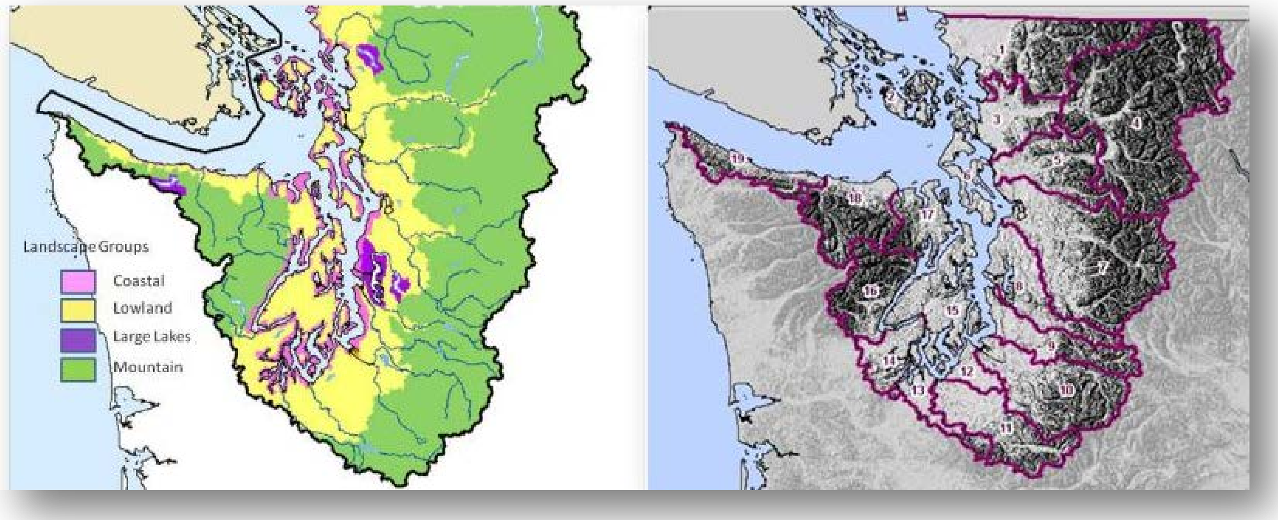
- Sediment Model – The Sediment export potential submodel assesses the relative capacity of an area under natural conditions to transport soil particles downstream based on an evaluation of areas that act as sources and sinks of sediment. The degradation submodel assesses the relative sediment load based on current land cover, using a modified universal soil loss equation.
- Phosphorous Model– The Phosphorous export potential submodel assesses the relative capacity of an area under natural conditions to transport phosphorous downstream based on areas that act as sources and sinks of phosphorous. Based on existing land cover, the degradation submodel assesses the relative capacity to generate and load phosphorous into aquatic systems during a storm.
- Nitrogen Model- The Nitrogen export potential submodel assesses the relative capacity of area to transport nitrogen downstream, based on an evaluation of areas that act as sinks which facilitate denitrification. Based on current land cover, the degradation submodel assesses the relative capacity to generate and load nitrogen into aquatic systems during a storm.
- Pathogens Model – The Pathogen export potential submodel assesses the relative capacity of an assessment unit under natural conditions to generate and transport pathogens downstream if disturbed, based on an evaluation of areas that act as sources and sinks for pathogens. Based on current land cover, the degradation submodel assesses the relative capacity to generate and load pathogens into aquatic systems during a storm.
- Metals Model– The Metals export potential submodel assess the relative capacity of area to generate and transport toxic metals downstream, based on an evaluation of areas that act as sinks which can trap metals. Based on current land cover, the degradation submodel assesses the relative capacity to generate and load toxic metals into aquatic systems during a storm.

Fish and Wildlife Habitats:

- Terrestrial – The Terrestrial index assesses the relative conservation value for terrestrial habitats as a function of landscape integrity and the locations of priority habitats and species.
- Freshwater – The Freshwater indices assess the relative conservation value for flowing water habitats as a function of: Salmonid habitats - the quantity and quality of habitats for all salmonids present or potentially present in the assessment unit (AU); Downstream habitats - the quality and quality of salmonid habitat downstream of the AU; and Hydrogeomorphic features - all extant wetlands and undeveloped floodplains in the AU.
- Marine - The Marine indices assess the relative conservation value for shoreline habitats as a function of all species, species groups, and habitats for which occurrence data were available: eight shellfish species or species groups of commercial/recreational interest, urchins, three forage fish species, eight salmonid species, numerous bird species, pinnipeds, kelp, eelgrass, surfgrass, and wetlands. The Marine Habitat Score presents the average relative conservation value of the shoreline segment.

The Puget Sound Watershed Characterization used assessment units (AUs) which roughly range in size from one square mile for coastal units to more than 40 square miles for mountainous units, with a median of 3.4 square miles. The water flow, water quality, terrestrial habitat, and freshwater habitat assessments all make use of these AUs which approximate small watersheds. These AUs are then grouped according to the Water Resource Inventory Areas (WRIA) they are located in and then further into “nested” smaller groupings within each WRIA. The second grouping occurs by dividing each WRIA into three landscape groups, identified as mountainous, lowland or coastal. The third grouping of AUs occurs by identifying Watershed Management Units (WMU) which nest generally within landscape groups and typically constitute individual stream drainages. In general, for the water flow, water quality and freshwater habitat assessments, AUs are evaluated relative to the first two groupings and not to AUs within other WRIAs. See Table 1 for additional details on these relative groupings.

Figure 4. Landscape groups (left side) and WRIA boundaries (right side) used to group assessment units for comparisons



The importance and degradation value of each AU is calculated through a comparison across an assessment area (e.g. WRIA and landscape group) resulting in relative values (lowest-highest) within that area. For the water flow importance and water quality export potential submodels, relative values are calculated for mountainous, lowland, large lakes, and coastal landscape groupings within a WRIA. This means direct comparisons of relative values should not be made across WRIAs or across landscape groupings within a WRIA. (Comparisons within Puget Sound Basin are available from Ecology but not presented here.)

Both the water flow and water quality degradation submodels were calculated within WRIAs, which allows for comparisons across landscape groupings but not WRIA boundaries. For the terrestrial habitat assessment, the models were run across the entire Puget Sound Basin extent, so AUs scores can be compared across WRIAs. For the freshwater habitat assessment, submodels were run within WRIAs, so comparisons should not be made across WRIAs. The marine shoreline habitat assessment did not use AUs. Instead it used small shoreline segments with an average length of 0.24 mile and the indices were calculated within each oceanographic sub-basin. This information is summarized in Table 1 and discussed in more detail in Section 3, Issues of Scale.

Table 1. Units and data presentation scales for assessments

Assessment	Base Unit	Aggregations	Comparison Area on the Website	Other Available Comparison areas
Water Flow	Analysis Unit (AU)	● WRIA ● Watershed Management Unit	● Importance model = WRIA by landscape group; ● Degradation model = WRIA; ● Restoration & Protection = WRIA by landscape group	Puget Sound Basin by landscape group
Water Quality	Analysis Unit (AU)	● WRIA ● Mountainous, lowland, coastal landscape groups ● Watershed Management Unit	● Export Potential model = WRIA by landscape group; ● Degradation model = WRIA; ● Restoration & Protection = WRIA by landscape group	Puget Sound Basin by landscape group
Terrestrial Habitat	Analysis Unit (AU)	Puget Sound Basin	Puget Sound Basin	Puget Sound Basin
Freshwater	Analysis Unit (AU)	WRIA, WMU	WRIA	None
Marine Shorelines	Shoreline segment	Oceanographic sub-basins	Oceanographic sub-basins	Puget Sound Basin

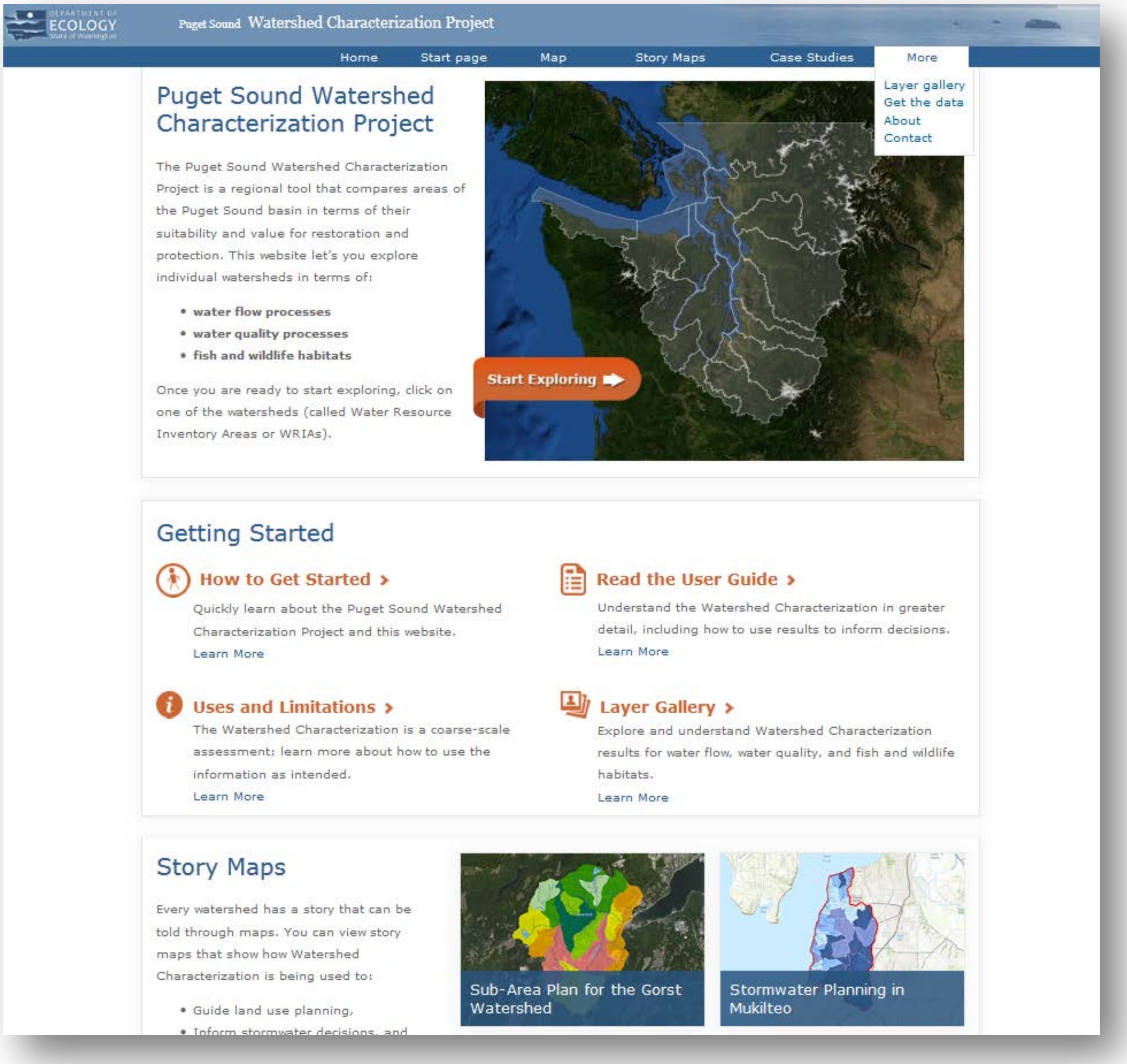
The primary interface for the Characterization is through the **Puget Sound Watershed Characterization Website**. This website allows users to explore all of the individual assessments through an interactive mapping tool.

Assessment Units

Assessment units are groupings of smaller catchments from the Salmon and Steelhead Habitat Inventory and Assessment Program (SSHIAP). They are based primarily on gradient and confinement and reflect the processes that form and maintain stream segments. There are two-thousand nine-hundred forty AUs in the Characterization.

The Characterization website also provides users with more detail on how to apply Characterization information within a watershed framework. This includes guidance on watershed-based management strategies and actions based on some common watershed management scenarios. **Story maps,** accompanying **case studies provide real-world examples** that illustrate how the Characterization information has been applied in a number of decision contexts across Puget Sound.

Figure 5. Watershed characterization website landing page



Puget Sound Watershed Characterization Project

The Puget Sound Watershed Characterization Project is a regional tool that compares areas of the Puget Sound basin in terms of their suitability and value for restoration and protection. This website let's you explore individual watersheds in terms of:

- **water flow processes**
- **water quality processes**
- **fish and wildlife habitats**

Once you are ready to start exploring, click on one of the watersheds (called Water Resource Inventory Areas or WRIAs).

Getting Started

How to Get Started ›

Quickly learn about the Puget Sound Watershed Characterization Project and this website.

Learn More

Read the User Guide ›

Understand the Watershed Characterization in greater detail, including how to use results to inform decisions.

Learn More

Uses and Limitations ›

The Watershed Characterization is a coarse-scale assessment; learn more about how to use the information as intended.

Learn More

Layer Gallery ›

Explore and understand Watershed Characterization results for water flow, water quality, and fish and wildlife habitats.

Learn More

Story Maps

Every watershed has a story that can be told through maps. You can view story maps that show how Watershed Characterization is being used to:

- Guide land use planning,
- Inform stormwater decisions, and

Sub-Area Plan for the Gorst Watershed

Stormwater Planning in Mukilteo

Limitations

Care should be taken to use the Puget Sound Watershed Characterization as intended. It is a coarse-scale, decision support tool that provides information for regional, county, and watershed –based planning. This multi-scale approach can help inform site scale decisions regarding restoration and protection actions but is not of sufficient resolution to aide in the final location or design of these actions.

There are other limitations that be taken into account when using this data:

- The Puget Sound Watershed Characterization is for planning purposes only. This information does not affect or alter existing land use/environmental regulations although it can be used to help inform future land use and regulatory decisions.
- The water quality assessments that are part of the Characterization are different from the State's Clean Water Act-mandated water quality assessment. The water quality ratings for each Assessment Unit (AU) are separate from and have no bearing on 303-d listings or any other aspect of the assessments required under Sections 303(d) and 305(b) of the federal Clean Water Act.
- As discussed earlier, in the main website display, results for water flow and water quality assessments are presented within landscape groups in each WRIA. This means it's not appropriate to compare the AUs ratings in one WRIA to AU ratings in a different WRIA. A Puget Sound Basin-wide scale that would allow such comparisons is available for download from Ecology. The terrestrial habitat assessment results are presented at the Puget Sound scale, so cross-WRIA comparisons are appropriate. The freshwater fish assessment results are presented at the WRIA scale, and the marine shoreline results are presented by oceanographic sub-basin so those results are comparable only within WRIA and sub-basins, respectively.
- Users should always examine the overall water flow integrity (aggregated condition of all AUs) of a Watershed Management Unit (WMU) relative to the actions within a single AU For example, even though an individual AU may be rated as a low priority for restoration processes in upstream AUs may be functioning properly (e.g. high rating for protection) indicating that downstream restoration has a higher probability of success Similarly, an individual AU that is rated for restoration may not be suitable location if upstream AUs are highly degraded. . Water flow integrity is discussed more in Section 4.
- The indices of relative conservation value are not comprehensive. They do not explicitly include all species, do not fully address habitat connectivity and do not address species or habitats that are mostly confined to higher elevations (>2000 ft) on public lands. The assessments may not adequately address the particular habitat needs of rare or imperiled (i.e., state or federally listed) species or species highly susceptible to human disturbance.
- The models developed for each of the assessments were based on a number of subjective judgments for which there was uncertainty: which factors to include, their relative influence,

and how to assemble them. Through numerous meetings with experts and intensive peer review we believe we have developed useful, scientifically credible indices of relative value.

2. Fundamental Concepts of Watershed Characterization

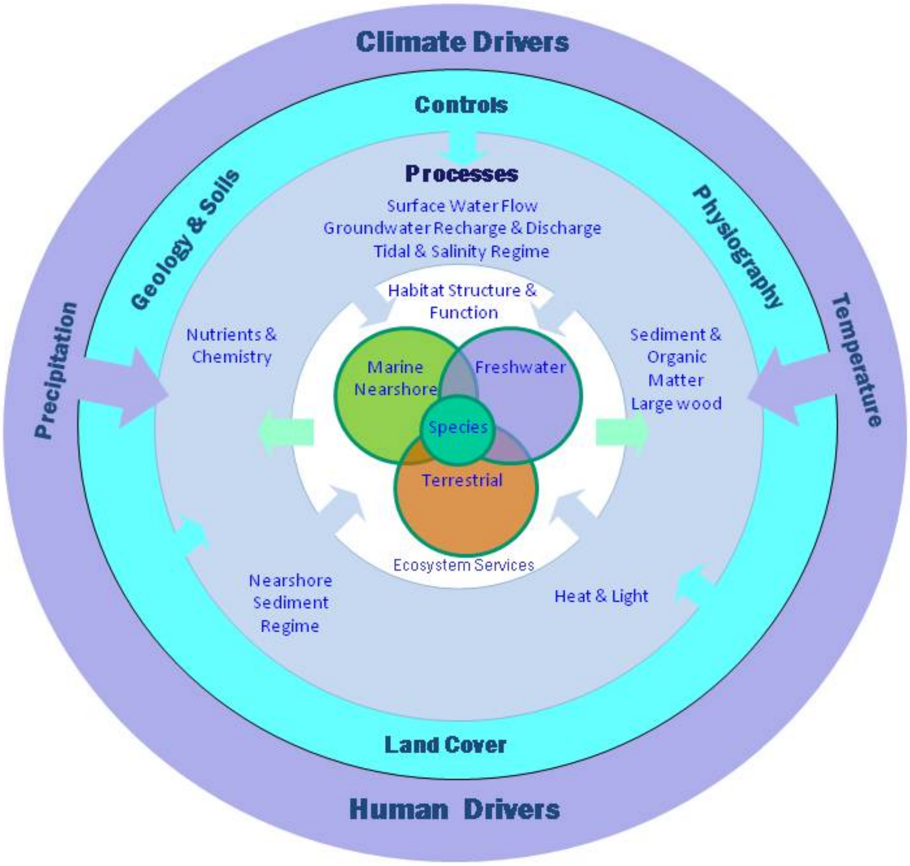
Watershed processes are defined as the dynamic physical and chemical interactions that form and maintain the landscape and ecosystems on a geographic scale of watershed to basins. This includes the movement of water, sediment, nutrients, pathogens, chemicals and wood. As described in Puget Sound Watershed Characterization - Volume 1: The Water Resource Assessments (Water Flow and Water Quality), the Puget Sound Watershed Characterization is built on the basic relationships between ecosystem processes, structure, and function. Environments are influenced by the broad physical and chemical fluxes (the driving processes) of water, nutrients, sediment, and organic material. In turn, processes lead to structures which provide function. In a river, for example, the processes of water and sediment movement produce sediment bars and channel features, which in turn provide off-channel rearing habitat for juvenile fish and other organisms.

Developing a watershed-level characterization requires a conceptual model of the basic workings of the ecosystem in question. The conceptual model (Figure 6) for the Puget Sound ecosystem that underpins the Puget Sound Watershed Characterization is described in detail in Puget Sound Watershed Characterization - Volume 1: The Water Resource Assessments (Water Flow and Water Quality). It is comprised of three primary environments (freshwater, terrestrial, and marine), and multiple spatial scales. The freshwater environment includes streams, wetlands and lakes, and the watersheds that contribute to these systems. The terrestrial environment is the land forms and land cover over which water reaches aquatic ecosystems and the source of wood and sediment, which provide habitat structure and function. The marine environment includes the nearshore zone. The principal interactions among these three environments occur through the movement of materials, both aboitic and biotic. Watershed processes transport materials from the terrestrial environment to both freshwater and marine environments through the movement, delivery, and loss of water, sediment, nutrients, and wood. In the Puget Sound region, for example, the primary biotic movers between the marine and freshwater ecosystems are salmon and other species of anadromous fish.

Watershed processes are influenced by natural controls and human actions. Natural controls on watershed processes include physical attributes of the ecosystem such as geomorphology, geology, and soils. Many human actions influence watershed processes. For example, timber harvest may reduce the amount of wood entering streams. Shoreline armoring can reduce sediment input from bluffs and alter the erosion, movement, and deposition of sediments along beaches. Urban development can alter the amplitude and timing of stormwater runoff.

As described in Puget Sound Watershed Characterization - Volume 1: The Water Resource Assessments (Water Flow and Water Quality), ecosystem patterns are the result of events occurring at multiple spatial scales. Large-scale drivers such as climate and ocean dynamics together with human activities such urbanization and deforestation operate at regional scale and directly interact with the drivers and controls of watershed processes. The interaction of natural and human-induced drivers and controls at multiple spatial and temporal scales ultimately governs the processes, structure, function, and ecological "health" of a watershed. Figure 6 illustrates the conceptual model for the Puget Sound ecosystem.

Figure 6. Conceptual model of the Puget Sound ecosystem for the approach used in the Characterization.



Benefits of Watershed Level Thinking

To maintain and restore function in the Puget Sound ecosystem important watershed processes that are still intact must be indentified and protected, and those that have been degraded and can be restored successfully must be restored. There is scientific consensus that proper function of the most highly valued ecosystems depends on what happens in the surrounding landscape, not just at the site or reach scale. This is particularly true of aquatic ecosystems, which express most directly the connectivity between different parts of the landscape.

Watershed-level thinking helps planners effectively consider the underlying landscape-level processes that support and deliver the natural resources and ecosystem services we value: clean, abundant water, habitat and species abundance and diversity, and land for development. When properly applied, watershed characterization will highlight the most important areas to protect and restore within each WRIA, and promote land use decisions that protect the health of Puget Sound's terrestrial and aquatic resources. In addition, by considering the fundamental landscape processes that create the conditions we experience on the ground, watershed characterization will help planners and decision makers direct management strategies and actions where they can make the most difference to protecting or repairing these fundamental processes, promote additive and synergistic benefits, and create restoration actions that have the most potential to be self-sustaining over time.

By using watershed characterization along with other science-based information planners and decision makers can:

- Develop and prioritize solutions to environmental problems based on an understanding of processes at a watershed or landscape scale;
- Replace planning based solely on jurisdictional boundaries with broader-scale more coordinated regional planning;
- Guide site-scale project review with watershed-scale context on ecological processes to ensure projects not only meet regulatory requirements but also more fully achieve their intended outcomes;
- Move towards integrated resource planning and management grounded in a landscape-scale understanding of how ecosystems work.

Over time, this will support better decisions about:

- Where to locate mitigation and/or restoration projects;
- Where to implement stormwater management strategies such as Low Impact Development;
- Where to focus future development;
- Where to limit or restrict future development;
- Where to strengthen regulatory protections (through critical area ordinances, shoreline master programs, and other regulatory mechanisms); and/or
- Where to take other actions to restore and protect watershed processes and the habitats those processes support.

It is important, however, to recognize that the watershed characterization is a decision support tool, not a decision-making tool. It provides an overview of likely conditions, problems, and opportunities based on available data, organized and analyzed in a consistent and systematic way in accordance with well-established scientific principles. Application of this information to land use planning is the role of local planners and decision makers who will weigh these results along with finer scale local information and other considerations that affect land use planning.

3. The Puget Sound Watershed Characterization—Key to Results

The Puget Sound Watershed Characterization is comprised of individual assessments of water flow, water quality, and fish and wildlife habitats over the entire drainage area of Puget Sound from the Olympic Mountains on the west to the Cascades on the east, including the Strait of Juan de Fuca and the San Juan Islands. This section discusses the scale of the results and provides a brief overview of how each individual assessment is carried out and how assessment results are integrated. Fuller details for the water flow and water quality assessments are provided in Puget Sound Watershed Characterization - Volume 1: The Water Resource Assessments (Water Flow and Water Quality); fuller details for the fish and wildlife habitat assessments are provided in Puget Sound Watershed Characterization - Volume 2: A Coarse-scale Assessment of the Relative Value of Small Drainage Areas and Marine Shorelines for the Conservation of Fish and Wildlife Habitats in Puget Sound Basin.

Issues of Scale

As presented on page 12 of the introduction and table 1, the assessment results are available in a series of nested scales. Scale refers, generally, to the size of the area of assessment (extent) and the resolution of the assessment results (grain, related to assessment unit size). There are different scales for the different components of the Characterization. In general, the water flow and water quality assessments share the same scales of assessment and level of data resolution, while the fish and wildlife assessments operate on different scales but generally at the same level of data resolution.

Scale for Water Flow and Water Quality Assessments

The main scale (extent of comparison) for the **water flow** and **water quality** assessment results is the **Water Resource Inventory Area (WRIA)** scale (200 mi^2 (500 km2) to more than ten times that size) by landscape group. A watershed is an area of land that drains into a common river, lake, or the ocean, the WRIA are the main watershed units in Washington State. The Puget Sound Basin is divided into 19 WRIA one for each of the main river systems that drain into Puget Sound. The upper and lower Skagit WRIA were combined for the purposes of the Characterization, resulting in 18 WRIA for this exercise. Each WRIA also was separated into distinct landscape groups consisting of the Coastal, Lowland, Large Lakes and Mountainous.

Finally to improve the ability of the Characterization to support consideration of the dynamics between conditions in different parts of a watershed (e.g., upper and lower watershed areas), each WRIA was further divided into sub-watersheds of 10's of square miles called **Watershed Management Units**

(WMU). These WMUs are aggregations of AUs which are connected hydrologically, but AU values are derived from the WRIA/landscape group extent of comparison.

For the water flow importance and water quality export potential assessments, each AU is assessed relative to all the other AUs in that landscape area in that WRIA (extent of comparison). The results then present an assessment of the relative value of each AU within the landscape group within the WRIA. By contrast, both the water flow and water quality degradation models are presented at the WRIA scale, which does allow for comparisons across landscape groupings but not WRIA boundaries. When combined into management matrices for water flow and water quality, comparisons are limited to the WRIA by landscape group. This is a very important consideration. *If your study area spans multiple WRIAs or spans landscape groups within a WRIAs, care should be taken not to misinterpret the relative results for water flow and water quality*.

Scale for the Fish and Wildlife Assessments

The primary scale (extent of comparison) for the fish and wildlife habitat assessments varies depending on the assessment. The terrestrial assessment covers the entire Puget Sound Basin with no spatial sub-divisions, and therefore valid comparisons can be made across WRIAs or counties. The freshwater assessments consist of separate assessments for each of 18 WRIAs in the basin, so scores cannot be compared across WRIAs. The marine shoreline habitat assessment splits Puget Sound into oceanographic sub-basins. Calculations are within sub-basins so scores cannot be compared across sub-basins. Furthermore, the terrestrial assessment ignores montane habitats and concentrates on the Puget Trough lowlands and foothills of the Cascade and Olympic mountains. The freshwater assessment was restricted to flowing water (lotic) habitats because the major conservation issues facing lentic systems (i.e., ponds and lakes), such as intensive shoreline development, are localized problems occurring at finer-scales than can be addressed by our assessment. The marine assessment is confined to shorelines segments because we lack data with which to assess the relative conservation value of deeper waters and the most direct impacts from development occur along shorelines.

Importance of Scale

It is important to consider issues of scale when using the Characterization to ensure that results are not misinterpreted. Table 2, which is drawn from Volume 1, presents the basic framework for integrating watershed information across multiple scales. The assessments provided by the Characterization provide information at the landscape or WRIA scale (first two columns in Table 2), but help inform decisions at the sub-basin, reach and site scale. Users of the Characterization information should always supplement the Characterization results with information and data, if available, at the reach and site scale, when making land use and resource management decisions. Similarly, site scale decisions on locating restoration and mitigation sites, should use the landscape scale assessment information from the Characterization.

Table 2. Relationships between the level of information and analysis at different spatial scales and the type of application of results to planning and permitting

Level of Information and Analysis	**Coarse/General → Fine/Detailed**			
Unit of Organization	Basin (WRIA)/ Sub-basin	Sub-basin /Valley segment/drift cell	Reaches / Water bodies	Segments / Sites
Typical spatial scale (area)	>100 mi^2	1–100 mi^2	100 acres–1 mi^2	< 100 acres
Type of Data-Acquisition Effort	Existing GIS data layers from Puget Sound Watershed Characterization	Existing GIS data layers from Puget Sound Watershed Characterization	Using existing data or field collection of new data on biological, physical and chemical conditions at these scales.	Usually requires field collection of new data on biological, physical, and chemical conditions at these scales.
Type of Application at Each Level	Land use planning and zoning, i.e., location, type, and/or intensity of new development to avoid and buffer existing, mapped watershed features.	Refinements of coarse-level assessment for application to land-use planning and zoning to protect existing watershed features serving important watershed processes and functions.	Reach and watershed-scale strategies for land and water protection & restoration. Reach-specific actions or BMPs to protect and restore conditions.	Site- and reach-scale project designs for specific BMPs to remediate stressors to restore and protect water bodies.
How the Puget Sound Watershed Characterization results could be applied	Water-flow and water-quality, fish & wildlife habitat assessments are most applicable at this scale, integrating sub-basin information on conditions of importance to each of these processes.	The water-flow and water quality assessments provide information at a sub-basin scale	The Puget Sound Watershed Characterization does not provide results at these scales. However, the characterization's results should be used to confirm whether actions at these scales are appropriate. For example, installation of wood at the site or reach scale should not be undertaken if upper water delivery and storage processes are highly degraded.	

Other Scales are Available

Water flow and water quality results also are available at the Puget Sound level, where all the AUs in the Puget Sound drainage are compared to each other within each landscape group (mountainous, lowland and coastal). The Puget Sound scale results for water flow and water quality are available via the website only as static layers; in the future they will be available through dynamic mapping interfaces, just as the WRIA scale results currently are. [1]

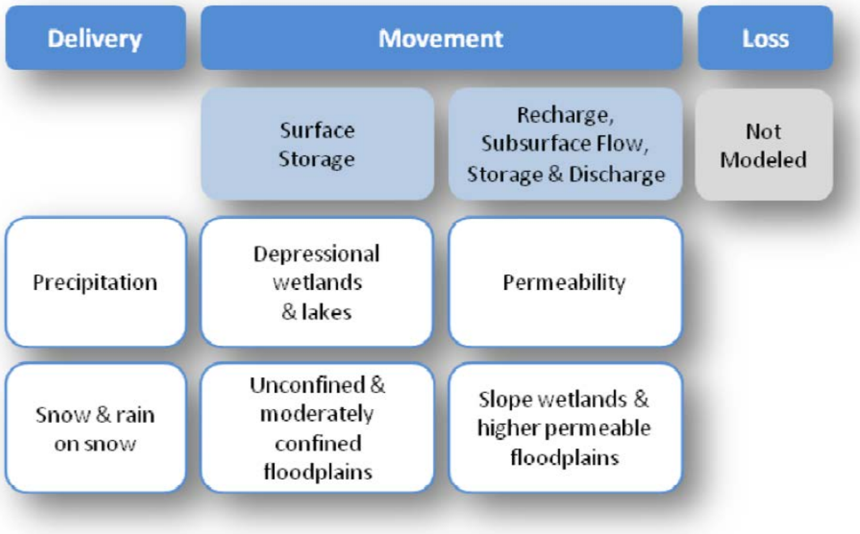
In addition, custom model outputs can be created that allow relative comparison of water flow and water quality results for AUs in particular sub-basins (e.g. see the Gorst case study and story map on the website), or at other custom scales (such as when a planning area crosses into another WRIA). If you are interested in this type of custom output, contact Ecology.[2]

Water Flow Assessments

The water flow assessment uses two models to indicate the relative importance and degradation of water flow processes in a watershed to identify areas that are relatively more suitable for protection or restoration of water flow processes. Each model provides a **ranking from low to high** for how important and how degraded each assessment unit is relative to the other units in the watershed.

The **importance model** evaluates the watershed in its "unaltered" state. This model combines the **Delivery, Surface Storage, Recharge**, and **Discharge** components to compare the relative **importance** of analysis units in regulating overall water flow processes in a non-degraded setting.

Figure 7. The water flow importance model



Importance = important areas for delivery + important areas for movement + important areas for loss.
Importance = [Precipitation + Timing of Water Delivery] + [Surface storage]+[(Sub-surface flow) + (Recharge +Discharge)] Where each component has a relative weight of 1.

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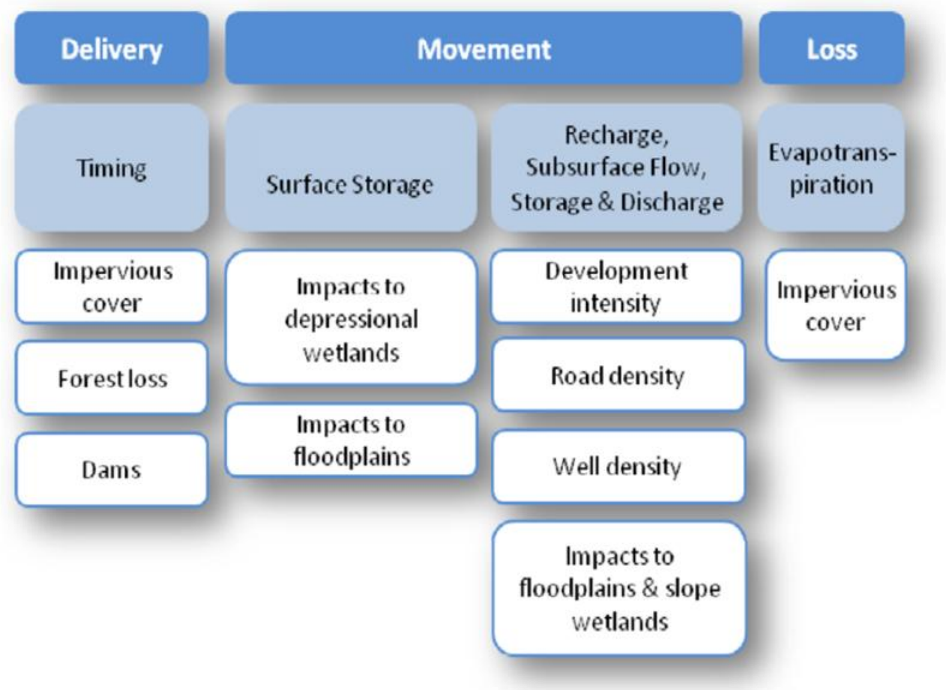
[1] The Puget Sound scale results are also available upon request by contacting Ecology. E-mail: colin.hume@ecy.wa.gov
[2] Contact Colin Hume. E-mail: colin.hume@ecy.wa.gov

In the water flow **degradation model** the watershed is evaluated in its “altered” state to consider the impact of human actions on water flow processes. This model combines the delivery, surface storage, recharge, and discharge components to compare the relative degradation to overall water flow processes in analysis units. Degradation to these processes generally accelerates the movement of surface flows downstream. This accelerated delivery increases downstream flooding and erosion and subsequently degrades aquatic habitat over time.

Figure 8. The water flow degradation model

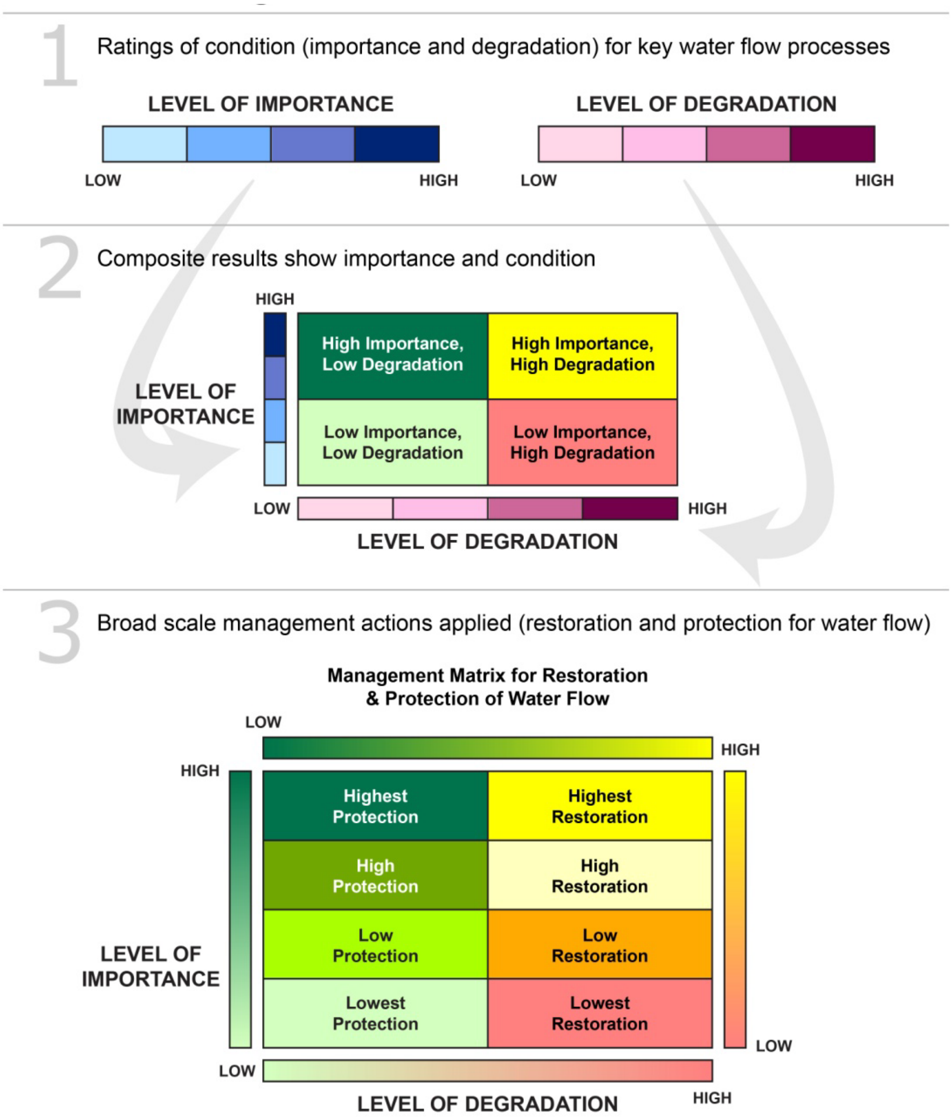


Degradation = Degradation to Delivery + Degradation to Movement + Degradation to Loss
Degradation = (degradation of timing of delivery)+ [(degradation of overland flow + degradation of surface storage)]+[(degradation of areas for recharge + degradation of subsurface flow + degradation of discharge areas)] + (degradation of evapotranspiration). Where each component has a relative weight of 1

As noted previously, each model results in a relative ranking of AUs from Low to High for importance or degradation to water flow processes. When presented in maps these rankings are “binned” into quartiles, each of which contain the same number of AUs (25% for each low, moderate, moderate-high, and high categories). As such, our categorizations are not based on the same “quantified” levels of importance and degradation across Puget Sound and therefore, should not be compared to categorizations in other WRIAs. In future versions of the models, there may be thresholds developed which could inform a different system of categorizing these results, but these have not yet been developed. It is appropriate for users of the Characterization results to bin and categorize the AU based on finer scale data and local knowledge.

Combining the importance and degradation models yields a simple matrix that planners can use, along with other science-based information, to inform land management strategies and actions. Figure 9 illustrates how the axes are combined to form the management matrix for water flow. For example, areas with relatively high importance and relatively low degradation (upper left in Figure 9) are most suitable for protection strategies, while areas with relatively low importance and low degradation (lower left) are lower priorities for protection. Areas with high importance and high degradation (upper right in Figure 9) should be considered for restoration actions, while areas with low importance and high degradation (lower right) are lower priorities for restoration. The combined matrix can be looked at for each individual model component (delivery, surface storage, recharge, discharge) and as a result that combines all the model components (Figure 9). As discussed previously, the assignment of an AU to one management category or another is ultimately based on how they were binned into quartiles for the Importance or Degradation models.

Figure 9. Understanding the water flow assessment, including the overall water flow matrix

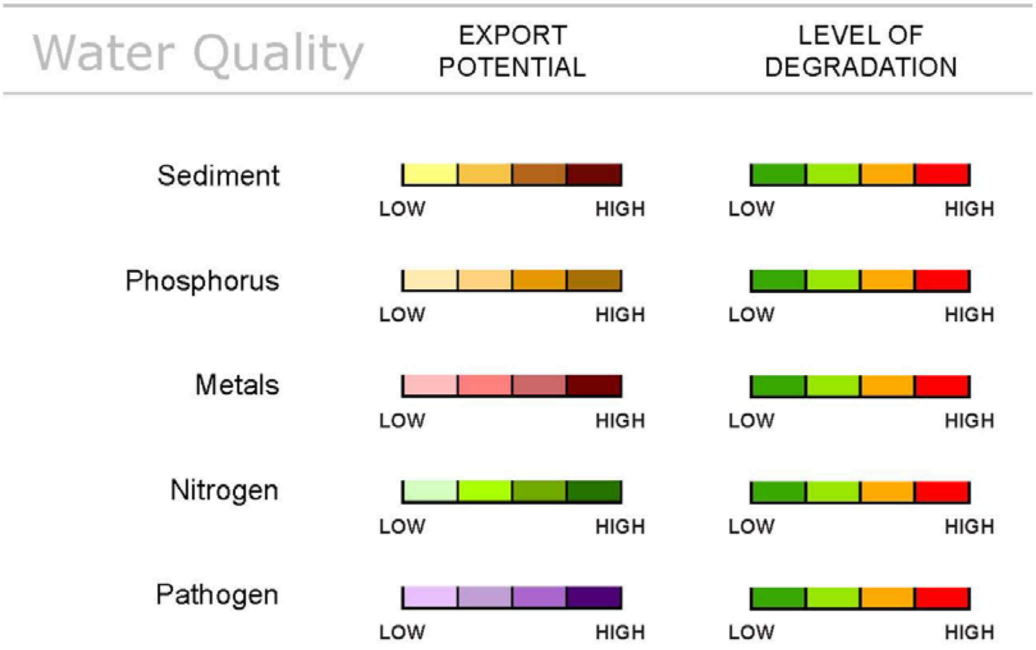


Details on how the water flow assessments were developed are available in the Layer Gallery and the Puget Sound Watershed Characterization - Volume 1: The Water Resource Assessments (Water Flow and Water Quality).

Water Quality Assessments

The water quality assessments include results for sediment, nutrients, pathogens, and metals. As with the water flow assessments, two models are used for each water quality parameter. The water quality export potential model evaluates how readily an AU can deliver sediment, nutrients, pathogens, and metals to downstream AUs based on parameter-specific factors. The water quality degradation model uses the output from N-SPECT to characterize the amount of degradation to parameter-specific water quality processes. N-SPECT is a GIS-based model that uses pollutant export coefficients to quantify the relationship between land use/land cover and pollutant amounts.

Figure 10. Results key for export potential and level of degradation for the water quality assessment



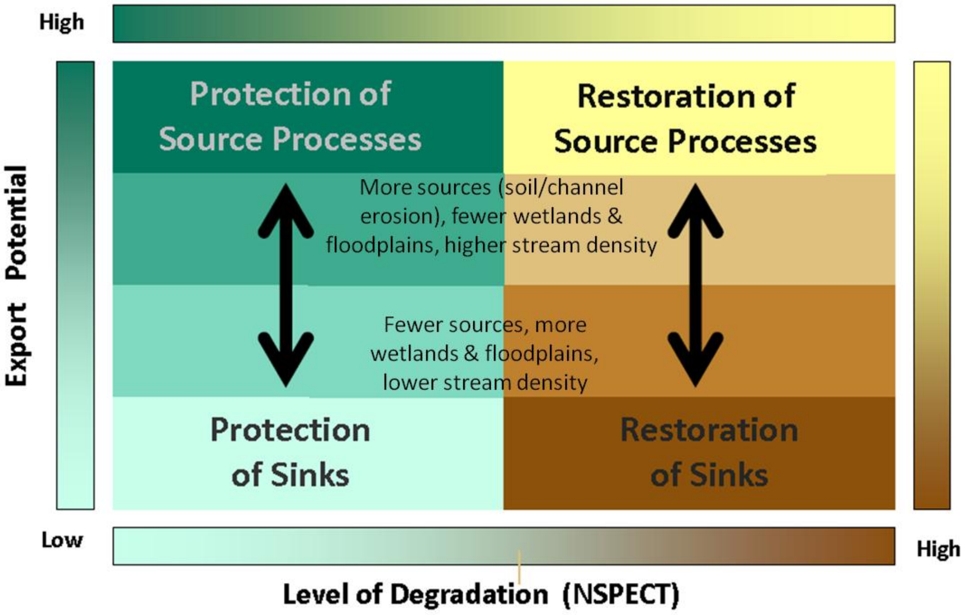
As with the water flow model, each water quality model results in a relative ranking of AUs from Low to High for export potential or degradation to water quality processes. When presented in maps these rankings are "binned" into quartiles, each of which contain the same number of AUs (25% for each low, moderate, moderate-high, and high categories). As such, our categorizations are somewhat arbitrary and users of the Characterization results may choose to bin and categorize the AU rankings in ways that make more sense to their application and local conditions.

Similarly to the water flow model, the export potential and degradation results can be combined to indicate relative water quality restoration / protection priorities within a WRIA. By combining the results, management actions at the broad scale can be identified which prioritize the protection or restoration of *sources* and *sinks* for each of the water quality processes. These management actions are represented in the matrix below (Figure 11) and identify assessment units with relatively:

- High Export Potential – Low Degradation (Protection of Source Processes)
- High Export Potential – High Degradation(Restoration of Source Processes)
- Low Export Potential – Low Degradation (Protection of Sinks)
- Low Export Potential – High Degradation(Restoration of Sinks)

Currently these matrices are presented only on a parameter-specific basis; over time, ongoing work seeks to create an indexing approach that integrates results across the five water quality parameters.

Figure 11. Water quality restoration/protection matrix for sediment



At a high level, management actions for sediment, phosphorous and metals models suggest:

- Protection of Source Processes: Preventing activities that remove vegetation cover and increase channel erosion
- Restoration of Source Processes: Restoring natural cover and controlling existing sources
- Protection of Sinks: Protecting wetlands, lakes, floodplains
- Restoration of Sinks: Restoring wetlands and floodplains

Management actions for nitrogen suggest:

- Protection of Source Processes = Limiting new sources of nitrogen and preventing impacts to headwater streams, wetland, lake and riparian denitrification areas
- Restoration of Source Processes = Controlling existing sources of nitrogen
- Protection of Sinks: Protecting headwater streams and areas of denitrification
- Restoration of Sinks: Restoring headwater streams and areas of denitrification

Management actions for pathogens suggest:

- Protection of Source Processes = Limiting new sources of pathogens
- Restoration of Source Processes = Controlling existing sources of pathogens and restoring wetlands
- Protection of Sinks: Protecting wetlands
- Restoration of Sinks: Restoring wetlands

For details on the water quality assessment, including water quality restoration / protection matrices for each of the models, see the Layer Gallery and information available in Puget Sound Watershed Characterization - Volume 1: The Water Resource Assessments (Water Flow and Water Quality).

Habitat Assessments

The fish and wildlife habitats assessments cover three separate environments: terrestrial, freshwater, and marine shorelines. The terrestrial and freshwater assessments indicate relative conservation value for each AU, and the marine shoreline assessment indicates the relative value of shoreline segments.

Certain places in a region are readily identified as valuable or even irreplaceable because they contain rare habitat-types, imperiled species, or abundant wildlife. For instance, in the Puget Trough Ecoregion, the prairies on Fort Lewis, the tidelands at the Nisqually River delta, the waterfowl over-wintering areas of the Skagit River delta, Protection Island with its dense colonies of breeding birds, and the Elwha River are universally recognized by biologists as crucial places for habitat conservation. The value of such places is obvious and absolute – experts are certain that these places should be protected or restored for their ecological values. Most other places lack rare habitats, imperiled species, or abundant wildlife. Such places may have value for the conservation of fish and wildlife habitats, but they lack those qualities that would make their protection indisputable. The value of places with “common” habitats can be assessed but only in a relative sense, and decisions regarding their protection must be based on relative value. Hence, for the multitude of places that contain only common species or common habitats, our assessment cannot determine whether site A or site B should be protected. Our assessment can only determine that site A is relatively more or less valuable for wildlife habitat than site B, and therefore, site A should be a higher or lower priority for habitat protection than site B.

In the terrestrial habitats assessment, relative conservation value was calculated in three stages. First, open-space blocks were identified. An open-space block is a contiguous area containing land uses –

such as commercial forest, agriculture, parks, and designated open-space – that maintain natural or semi-natural habitats or serve as habitats for native wildlife. Second, the landscape integrity of open-space blocks was assessed. Landscape integrity of each open-space block was a function of land use impacts and open-space fragmentation. In the third stage, the landscape integrity of open-space blocks was combined with PHS habitats located in each AUs to yield a relative value for habitat conservation.

Figure 12. Major components of the terrestrial index of relative conservation value. Left branch consists of fine filter species and habitats. Right branch is effectively a coarse filter that identifies places with high landscape integrity.

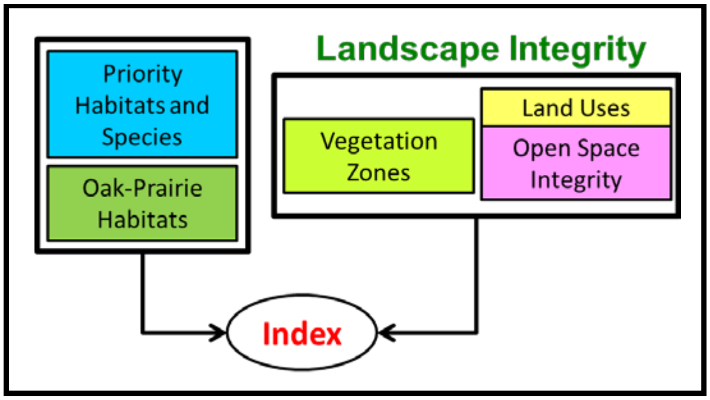


Table 3. A summary of models available for the terrestrial habitats assessment on the website

Terrestrial Habitat Index	The relative value of assessment units for conservation of terrestrial wildlife; comprised of two main components: landscape integrity and the locations of priority habitats and species
Terrestrial Open Space Blocks	A function of: the size and shape of each open space blocks, the proximity of each block to other open space blocks, and the land uses inside and surrounding each open space block.

The freshwater habitats assessment focuses on the dominant property of lotic systems – connectivity. Aquatic habitat quality in a stream reach is affected by conditions occurring upstream, and the conditions of that same reach affect habitat quality downstream. Therefore, the assessment of relative conservation value entails both upstream and downstream habitat assessments. The assessment uses salmonids as an “umbrella species” meaning a species whose conservation protects numerous other co-occurring species. Two indices of relative conservation value are calculated for each AU. The indices are based on: (1) the density of wetlands and undeveloped floodplains inside an AU, (2) the quantity and quality of salmonid habitats inside an AU, and (3) the quantity and quality of salmonid habitats downstream of an AU. Quantity and quality of habitats are assessed for eight salmonid species. The two indices of relative conservation value reflect an AU’s total contribution to habitat conservation (i.e., the habitat units a place contributes) and its most significant contribution (i.e., the habitat quality a place contributes).

Figure 13. (A) Relative conservation value of a watershed is a function of what is upstream and downstream. Upstream conditions (yellow) affect habitat quality in watershed X (purple). Conditions in watershed X affect habitat quality in downstream reaches (green). Red and gray lines are WRIA and small watershed boundaries, respectively. (B) Upstream conditions affect local conditions which affect local habitats and downstream habitats. Colors correspond to those in panel A.

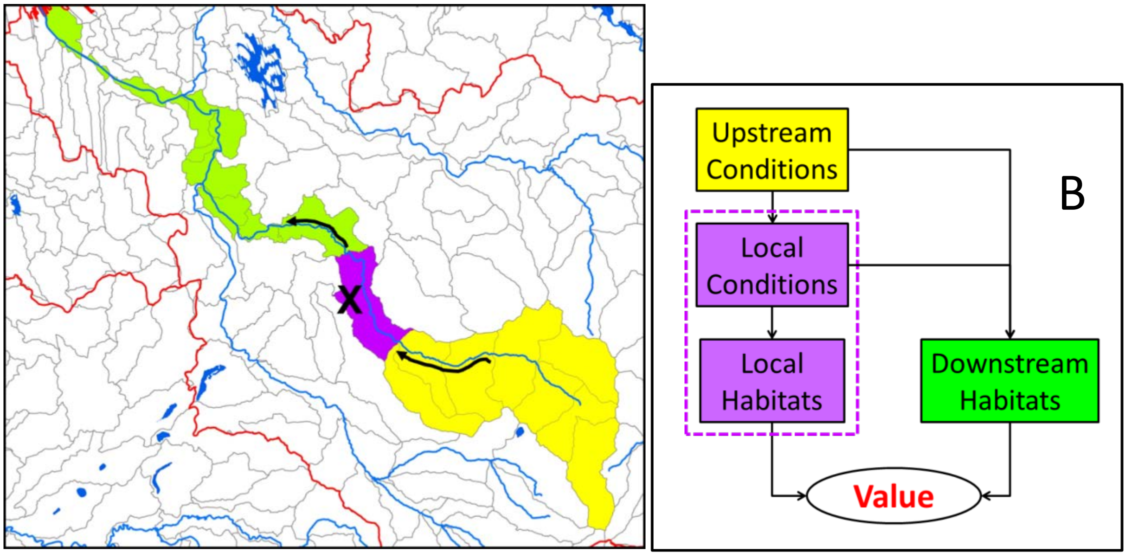


Table 4. A summary of models available for the freshwater habitats assessment on the website

Sum of Freshwater Index Components	The sum of the three components: hydro-geomorphic features (wetlands and undeveloped floodplains in the AU), local salmonid habitats (quantity and quality of habitats for all salmonids present or potentially present in the AU), and downstream salmonid habitats (salmonid habitat downstream of the AU)
Maximum of Freshwater Index Components	The maximum component score for the same three components included in the 'Sum of Freshwater Index Components' layer
Hydrogeomorphic Features	Based on the relative extent of wetlands and floodplains, which are crucial to maintaining the quality of salmonid habitats.
Local Salmonid Habitats Index (within WRIA)	Also known as the Watershed Habitats Index; based on the sum of habitat units for all stream reaches in an AU, normalized at the WRIA scale.
Downstream Salmonid Habitats Index	Indicates the relative value of streams, especially headwater streams, based on the quantity and quality of salmonid habitats that are downstream.
Aquatic Ecological Integrity	Ecological integrity is an important factor in determining salmonid habitat quality; calculation based on multiple spatial scales and the spatial arrangement of land uses within a watershed

The marine shoreline assessment consists of two indices that summarize data on the occurrence or abundance of 41 species, species groups, and habitat types. The indices indicate the relative value of marine shoreline segments based on habitat functions – i.e., higher scores indicate shoreline segments with relatively more habitat functions than segments with lower scores. The composite index is a sum of the 41 components, hence, it mainly reflects the quantity of habitat functions at shoreline segments. However, if the assessment relied on only the composite index, then segments with a small number of high value habitat functions could be obscured. Thus, the top-5 index was created to identify such places and should be used in conjunction with the composite index.

Figure 14. Data used in the calculation of conservation value indices. Forty-one types of data contribute to the indices. Salt marsh box includes sedges, high salt marsh, and low salt marsh (Table 4.3). Different data come in different forms: green = relative likelihood of occurrence models, orange = counts; blue = density; black = amount.

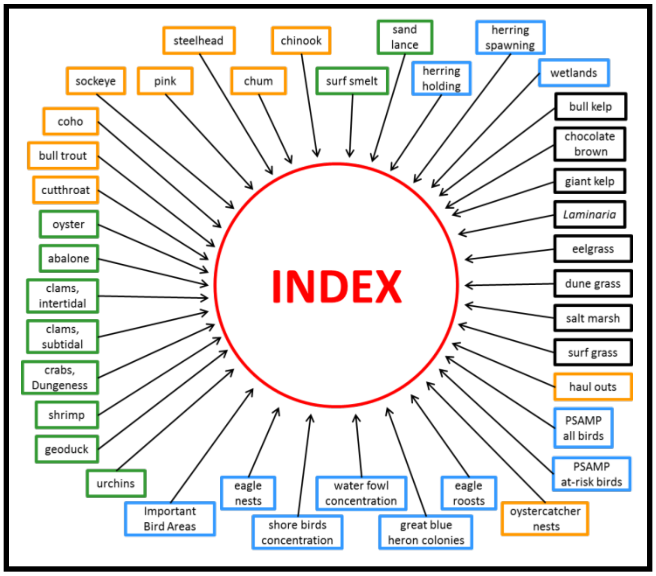


Table 5. A summary of models available for the marine shoreline habitats assessment on the website

Average of All Marine Shoreline Components	The “normalized sum” of all marine shoreline components (species, species groups, and habitats) – which effectively is the average relative conservation value of the shoreline segment.
Average of Top 5 Marine Shoreline Components	Presents the average of the top 5 components (species, species groups, and habitats)at each shoreline segment.

A full description of how the habitat assessments were developed is in Puget Sound Watershed Characterization - Volume 2: A Coarse-scale Assessment of the Relative Value of Small Drainage Areas and Marine Shorelines for the Conservation of Fish and Wildlife Habitats in Puget Sound Basin.

Summary of Assessment Descriptions and Display Scales

Appendix A is a table that summarizes the water flow, water quality and habitat assessments in the Puget Sound Watershed Characterization, each of the individual components that comprise these assessments, and illustrates the display legend that is used to display assessment-specific results. It is intended as a quick reference guide for users who are viewing the interactive mapping tool.

4. Using the Puget Sound Watershed Characterization to Inform Decisions

The Puget Sound Watershed Characterization provides a coarse-scale tool that planners and decision makers can use, along with other scientific information and policy considerations, to inform land use and resource management planning. The Characterization should be used to answer three fundamental questions:

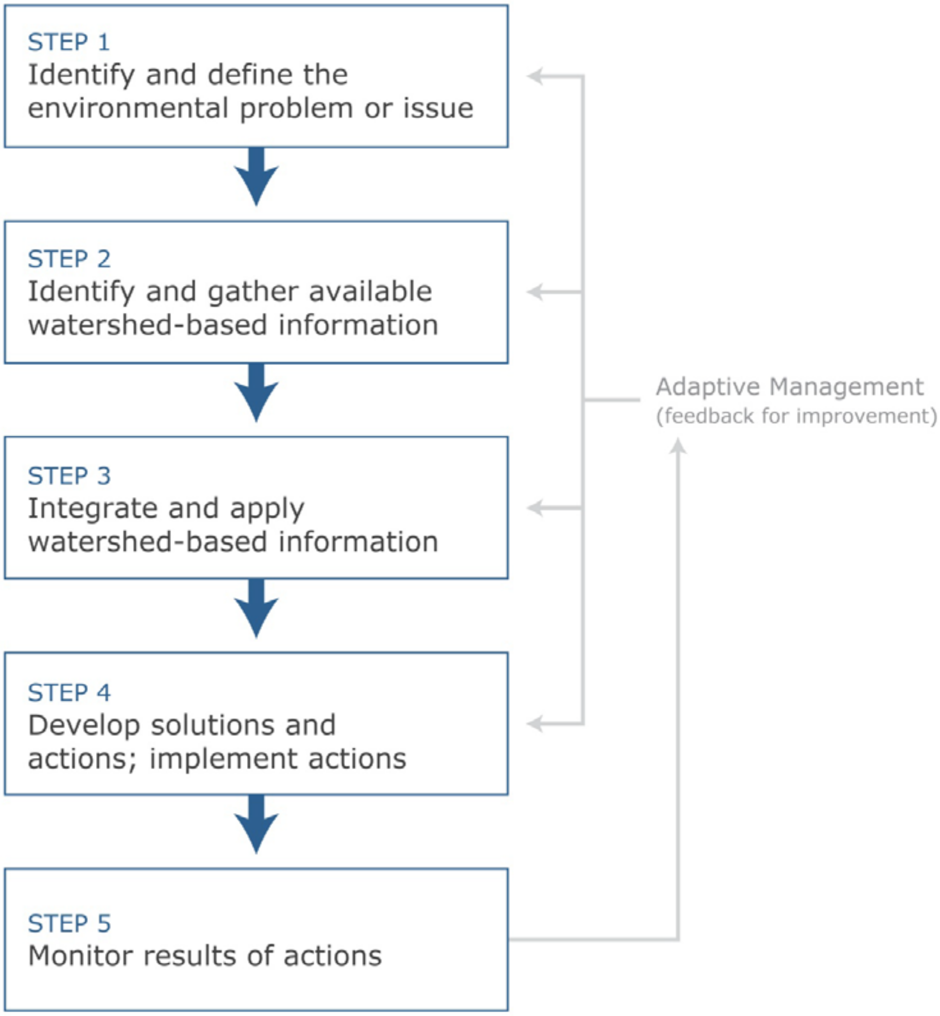
1. ***Where on the landscape*** should management efforts be focused first, be they actions for planning (e.g., protection) or mitigation (e.g., restoration)?
2. ***Why specific areas on the landscape*** may be more important to maintaining watershed processes and functions?
3. ***What types of activities and actions*** are most appropriate to that place, be they restoration, protection, conservation, or development?

By answering these three questions and combining with watershed information from multiple scales (see table2) , regional planning should begin to produce land use patterns that are more protective of processes, thereby increasing the success of restoration and protection actions and over the long term increase of the overall health of Puget Sound. This approach can benefit Shoreline Master Plans , Comprehensive Planning (including critical area regulations), subarea and stormwater plans, and when establishing the basis for a variety of mitigation and resource management programs such as in-lieu fee, transfer of development rights, ecosystem services and others.

Because land use and permit decisions have predominately used a single scale (site scale), the watershed framework is based on integrating information and data from multiple scales. As part of the watershed framework approach, the following five-steps can used to facilitate a watershed-based decision. The steps are:

1. Identify and Define the Environmental Problem or Issue
2. Identify and gather available watershed-based information
3. Apply watershed-based information
4. Develop and implement solutions and actions
5. Monitor results and adapt

Figure 15. Watershed-based framework for making land use and land management decisions



Step 1 - Using Watershed Characterization to Identify and Define the Environmental Problem or Issue

The first step in using the Watershed Characterization is to determine your study area and your problem statement. Your study area might be a landscape-based unit such as a WRIA or a sub-watershed, or might be based on political boundaries, such as a county or a city. You might be using the Characterization to inform landscape-level planning such as where to locate urban growth areas; or, you might be using it to inform where to prioritize various management strategies, such as stormwater retrofits.

Carefully consider which management question you are trying to address. Try using the Characterization data:

- As a diagnostic tool to evaluate conditions
- As a validation tool, paired with other data
- As a way of prioritizing and developing management strategies

Also consider the scale of your problem. Are you planning at a WRIA scale, watershed scale, or jurisdictional (county or city) scale? The Interactive Mapping Tool presents results at the WRIA scale (meaning the AUs are scored based on a how they compare with other AUs in that WRIA). Custom model outputs can be created that allow relative comparison water flow and water quality results for AU in particular sub-basins, or at other custom scales (such as when a planning area spans WRIA). If you are interested in this type of custom output contact Ecology.[3]

Step 2 - Identify and Gather Available Watershed-based information

Step two is to gather the information that is relevant to your study area and the problem you are trying to address. Use the Interactive Map Application on the Home Page to locate your area of interest. When you click on your WRIA, the Interactive Map Application will open and you can zoom in to your area of interest. When you select a WRIA, WMU and AU boundaries will be apparent, and you can zoom to different areas and units by clicking on the unit of interest.

The Interactive Map Application will display, when a user selects the overall water flow assessment , the relative priority of each AU for restoration, conservation, and protection compared to other AUs in the same WRIA and landscape group. The overall water flow assessment results are determined by combining the relative importance and current condition (amount of degradation) of each AU for water flow processes. The possible range of results from the water flow assessment are:

🟨 **Yellow AUs are highest priorities for restoration:** These AUs are most important in WRIA for water flow but also most degraded in WRIA. Restoration activities in Yellow AUs have the most significant potential for improving watershed processes.

🟩 **Dark Green AUs are highest priorities for protection:** These AUs rate relatively high for importance and have a relatively low level of degradation; preventing further degradation in these areas is vital for water flow processes.

🟩 **Light Green AUs are lower priorities for protection:** The AUs are not as important to water flow processes. However, existing degradation is relatively low. Future development may be appropriate if conservation measures are implemented to minimize adverse effects.

🟧 **Pink and Orange AUs are lower priorities for restoration**, conservation, or protection: these AUs have the highest levels of degradation and have low importance to processes. Relative to other AUs, further development in these areas will have the least impact on water flow processes.

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[3] Contact Colin Hume; Email . E-mail: colin.hume@ecy.wa.gov

The overall water flow assessment results are a good general indicator of watershed conditions. However, if you are attempting to identify what specific restoration/protection actions may be required for a watershed the individual results of all of the assessments (e.g. delivery, storage and discharge results for water flow model) must be reviewed. You can use the Interactive Map Application to view all of the watershed characterization components and results including:

- **Water flow process Importance and Degradation submodels** (individual and overall results for delivery, surface storage, recharge, and discharge processes)
- **Water quality process Export Potential and Degradation submodels** (results from five models for : sediment, phosphorus, nutrients, pathogens, and metals); and
- **Fish and wildlife habitats Relative Conservation Value** (for terrestrial, freshwater and marine shoreline habitats).

In addition to selecting and viewing individual model results, when you click on an AU of interest a dashboard will appear at the bottom of the map showing the results of each assessment for that AU. Tabs on the dashboard menu allow users to switch between water flow, water quality, and habitat assessments for the same AU.

You also may wish to consider other regional assessments such as the PSNERP Nearshore Assessment or the DNR Aquatic Lands Habitat Assessment, and additional finer-scale and local data, during this initial information gathering phase.

Water Flow Integrity

As you explore your study area and gather information, use a watershed-based approach. Look at results for individual AUs and look for patterns across an entire WMU or multiple WMUs. Patterns and relationships between units in the upper watershed (upstream units) and those in the lower watershed (downstream units) are particularly important to understanding water flow integrity.

Urban and rural development changes the timing and delivery of flows to streams and wetlands, creating abnormal flow regimes and extremes in water level fluctuations. Studies have repeatedly shown that these flow changes, due to increased volume, frequency, and duration, result in simplification of the physical structure of streams and wetlands, which in turn reduces overall species richness. The processes in these watersheds are less intact, or have less integrity.

In general, watersheds that have a higher degree of forest cover, more area of intact floodplains and wetlands and less impervious cover, are more likely to have or closely approximate normal water flow regimes (e.g. water flow processes). This is particularly true if these characteristics predominate in the upper watershed. The processes in these watersheds are more intact, or have more integrity.

The water flow model identifies individual AUs that range from relatively intact and important for water flow processes to those that are significantly impacted and not important to water flow processes.

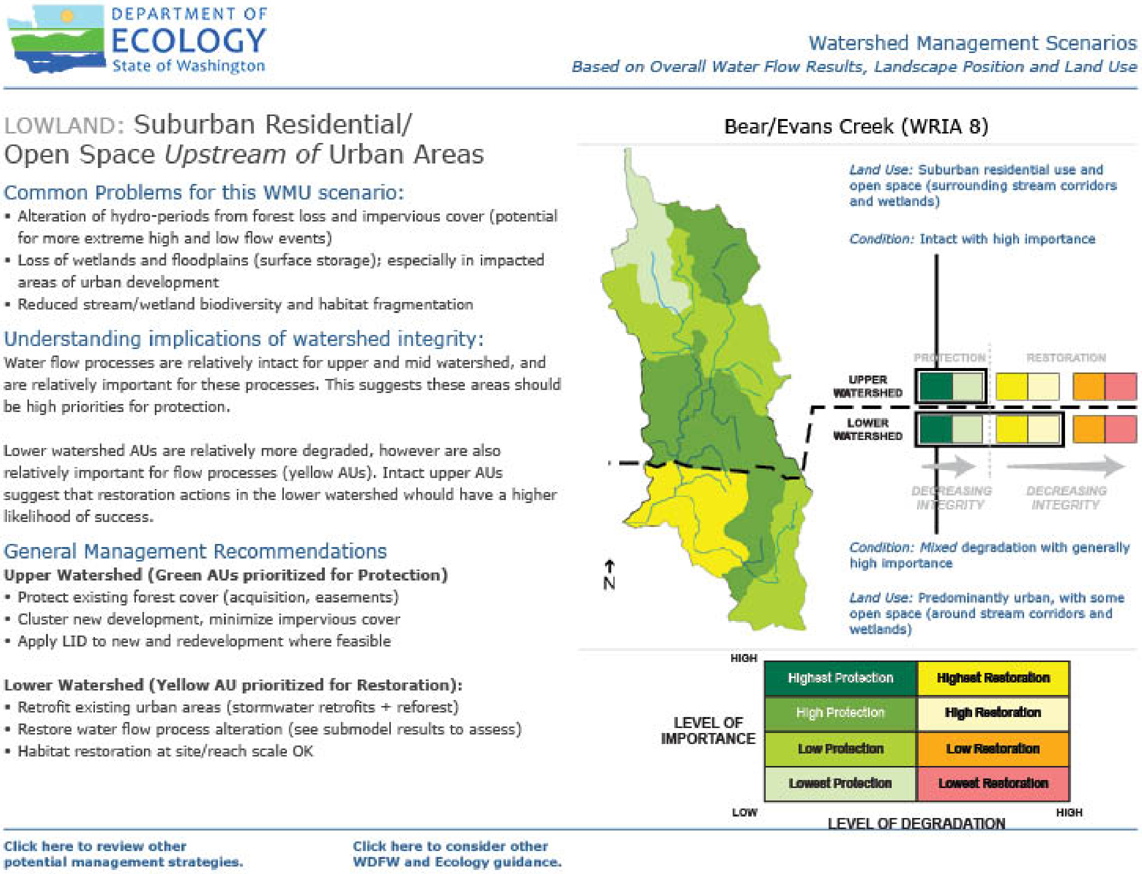
Important watersheds, on a relative basis, have higher precipitation, more recharge, greater area of wetlands and floodplains and more area of groundwater discharge.

By using the overall water flow results and examining the spatial arrangement of AUs within a Watershed Management Unit (WMU) the degree of relative intactness, or integrity, within a watershed can be determined. Watersheds that are more intact are more likely to have water flow regimes that are within or approximate normal patterns. This suggests that restoration or protection actions within these watersheds have a greater probability of contributing to the recovery and stability of a functioning aquatic ecosystem relative to watersheds that are highly degraded and of low importance to water flow processes.

To estimate the integrity of your watershed, look at the overall restoration and protection results for water flow to identify conditions in the upper and lower AUs in your study area. Look for patterns of dark and light green, yellow, orange, and pink. Using these results you can generally divide your study area in half based on the dominant color or color combinations in the upper versus the lower watershed areas.

The WMUs for Bear/Evans Creek (WRIA 8) provides an example of how to estimate water flow integrity. In this area, protected forest lands in upper watershed mountainous areas flow to urban, lowland areas in the lower watershed. Intact upper watershed areas have low levels of degradation, and are relatively important for water flow processes. This suggests these areas should be high priorities for protection, and that restoration actions in the lower watershed (higher levels of degradation, and also important for water flow processes) should have a high likelihood for success. (See figure 16) More information also is available in the Management Considerations tab on the Characterization Website.

Figure 16. Determining Watershed Integrity



DEPARTMENT OF ECOLOGY
State of Washington

Watershed Management Scenarios
Based on Overall Water Flow Results, Landscape Position and Land Use

LOWLAND: Suburban Residential/
Open Space *Upstream of* Urban Areas

Common Problems for this WMU scenario:

- Alteration of hydro-periods from forest loss and impervious cover (potential for more extreme high and low flow events)
- Loss of wetlands and floodplains (surface storage); especially in impacted areas of urban development
- Reduced stream/wetland biodiversity and habitat fragmentation

Understanding implications of watershed integrity:

Water flow processes are relatively intact for upper and mid watershed, and are relatively important for these processes. This suggests these areas should be high priorities for protection.

Lower watershed AUs are relatively more degraded, however are also relatively important for flow processes (yellow AUs). Intact upper AUs suggest that restoration actions in the lower watershed whould have a higher likelihood of success.

General Management Recommendations

Upper Watershed (Green AUs prioritized for Protection)

- Protect existing forest cover (acquisition, easements)
- Cluster new development, minimize impervious cover
- Apply LID to new and redevelopment where feasible

Lower Watershed (Yellow AU prioritized for Restoration):

- Retrofit existing urban areas (stormwater retrofits + reforest)
- Restore water flow process alteration (see submodel results to assess)
- Habitat restoration at site/reach scale OK

Bear/Evans Creek (WRIA 8)

Land Use: Suburban residential use and open space (surrounding stream corridors and wetlands)

Condition: Intact with high importance

Condition: Mixed degradation with generally high importance

Land Use: Predominantly urban, with some open space (around stream corridors and wetlands)

LEVEL OF IMPORTANCE (HIGH to LOW) / LEVEL OF DEGRADATION (LOW to HIGH)

Highest Protection	Highest Restoration
High Protection	High Restoration
Low Protection	Low Restoration
Lowest Protection	Lowest Restoration

Click here to review other potential management strategies.

Click here to consider other WDFW and Ecology guidance.

Steps 3 & 4 - Apply Watershed-based Information and Develop Solutions and Actions

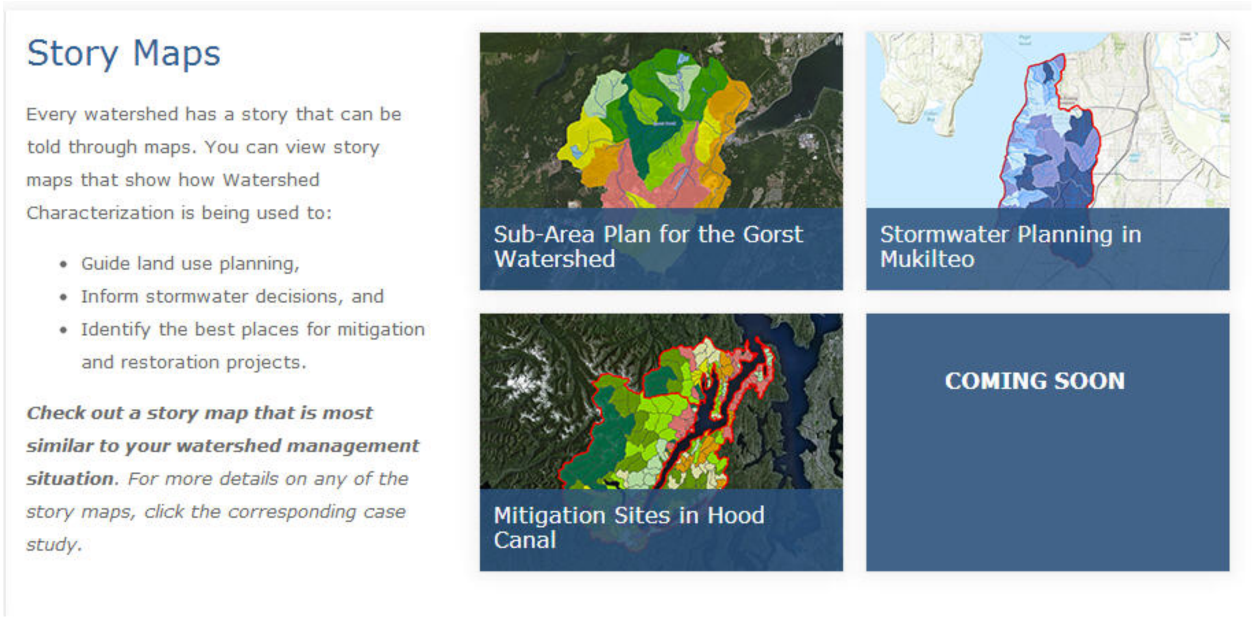
Steps three and four are to integrate and apply the watershed-based information to develop solutions and actions. *The Watershed Characterization results can help you make management decisions, but you need to look at individual AUs in the context of the entire watershed management unit.* Consider the conditions that are influencing the assessment results, the patterns between adjacent AUs in your area, and other finer-scale or local information.

Story Maps

Story maps show how some Puget Sound communities have used the watershed characterization data:

- To guide land use planning (**Bremerton's Gorst Watershed** planning)
- To inform stormwater decisions (**Mukilteo**)
- To identify the best places for mitigation and restoration projects (within the **Hood Canal Watershed**)

Figure 17. Story Maps



Story Maps

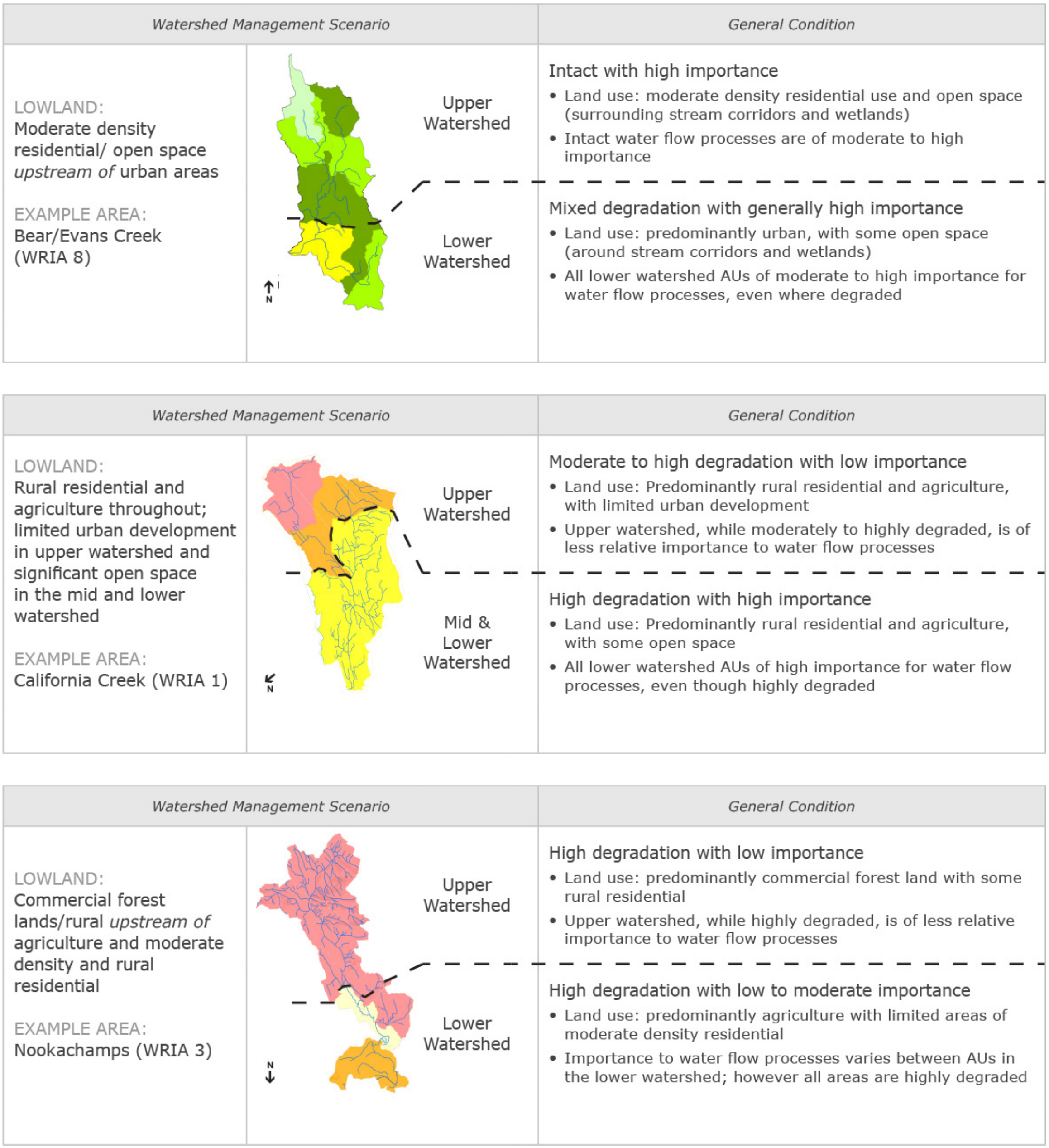
Every watershed has a story that can be told through maps. You can view story maps that show how Watershed Characterization is being used to:

- Guide land use planning,
- Inform stormwater decisions, and
- Identify the best places for mitigation and restoration projects.

Check out a story map that is most similar to your watershed management situation*. For more details on any of the story maps, click the corresponding case study.*

The **Watershed Management Scenarios** presents a set of common watershed conditions occurring across the Puget Sound. Each watershed scenario reflects a general pattern of upstream and downstream conditions within a WMU as well as well as the general patterns of land use. You can compare your upper and lower watershed conditions identified during step 2 to the Watershed Management Index and identify the watershed management scenario with the greatest parallels to the upper and lower watershed dominant colors for your study area. The Scenarios also highlights common land use and landscape patterns that occur for each scenario, so you can consider these factors when determining the best match to your study area. It then provides guidance on c**ommon watershed-level management strategies** that are generally appropriate in each setting. The nine landscape scenarios and corresponding watershed-level management strategies are described in Appendix C. You also reach the landscape scenarios and associated management recommendations through the **Management Considerations** tab in the Interactive Map Application.

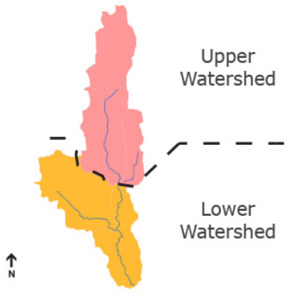
Figure 18. Watershed Management Scenarios

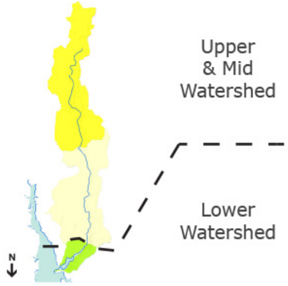


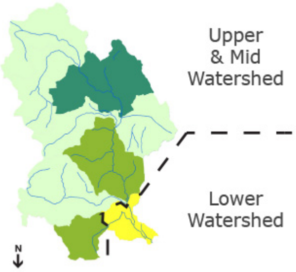
Watershed Management Scenario		*General Condition*
LOWLAND: Moderate density residential/ open space *upstream of* urban areas EXAMPLE AREA: Bear/Evans Creek (WRIA 8)	Upper Watershed	Intact with high importance • Land use: moderate density residential use and open space (surrounding stream corridors and wetlands) • Intact water flow processes are of moderate to high importance
	Lower Watershed	Mixed degradation with generally high importance • Land use: predominantly urban, with some open space (around stream corridors and wetlands) • All lower watershed AUs of moderate to high importance for water flow processes, even where degraded

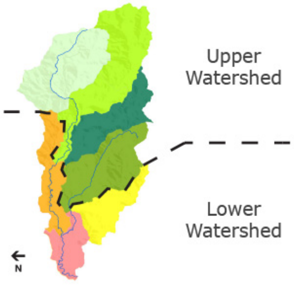
Watershed Management Scenario		*General Condition*
LOWLAND: Rural residential and agriculture throughout; limited urban development in upper watershed and significant open space in the mid and lower watershed EXAMPLE AREA: California Creek (WRIA 1)	Upper Watershed	Moderate to high degradation with low importance • Land use: Predominantly rural residential and agriculture, with limited urban development • Upper watershed, while moderately to highly degraded, is of less relative importance to water flow processes
	Mid & Lower Watershed	High degradation with high importance • Land use: Predominantly rural residential and agriculture, with some open space • All lower watershed AUs of high importance for water flow processes, even though highly degraded

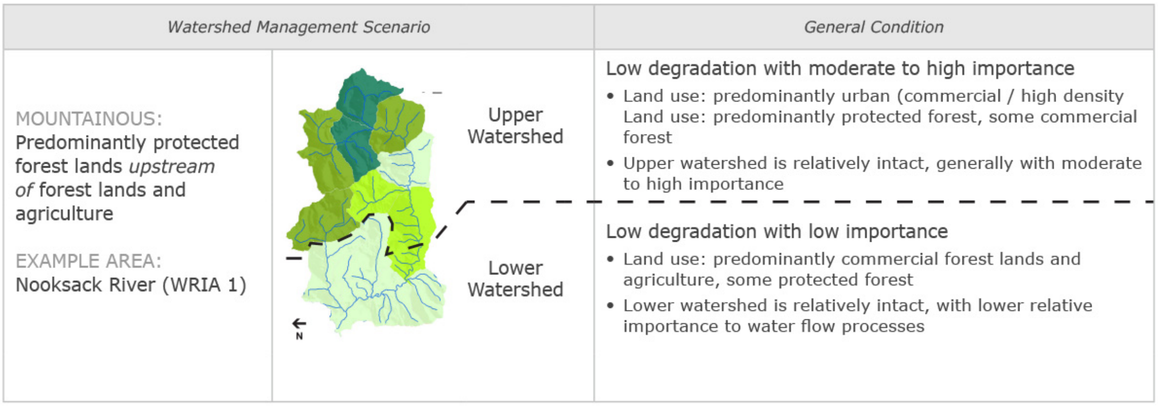
Watershed Management Scenario		*General Condition*
LOWLAND: Commercial forest lands/rural *upstream of* agriculture and moderate density and rural residential EXAMPLE AREA: Nookachamps (WRIA 3)	Upper Watershed	High degradation with low importance • Land use: predominantly commercial forest land with some rural residential • Upper watershed, while highly degraded, is of less relative importance to water flow processes
	Lower Watershed	High degradation with low to moderate importance • Land use: predominantly agriculture with limited areas of moderate density residential • Importance to water flow processes varies between AUs in the lower watershed; however all areas are highly degraded

Watershed Management Scenario		*General Condition*
LOWLAND: Predominantly urban and moderate density development *throughout* WMU EXAMPLE AREA: Swamp Creek (WRIA 8)		**High degradation with low importance** • Land use: predominantly urban (commercial / high density residential) and moderate density residential • Upper watershed is highly degraded and is of less relative importance to water flow processes
		High degradation with moderate importance • Land use: predominantly urban (commercial / high density residential) and moderate density residential • Lower watershed is highly degraded and is of moderate relative importance to water flow processes

Watershed Management Scenario		*General Condition*
COASTAL & LOWLAND: Urban *upstream of* rural residential and forest EXAMPLE AREA: Woodard Creek (WRIA 13)		**High degradation with moderate to high importance** • Land use: predominantly urban (commercial / high density residential) and moderate density residential • Upper watershed is highly degraded, however is relatively important to water flow processes
		Low degradation with moderate importance • Land use: predominantly rural residential, forested • Lower watershed has relatively low degradation and is of moderate relative importance to water flow processes

Watershed Management Scenario		*General Condition*
LOWLAND & MOUNTAINOUS: Protected forest lands and some residential *upstream* of urban areas EXAMPLE AREA: Issaquah Creek (Tiger WMU) (WRIA 8)		**Low degradation with mixed importance** • Land use: predominantly protected forest land, with some residential • Upper and mid watershed is relatively intact, with areas of low, moderate, and high importance to water flow processes
		High degradation with high importance • Land use: predominantly urban (commercial / high density residential) • Lower watershed AU has relatively high degradation, however is also of high importance to water flow processes

Watershed Management Scenario		*General Condition*
LOWLAND & MOUNTAINOUS: Forest lands *upstream of* urban areas, residential and some agriculture EXAMPLE AREA: Mashel River (WRIA 11)		**Low degradation with mixed importance** • Land use: predominantly commercial forest lands, some protected forest • Upper and mid watershed is relatively intact, with areas of low, moderate, and high importance to water flow processes
		High degradation with mixed importance • Land use: predominantly urban and suburaban / rural, with some agriculture • Lower watershed is relatively highly degraded, with mixed relative importance to water flow processes



Watershed Management Scenario		*General Condition*
MOUNTAINOUS: Predominantly protected forest lands *upstream of* forest lands and agriculture EXAMPLE AREA: Nooksack River (WRIA 1)	Upper Watershed	Low degradation with moderate to high importance • Land use: predominantly urban (commercial / high density Land use: predominantly protected forest, some commercial forest • Upper watershed is relatively intact, generally with moderate to high importance
	Lower Watershed	Low degradation with low importance • Land use: predominantly commercial forest lands and agriculture, some protected forest • Lower watershed is relatively intact, with lower relative importance to water flow processes

Fundamentally watershed management choices will be place-specific decisions that are made in the context of balancing available, relevant information with other land-use decision factors. In addition to the Watershed Management Scenarios, the Puget Sound Watershed Characterization materials provide two additional types of guidance to help you.

First, **story maps** and companion **case studies** illustrate how the Characterization has been used by jurisdictions around Puget Sound. Three story maps and companion case studies are presented.

- Guiding land use planning illustrated by **Bremerton's Gorst Watershed planning**
- Informing stormwater decisions illustrated by **Mukilteo**
- Identifying the best places for mitigation and restoration projects illustrated by the **Hood Canal Watershed** in lieu fee planning process

The case studies are in Appendix B and can be reached from the landing page at the Watershed Characterization Website.

Second, the **Watershed Management Matrix** provides a list of common watershed management actions categorized by regulatory driver, applicable land uses, and water flow processes addressed. The management matrix is focused on water flow processes; however it may also be useful for integrated approaches to address water quality and habitat. The management action matrix is included as Appendix D. You also can reach the management matrix through the **Management Considerations** tab in the Interactive Map Application. There also are links to other WDFW and Ecology publications that provide further information and context for watershed management strategies.

Of course, the management strategies and management actions are provided as a starting-place for users to build from. Actual decisions should integrate finer-scale and local information and will need to balance a variety of land-use planning factors.

Figure 19. Watershed Management Matrix- example management recommendation

Management Objective	**Management Recommendations**	**Regulatory Driver(s)**	**Forest Lands**	**Rural Lands**	**Agricultural**	**Urban and Suburban**	**Higher Protection**	**Higher Restoration**	**Lower Protection**	**Lower Development**	**Delivery**	**Surface Storage**	**Recharge / Discharge**		
Maintain stream and wetland physical structure and ecological functions (DE, SS, RD).	Review and update (as needed) Critical Areas Ordinance based on Best Available Science to provide protection for wetlands and streams, and to require buffers sufficient to protect riparian zones. Use current use property tax incentive programs to encourage conservation. Acquire property or easements to provide permanent protection.	**Local:** Critical Areas Ordinance, Shoreline Master Program	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑		

Step 5 - Monitor Results and Adapt

As with any ecosystem management approach, it is important to monitor the results of your management decisions and adapt as needed over time. Watershed characterization provides a framework for determining if your actions are having the expected outcomes on the underlying ecological processes and for adjusting management strategies over time.

At the coarse or broad scale, the Puget Sound Watershed Characterization uses ecosystem models to help guide resource management and planning decisions and actions. The goal is to help restore water flow and water quality processes and return their range of variation to one which supports a healthy and resilient watershed ecosystem.

For example, restoration of formerly forested areas within the upper portion of a rural watershed can improve delivery processes and reduce the downstream flood peaks and their duration/frequency. If hydrograph records (measurements of stream flows) are available from a period when the watershed was forested then that normal pattern or range of flows can be used as a target to determine when and if reforestation patterns are successful. If records are not available in the study watershed, then records from similar watersheds can be used as a target.

However, to determine if a “target” is being achieved, monitoring of the processes on a regular basis such as hydrology in the above example is necessary. The results of the monitoring help: 1) confirm whether the models and the management actions are working as intended; and 2) identify what changes should be made to the model or actions in order to improve observed results. This is known as “adaptive management.”

Downloading the Full Watershed Characterization Data

Download full data: If you are interested in using the Characterization data in greater depth and detail, all data is available for download on the Get the Data webpage.

5. References and Additional Help

This document draws heavily on previous work and documents that describe the Puget Sound Watershed Characterization. In particular: Puget Sound Watershed Characterization - Volume 1: The Water Resource Assessments (Water Flow and Water Quality) and Puget Sound Watershed Characterization - Volume 2: A Coarse-scale Assessment of the Relative Value of Small Drainage Areas and Marine Shorelines for the Conservation of Fish and Wildlife Habitats in Puget Sound Basin

Additional help applying the Puget Sound Watershed Characterization Information is available, and users are encouraged to avail themselves of this help. In some cases, technical expertise on application of the Characterization information is available for specific planning projects through the **Puget Sound Watershed Characterization Technical Assistance Team (WCTAT)**.

For questions concerning the Puget Sound Watershed Characterization Project contact:

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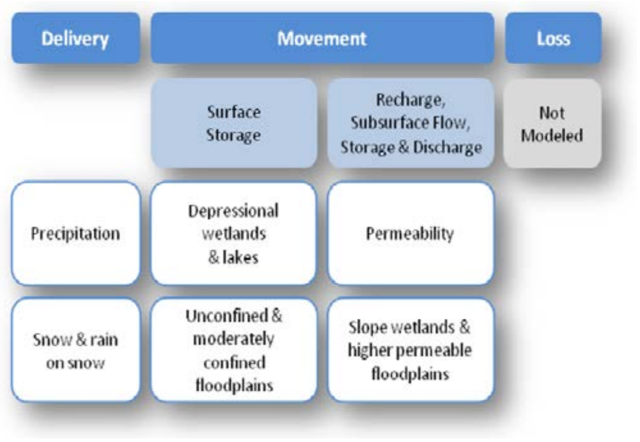
Appendix A: Summary of Water Flow, Water Quality and Habitat Assessments and Sub-models with Display Scales and Management Matrices

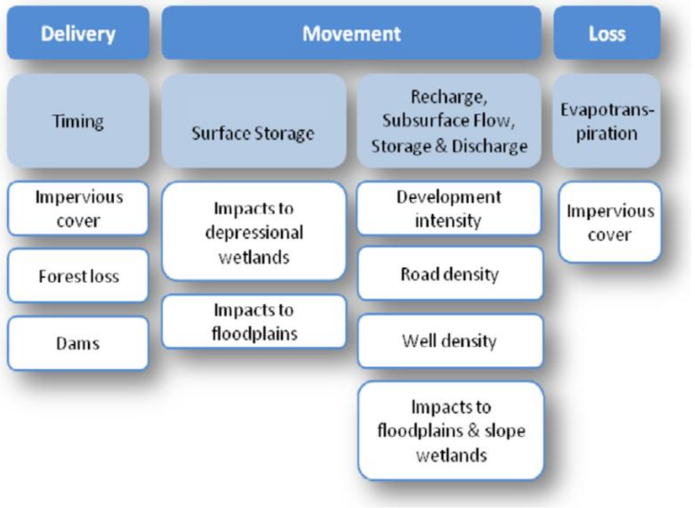
Water Flow: Importance Results

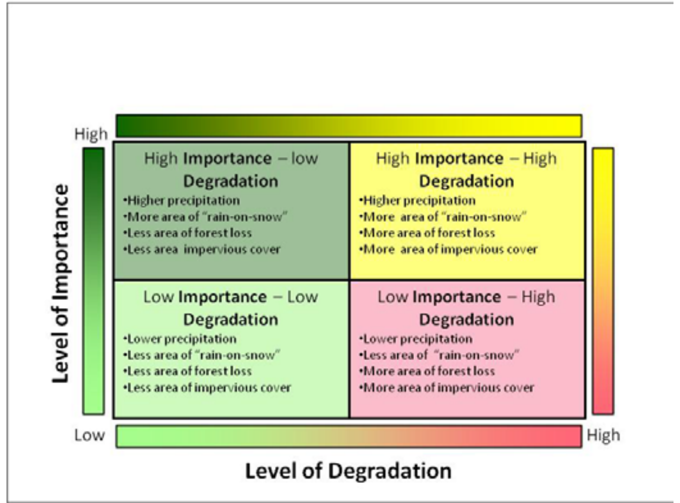
Sub Model	Sub Model Description	Display Legend
Delivery	The **Delivery** component of the *water flow model* assesses the relative **importance** of areas that control the quantity and timing of water available for surface waters and groundwater. These areas include: • Higher precipitation zones • Rain on Snow Zones See https://fortress.wa.gov/ecy/publications/publications/1106016part2.pdf for details.	🟦 H - High 🟦 MH - Moderate High 🟦 M - Moderate 🟦 L - Low
Surface Storage	The **Surface Storage** component of the *water flow model* assesses the relative **importance** of areas that control the movement of water at the surface during storm events. These areas include: • Depressional Wetlands • Lakes • Floodplains See https://fortress.wa.gov/ecy/publications/publications/1106016part2.pdf for details.	🟦 H - High 🟦 MH - Moderate High 🟦 M - Moderate 🟦 L - Low
Recharge	The **Recharge** component of the *water flow model* assesses the relative **importance** of areas that control the infiltration and percolation of precipitation into groundwater. These areas include: • Surface deposits with high permeability • Higher precipitation zones See https://fortress.wa.gov/ecy/publications/publications/1106016part2.pdf for details.	🟦 H - High 🟦 MH - Moderate High 🟦 M - Moderate 🟦 L - Low
Discharge	The **Discharge** component of the *water flow model* assesses the relative **importance** of areas that control the movement of groundwater back to the surface. These areas include: • River floodplains intersecting permeable geologic deposits • Wetlands on slopes See https://fortress.wa.gov/ecy/publications/publications/1106016part2.pdf for details.	🟦 H - High 🟦 MH - Moderate High 🟦 M - Moderate 🟦 L - Low
Overall	This model combines the **Delivery, Surface Storage, Recharge**, and **Discharge** components to compare the relative **importance** of analysis units in maintaining overall water flow processes in a non-degraded setting. When precipitation is "delivered" as either rain or snow, there are physical features that control its surface and subsurface movement within an assessment unit. These physical features include land cover, storage areas such as wetlands and floodplains, areas of higher permeability and recharge and areas that discharge groundwater. These areas are considered "important" to the overall water flow process. **Important areas for the water flow process are modeled as**: important areas for **Delivery +** important areas for **Movement +** important areas for **Loss**. In Western Washington the assumption is that all hydrologic units have approximately the same rate of evapotranspiration in non-degraded conditions because they were primarily forested. The equation for Model 1 can then be simplified to: ***Model 1 = [(Precipitation + Timing of Water Delivery] + [(Surface storage +Sub-surface flow + Recharge +Discharge)]*** Where each component has a relative weight of 1.	

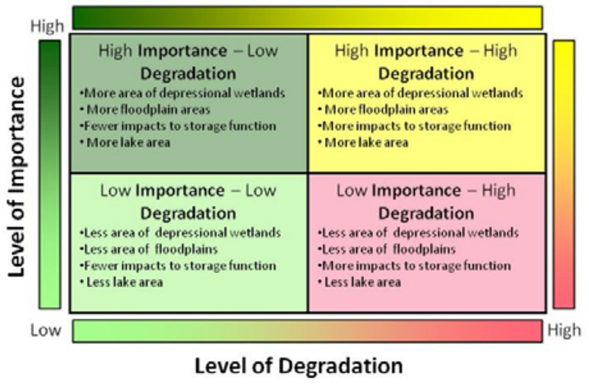
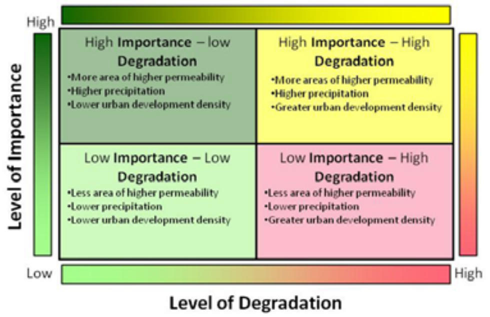
	 Details can be found at https://fortress.wa.gov/ecy/publications/publications/1106016.pdf	

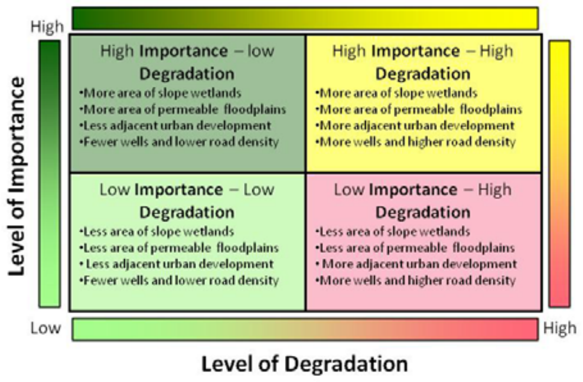
Water Flow Degradation Model		
Sub Model	**Description**	**Display Legend**
Delivery	The **Delivery** component of the *degradation to water flow* model assesses the relative changes to areas important for governing the timing and quantity of water entering a watershed. Areas considered *degraded* for **Delivery** processes have one or more of the following : • Greater loss of forest vegetation, and/or • Higher percent cover of impervious surfaces in a watershed See https://fortress.wa.gov/ecy/publications/publications/1106016part2.pdf for details.	■ H - High ■ MH - Moderate High ■ M - Moderate ■ L - Low
Surface Storage	The **Surface Storage** component of the *degradation to water flow model* assesses changes, relative to natural conditions (i.e. importance model), that decrease the capacity to store water which results in increased surface water velocity, and changes to the timing of downstream flows. Areas considered *degraded* for **Surface Storage** processes have one or more of the following: • Greater loss of historic depressional wetlands • Greater channelization of streams • More streams disconnected from associated floodplain areas • More dams with storage capacity that is greater than annual runoff upstream See https://fortress.wa.gov/ecy/publications/publications/1106016part2.pdf for details.	■ H - High ■ MH - Moderate High ■ M - Moderate ■ L - Low
Recharge	The **Recharge** component of the *degradation to water flow model* assesses the relative changes that reduce infiltration of water into sub-surface flows and groundwater, and increase surface runoff. Areas considered *degraded* for **Recharge** processes have one or more of the following: • More impervious surface • Higher intensity of development See https://fortress.wa.gov/ecy/publications/publications/1106016part2.pdf for details.	■ H - High ■ MH - Moderate High ■ M - Moderate ■ L - Low

Water Flow Degradation Model		
Sub Model	**Description**	**Display Legend**
Discharge	The **Discharge** component of *the degradation to water flow model* assesses relative changes that are important for the return of groundwater to surface water and aquatic resources. Areas considered *degraded* for **Discharge** processes have one or more of the following: • Greater extent of urban and rural development within or adjacent to slope wetlands • Greater extent of urban and rural development within or adjacent to floodplains with high permeability • Higher density of roads and ditches • Higher number of groundwater wells See https://fortress.wa.gov/ecy/publications/publications/1106016part2.pdf for details.	■ H - High ■ MH - Moderate High ■ M - Moderate ■ L - Low
Overall	This model assesses the overall "relative" degradation to the **Delivery**, **Surface Storage**, **Recharge**, and **Discharge** components of the water flow process for analysis units. Degradation to these processes results in the accelerated movement of surface flows downstream. This accelerated delivery increases downstream flooding and erosion and which degrades aquatic habitat over time. **Degradation to water processes are modeled as:** Degradation to **Delivery +** Degradation to **Movement +** Degradation to **Loss** *Degradation* to **Delivery** addresses changes to areas that control the timing of delivery of precipitation to downstream areas; this is modeled as the percent of forest loss and percent impervious cover. *Degradation* to **Movement** is modeled as the relative area of storage loss, reduction in the amount of recharge and changes to areas that contribute to discharge. These impacts decrease the quantity of water stored subsurface and subsequently discharged to streams and wetlands. The model assesses the degree of storage loss to wetlands and floodplains based on surrounding development type (e.g. urban or rural). For recharge reduction the model evaluates both the rainfall amount and development density. *Degradation* to **Discharge** is evaluated by the relative number of wells within a watershed. Degradation to **loss** is modeled by the amount of impervious surface in the analysis unit which captures the loss of evapotranspiration due to the complete loss of vegetative cover. ***Model 2 =(degradation of timing of delivery)+ [(degradation of surface storage)+(degradation of areas for recharge + degradation of subsurface flow + degradation of discharge areas)] + (degradation of evapotranspiration)*** Where each component has a relative weight of 1	

Water Flow Degradation Model		
Sub Model	**Description**	**Display Legend**
	 Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf	

Combined Results of the Water Flow Importance and Degradation Models and Management Matrix			
Component	**Description**	**Display Legend**	**Management Matrix**
Delivery	Results of the *Importance* and *Degradation* models for the **Delivery** component of the water flow model can be combined into a Management Matrix for **Delivery** processes. This identifies those assessment units which are relatively: • Highly important – Less degraded • Highly important – More degraded • Less important – Less degraded • Less important – More degraded These results can be used to prioritize management actions directed at **Delivery** processes, that will protect the *most important – less degraded* areas of a watershed and focus more intense land use (e.g. development) into areas that are relatively *less important-more degraded*. The following matrix identifies which areas in a watershed are considered indicators of relative *importance* or *degradation* for **Delivery** processes. Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf	🟩 Highest Protection 🟩 Protection 🟩 Protection/Conservation 🟩 Conservation 🟨 Highest Restoration 🟨 Restoration 🟧 Restoration/Development 🟥 Development/Restoration	

Combined Results of the Water Flow Importance and Degradation Models and Management Matrix			
Component	**Description**	**Display Legend**	**Management Matrix**
Surface Storage	Results of the *Importance* and *Degradation* models for the **Surface Storage** component of the water flow model can be combined into a Management Matrix for **Surface Storage** processes. This identifies those assessment units which are relatively: • Highly important – Less degraded • Highly important – More degraded • Less important – Less degraded • Less important – More degraded These results can be used to prioritize management actions aimed at **Surface Storage** processes, that will protect the *most important – less degraded* areas of a watershed and focus more intense land use (e.g. development) into areas that are relatively *less important-more degraded*. The following matrix identifies which areas in a watershed are considered indicators of relative *importance* or *degradation* for **Surface Storage** processes. Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf	🟩 Highest Protection 🟩 Protection 🟩 Protection/Conservation 🟩 Conservation 🟨 Highest Restoration 🟨 Restoration 🟧 Restoration/Development 🟥 Development/Restoration	
Recharge	Results of the *Importance* and *Degradation* models for the **Recharge** component of the water flow model can be combined into a Management Matrix for **Recharge** processes. This identifies those assessment units which are relatively: • Highly important – Less degraded • Highly important – More degraded • Less important – Less degraded • Less important – More degraded These results can be used to prioritize management actions directed at **Recharge** processes, that will protect the *most important – less degraded* areas of a watershed and focus more intense land use (e.g. development) into areas that are relatively *less important-more degraded*. The following matrix identifies which areas in a watershed are considered indicators of relative *importance* or *degradation* for **Recharge** processes. Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf	🟩 Highest Protection 🟩 Protection 🟩 Protection/Conservation 🟩 Conservation 🟨 Highest Restoration 🟨 Restoration 🟧 Restoration/Development 🟥 Development/Restoration	

Combined Results of the Water Flow Importance and Degradation Models and Management Matrix			
Component	**Description**	**Display Legend**	**Management Matrix**
Discharge	Results of the *Importance* and *Degradation* models for the **Discharge** component of the water flow model can be combined into a Management Matrix for **Discharge** processes. This identifies those assessment units which are relatively: • Highly important – Less degraded • Highly important – More degraded • Less important – Less degraded • Less important – More degraded These results can be used to prioritize management actions directed at **Discharge** processes, that will protect the *most important – less degraded* areas of a watershed and focus more intense land use (e.g. development) into areas that are relatively *less important-more degraded*. The following matrix identifies which areas in a watershed are considered indicators of relative *importance* or *degradation* for **Discharge** processes. Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf	🟩 Highest Protection 🟩 Protection 🟩 Protection/Conservation 🟩 Conservation 🟨 Highest Restoration 🟨 Restoration 🟧 Restoration/Development 🟥 Development/Restoration	

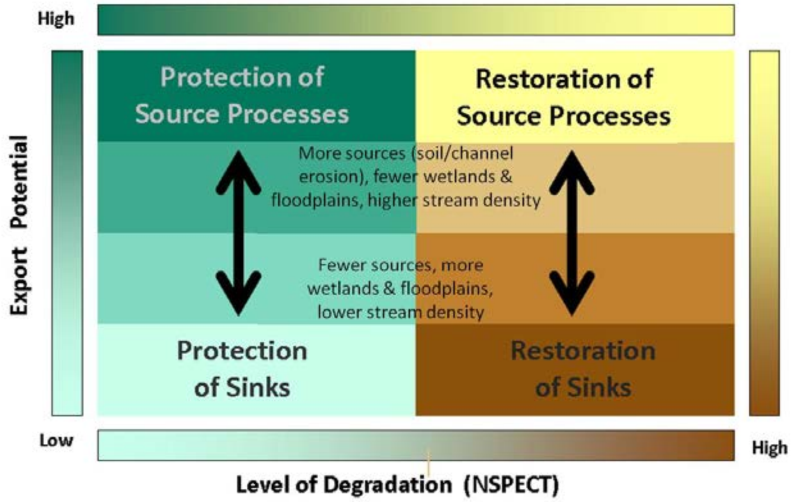
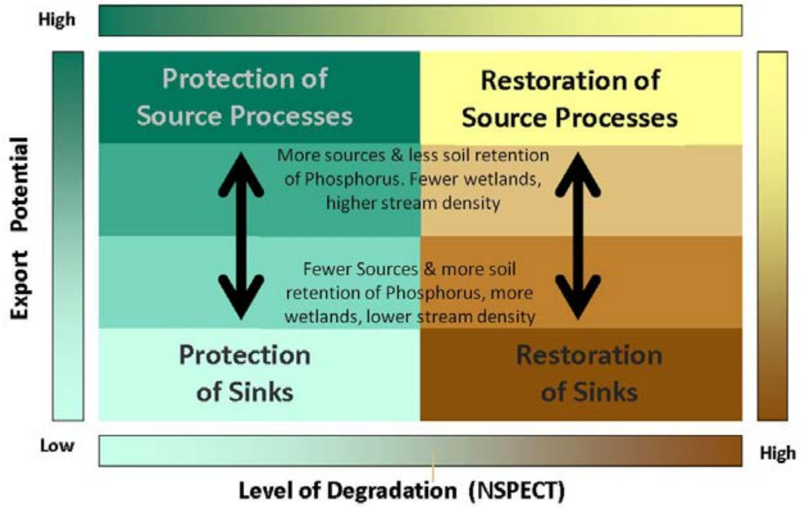
Water Quality: Export Model Results		
Parameter	**Sub-Model Description**	**Display Scale**
Sediment	The *Export Potential* for **Sediment** model compares the relative capacity of an assessment unit to generate and transport soil particles downstream if disturbed, based on an evaluation of areas that act as *sources* and *sinks* of **sediment**. Areas with a *high export potential* for **Sediment** have relatively: • Higher intensity rainfall • Steeper topography • More erosive soils • Greater extent of areas subject to landslide hazards & higher stream density • More erosive stream channels • Fewer depressional wetlands and floodplain storage areas to trap sediment See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	🟫 H - High 🟫 MH - Moderate High 🟧 M - Moderate 🟨 L - Low
Phosphorus	The *Export Potential* for **Phosphorus** model compares the relative capacity of an assessment unit to generate and transport **phosphorus** downstream if disturbed, based on an evaluation of areas that act as *sources* and *sinks* for **phosphorus**. Areas with a *high export potential* for **phosphorus** have relatively : • Higher intensity rainfall • Steeper topography • More erosive soils • Greater extent of areas subject to landslide hazards & higher stream density • More erosive stream channels • Fewer depressional wetlands, lakes and floodplain storage areas to trap phosphorus	🟫 H - High 🟧 MH - Moderate High 🟧 M - Moderate 🟨 L - Low

Water Quality: Export Model Results		
Parameter	**Sub-Model Description**	**Display Scale**
	• Lesser extent of soils with a high clay content See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	
Metals	The *Export Potential* for **Metals** model compares the relative capacity of an assessment unit to generate and transport toxic Metals downstream if disturbed, based on an evaluation of areas that act as *sink* which can trap **metals.** Areas with a *high export potential* for **metals** have relatively: • Fewer lakes, wetlands, and floodplain storage areas • Lesser extent of soils with high organic and clay content See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	🟥 H - High 🟥 MH - Moderate High 🟥 M - Moderate 🟥 L - Low
Nitrogen	The *Export Potential* for **Nitrogen** model compares the relative capacity of an assessment unit to generate and transport **nitrogen** downstream if disturbed based on an evaluation of areas that act as *sinks* in which denitrification is likely to occur. Areas with a *high export potential* for **nitrogen** have relatively fewer: • wetlands and lakes • riparian areas with hydric soils See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	🟩 H - High 🟩 MH - Moderate High 🟩 M - Moderate 🟩 L - Low
Pathogens	The *Export Potential* for **Pathogens** model, which compares the relative capacity of an assessment unit to generate and transport bacteria into aquatic systems if disturbed, is based on an evaluation of areas that act as *sinks* in which removal of **pathogens** can occur via natural processes. Areas with a *high export potential* for **pathogens** have relatively : • Fewer depressional wetlands See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	🟪 H - High 🟪 MH - Moderate High 🟪 M - Moderate 🟪 L - Low

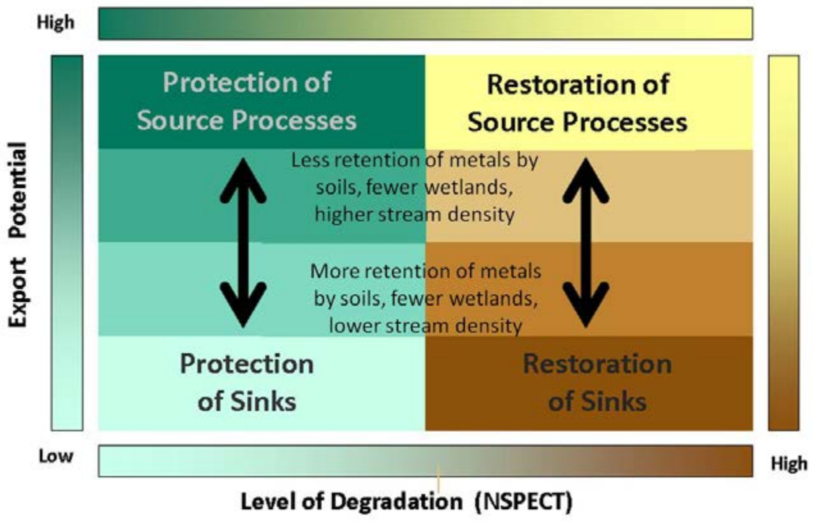
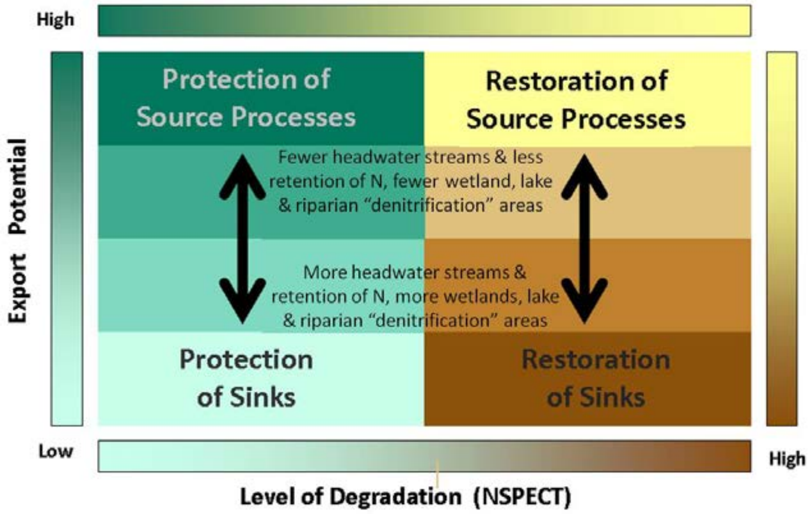
Water Quality: Degradation Model Results		
Parameter	**Sub Model Description**	**Display Legend**
Sediment	The *Degradation to* **Sediment** process model (MUSLE) evaluates the current land cover type within assessment units and the relative capacity to generate and transport **sediment** to aquatic systems during a storm. Areas that generate *relatively high quantities* of **sediment** typically have higher gradients with more erosive soils with extensive change in land cover from native cover by the following land uses: • Forestry • Urban and rural residential development • Agriculture See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	🟥 H - High 🟧 MH - Moderate High 🟩 M - Moderate 🟩 L - Low

Water Quality: Degradation Model Results

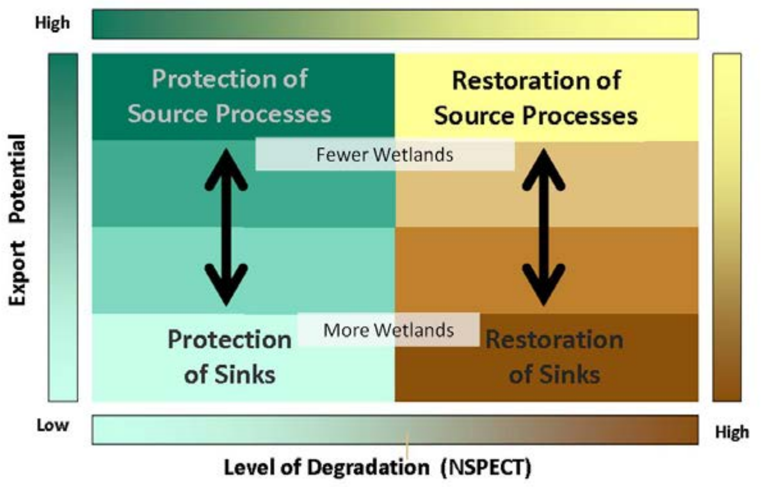
Parameter	Sub Model Description	Display Legend
Phosphorus	The *Degradation to* **Phosphorus** process model (NSPECT) compares the land cover within assessment units to evaluate the relative capacity to generate and load **phosphorus** into aquatic systems during a storm. Areas that generate *relatively high quantities* of **phosphorus** include the following land uses: • Agriculture • Residential • Commercial and Industrial • Extensive highway systems See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	🟥 H - High 🟧 MH - Moderate High 🟩 M - Moderate 🟩 L - Low
Metals	The *Degradation to* **Metals** process model (NSPECT) compares the land cover within assessment units to evaluate the relative capacity to generate and load **metals** into aquatic systems during a storm. Areas that generate *relatively high quantities* of **metals** include the following land uses: • Commercial and industrial • High density residential • Agricultural See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	🟥 H - High 🟧 MH - Moderate High 🟩 M - Moderate 🟩 L - Low
Nitrogen	The *Degradation to **Nitrogen*** process model (NSPECT) compares the land cover within assessment units to evaluate the relative capacity to generate and load **nitrogen** into aquatic systems during a storm. Areas that generate *relatively high quantities* of **nitrogen** include the following land uses: • Agriculture • Commercial and industrial • Residential See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	🟥 H - High 🟧 MH - Moderate High 🟩 M - Moderate 🟩 L - Low
Pathogens	The *Degradation to* **Pathogen** process model (NSPECT) compares the land cover within assessment units to evaluate the relative capacity to generate and transport **pathogens** to aquatic systems during a storm. Areas that generate *relatively high quantities* of **pathogens** include the following land uses: • Commercial and Industrial • Residential • Agricultural See https://fortress.wa.gov/ecy/publications/publications/1106016part3.pdf for details	🟥 H - High 🟧 MH - Moderate High 🟩 M - Moderate 🟩 L - Low

<table>
<tr><th colspan="4">Water Quality Combined Export Potential and Degradation Model Results and Management Matrix</th></tr>
<tr><th>Component</th><th>Description</th><th>Display Legend</th><th></th></tr>
<tr><td>Sediment</td><td>By combining the results of the *Export Potential* and *Degradation (MUSL)* models, management actions at the broad scale can be identified which prioritize the protection or restoration of *sources* and *sinks* of **sediment**. These management actions are represented in the matrix below and identify assessment units with relatively:
• High Export Potential – Low Degradation
• High Export Potential – High Degradation
• Low Export Potential – Low Degradation
• Low Export Potential – High Degradation
Management Actions for Sediment, Phosphorous & Metals Models:
Protect Source Processes = Prevent activities that remove vegetation cover & increase channel erosion
Restore Source Processes = Restore natural cover and control existing sources
Protect Sinks = Protect wetlands, lakes, floodplains
Restore Sinks = Restore wetland and floodplains
Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf</td><td>🟩 Protection of Source Processes
🟦 Protection of Sinks
🟨 Restoration of Source Processes
🟫 Restoration of Sinks</td><td> </td></tr>
<tr><td>Phosphorus</td><td>By combining the results of the *Export Potential* and *Degradation* models, management actions at the broad scale can be identified which prioritize the restoration of *sources* and *sinks* for **phorphorus**. These management actions are represented in the matrix below and identify assessment units with relatively:
• High Export Potential – Low Degradation
• High Export Potential – High Degradation
• Low Export Potential – Low Degradation
• Low Export Potential – High Degradation
Management Actions for Sediment, Phosphorous & Metals Models:
Protect Source Processes = Prevent activities that remove vegetation cover & increase channel erosion
Restore Source Processes = Restore natural cover and control existing sources
Protect Sinks = Protect wetlands, lakes, floodplains
Restore Sinks = Restore wetland and floodplains
Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf</td><td>🟩 Protection of Source Processes
🟦 Protection of Sinks
🟨 Restoration of Source Processes
🟫 Restoration of Sin</td><td> </td></tr>
</table>

Water Quality Combined Export Potential and Degradation Model Results and Management Matrix

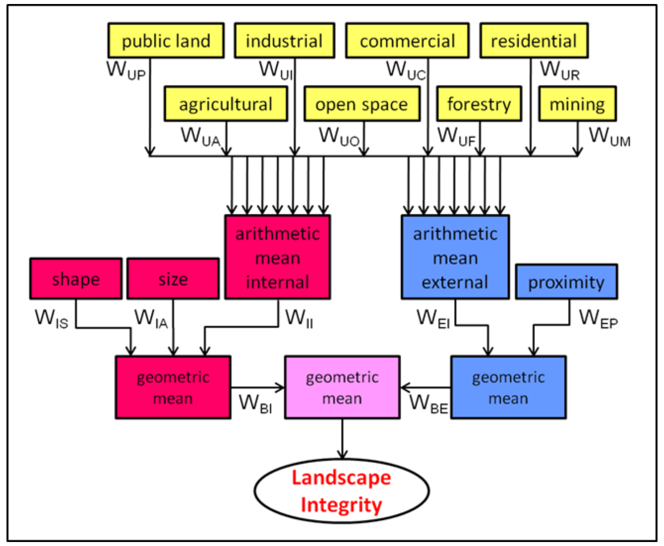
Component	Description	Display Legend	
Metals	By combining the results of the *Export Potential* and *Degradation* model, management actions at the broad scale can be identified for **metals**. These management actions are represented in the matrix below and identify assessment units with relatively: - High Export Potential – Low Degradation - High Export Potential – High Degradation - Low Export Potential – Low Degradation - Low Export Potential – High Degradation **Management Actions for Sediment, Phosphorous & Metals Models**: Protect Source Processes = Prevent activities that remove vegetation cover & increase channel erosion Restore Source Processes = Restore natural cover and control existing sources Protect Sinks = Protect wetlands, lakes, floodplains Restore Sinks = Restore wetland and floodplains Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf	🟩 Protection of Source Processes 🟩 Protection of Sinks 🟨 Restoration of Source Processes 🟫 Restoration of Sin	
Nitrogen	By combining the results of the *Export Potential* and *Degradation* model, management actions at the broad scale can be identified for **nitrogen**. These management actions are represented in the matrix below and identify assessment units with relatively: - High Export Potential – Low Degradation - High Export Potential – High Degradation - Low Export Potential – Low Degradation - Low Export Potential – High Degradation **Management Actions for Nitrogen**: Protect Source Processes = Limit new sources of N & prevent impacts to headwater streams, wetland, lake and riparian denitrification areas Restore Source Processes = Control existing sources of N Protect Sinks = Protect headwater streams and areas of denitrification Restore Sinks = Restore headwater streams and areas of denitrification Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf	🟩 Protection of Source Processes 🟩 Protection of Sinks 🟨 Restoration of Source Processes 🟫 Restoration of Sin	

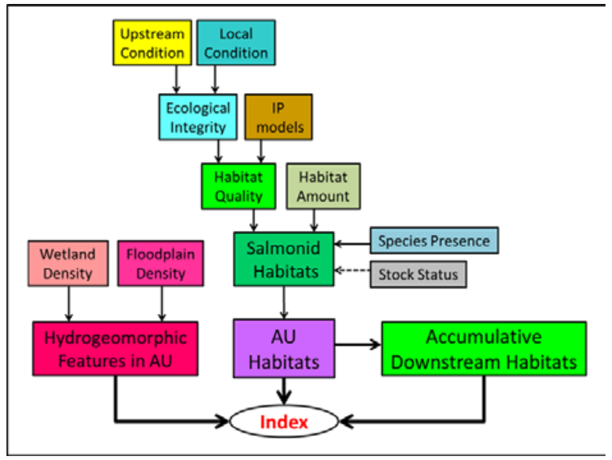
Water Quality Combined Export Potential and Degradation Model Results and Management Matrix

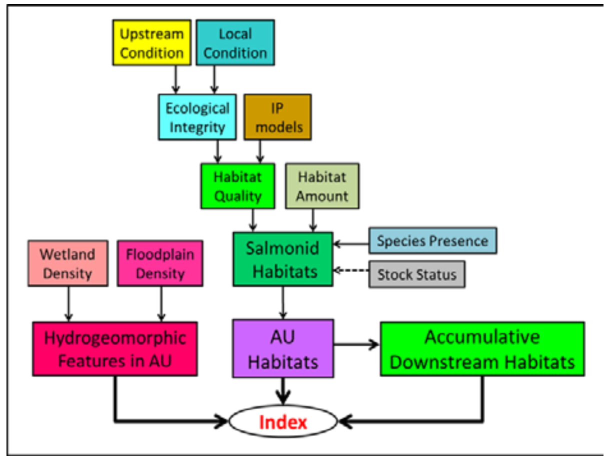
Component	Description	Display Legend	
Pathogen	By combining the results of the *Export Potential* and *Degradation* model, management actions at the broad scale can be identified for **pathogens**. These management actions are represented in the matrix below and identify assessment units with relatively: • High Export Potential – Low Degradation • High Export Potential – High Degradation • Low Export Potential – Low Degradation • Low Export Potential – High Degradation **Management Actions for Pathogens**: Protect Source Processes = Limit new sources of pathogens Restore Source Processes = Control existing sources of pathogens and restore wetlands Protect Sinks = Protect wetlands Restore Sinks = Restore wetlands Details can be found at: https://fortress.wa.gov/ecy/publications/publications/1106016.pdf	🟩 Protection of Source Processes 🟩 Protection of Sinks 🟨 Restoration of Source Processes 🟫 Restoration of Sinks	

Habitat Assessments

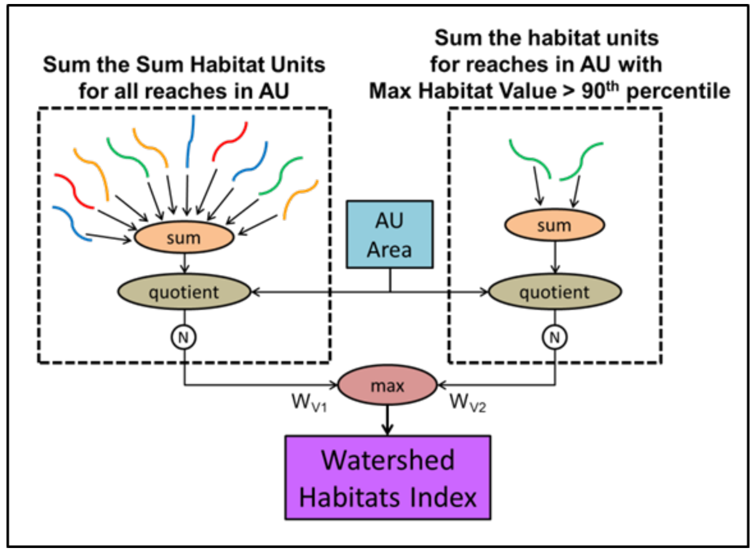
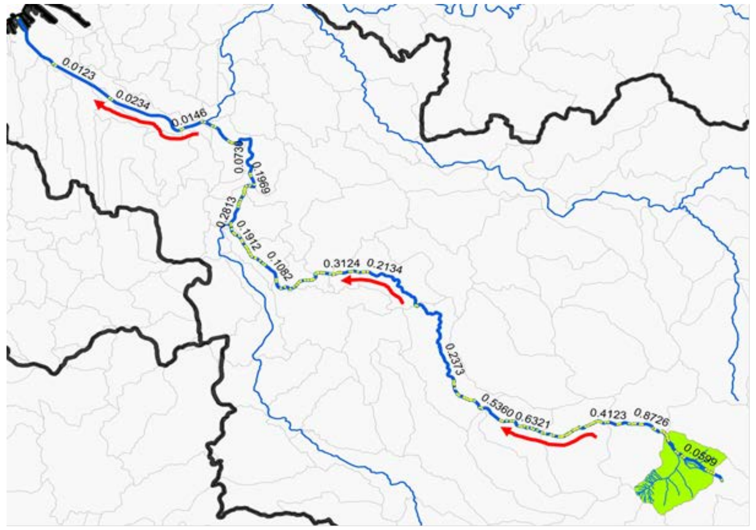
Model	Description	Display Legend
Terrestrial habitats: Overall Index	The index **of relative conservation value** for the terrestrial habitats is comprised of two main components: **landscape integrity** and the locations of **priority habitats and species**. Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	🟥 0.00 - 1.91 (Lowest) 🟥 1.92 - 3.91 🟧 3.92 - 6.06 🟧 6.07 - 8.38 🟧 8.39 - 10.93 🟧 10.94 - 13.98 🟧 13.99 - 17.74 🟨 17.75 - 22.77 🟨 22.78 - 28.39 🟨 28.40 - 34.81 🟨 34.82 - 42.85 🟨 42.86 - 51.50 🟩 51.51 - 60.21 🟩 60.22 - 69.26 🟩 69.27 - 78.21 🟩 78.22 - 86.18 🟩 86.19 - 92.42 🟩 92.43 - 96.73

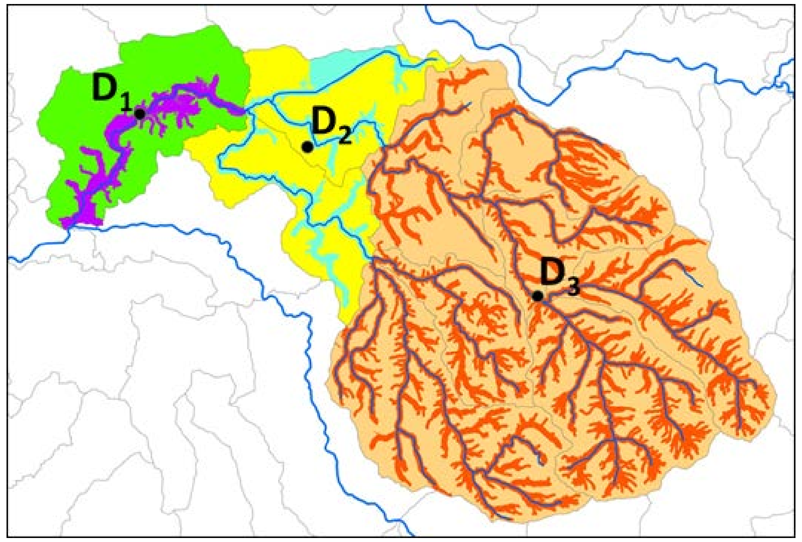
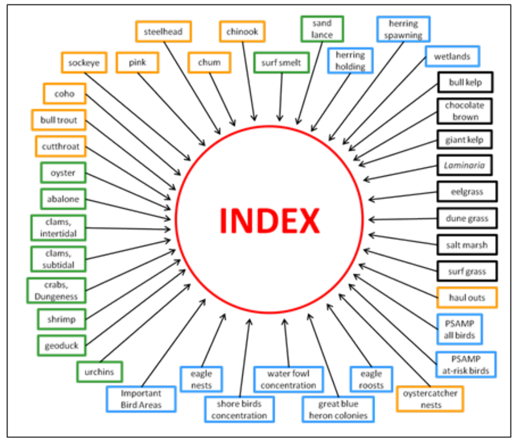
Habitat Assessments		
Model	**Description**	**Display Legend**
		🟩 96.74 - 99.09 🟩 99.10 - 100.00 (Highest)
Terrestrial habitat: Open Space Blocks	Landscape integrity of **Open Space Blocks** is a function of the size and shape of each open space blocks, the proximity of each block to other open space blocks, and the land uses inside and surrounding each open space block.  Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	🟥 0.00 - 1.91 (Lowest) 🟥 1.92 - 3.91 🟧 3.92 - 6.06 🟧 6.07 - 8.38 🟧 8.39 - 10.93 🟧 10.94 - 13.98 🟧 13.99 - 17.74 🟧 17.75 - 22.77 🟨 22.78 - 28.39 🟨 28.40 - 34.81 🟨 34.82 - 42.85 🟨 42.86 - 51.50 🟩 51.51 - 60.21 🟩 60.22 - 69.26 🟩 69.27 - 78.21 🟩 78.22 - 86.18 🟩 86.19 - 92.42 🟩 92.43 - 96.73 🟩 96.74 - 99.09 🟩 99.10 - 100.00 (Highest)
Freshwater: Sum All Quantiles	The **Sum of 3 Components** score is based on: **Local salmonid habitats** - the quantity and quality of habitats for all salmonids present or potentially present in the assessment unit (AU). **Downstream salmonid habitats** - the quality and quality of salmonid habitat downstream of the AU. **Hydrogeomorphic features** - all extant wetlands and undeveloped floodplains in the AU. Where scores for each component are **added together** to determine a Freshwater Habitat Index Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	🟥 1 (Lowest) 🟥 2 🟧 3 🟧 4 🟧 5 🟧 6 🟧 7 🟧 8 🟧 9 🟧 10

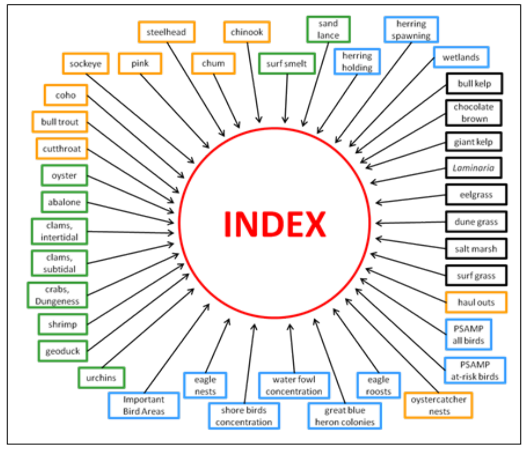
Habitat Assessments		
Model	**Description**	**Display Legend**
		🟧 11 🟧 12 🟨 13 🟨 14 🟨 15 🟨 16 🟨 17 🟨 18 🟨 19 🟩 20 🟩 21 🟩 22 🟩 23 🟩 24 🟩 25 🟩 26 🟩 27 🟩 28 🟩 29 🟩 30 (Highest)
Freshwater: Max All Quantiles	The **Maximum of 3 components** score for Freshwater Habitats is based on: **Local salmonid habitats** - the quantity and quality of habitats for all salmonids present or potentially present in the assessment unit (AU). **Downstream salmonid habitats** - the quality and quality of salmonid habitat downstream of the AU. **Hydrogeomorphic features** - all extant wetlands and undeveloped floodplains in the AU. Where that component which has the **maximum** score is presented	🟥 1 (Lowest) 🟧 2 🟧 3 🟧 4 🟨 5 🟨 6 🟩 7 🟩 8 🟩 9 🟩 10 (Highest)

Habitat Assessments		
Model	**Description**	**Display Legend**
	 Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	
Freshwater: Wetland score quantiles	**Hydrogeomorphic Features Score** is based on the relative extent of wetlands and floodplains, which are crucial to maintaining the quality of salmonid habitats. High scores have relatively greater extent of wetlands and floodplains than other assessment units. Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	🟥 1.0 - 1.9 = Lowest Density 🟧 2.0 - 2.8 🟧 2.9 - 3.7 🟧 3.8 - 4.6 🟨 4.7 - 5.5 🟨 5.6 - 6.4 🟩 6.5 - 7.3 🟩 7.4 - 8.2 🟩 8.3 - 9.1 🟩 9.2 - 10.0 = Highest Density
Freshwater: Salmonid habitats score quantiles	**Local Salmonid Habitats component** (also known as the Watershed Habitats Index, WHI) is the maximum of either the: A) the sum of sum habitat units for all stream reaches in the AU or B) the sum of habitat units for reaches in the AU that have maximum habitat value greater than the 90th percentile for the WRIA where the AU is located. N stands for normalization which is done within WRIAs	⬜ 0 (No Freshwater Lotic Salmonid Habitat) 🟧 1 = Lowest Value of Salmonid Habitats 🟧 2 🟧 3 🟨 4 🟨 5 🟨 6 🟩 7 🟩 8 🟩 9

Habitat Assessments

Model	Description	Display Legend
	 Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	🟩 10 = Highest Value of Salmonid Habitats
Freshwater: Accumulative downstream habitats quantiles	The **Downstream Salmonid Habitats** component (or accumulative downstream habitats) is a component of the freshwater index of relative conservation value. It indicates the relative value of streams, especially headwater streams, based on the quantity and quality of salmonid habitats that they potentially impact.  Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	⬜ 0 = No downstream freshwater habitats 🟥 1 = Lowest potential impact 🟧 2 🟧 3 🟨 4 🟨 5 🟩 6 🟩 7 🟩 8 🟩 9 🟩 10 = Highest potential impac
Freshwater: Aquatic Ecological Integrity	Calculation of **aquatic ecological integrity** is based on multiple spatial scales and the spatial arrangement of land uses within a watershed. Spatial arrangement has both lateral and longitudinal dimensions. The difference between riparian areas and uplands (purple versus green, light blue versus yellow) illustrates the lateral dimension. Movement upstream from the green AU to yellow AUs to orange AUs occurs along the longitudinal dimension. We measured the longitudinal dimension at three distances: D1, D2, and D3. Different polygon colors correspond to six distinct zones.	🟥 0 - 10 🟧 11 - 20 🟧 21 - 30 🟨 31 - 40

Habitat Assessments		
Model	**Description**	**Display Legend**
	 Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	🟨 41 - 50 🟨 51 - 60 🟩 61 - 70 🟩 71 - 80 🟩 81 - 90 🟩 91 - 100
Marine shorelines: Sum All Variables	The **Average of All Marine Shoreline Components** is the "normalized sum" – which effectively is the average relative conservation value of the shoreline segment. The components were species, species groups, and habitats for which occurrence data were available: eight shellfish species or species groups of commercial/recreational interest, urchins, three forage fish species, eight salmonid species, numerous bird species, pinnipeds, kelp, eelgrass, surfgrass, and wetlands.  Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	🟥 1 (Lowest) 🟥 2 🟧 3 🟧 4 🟧 5 🟧 6 🟨 7 🟨 8 🟨 9 🟨 10 🟨 11 🟩 12 🟩 13 🟩 14 🟩 15 🟩 16 🟩 17 🟩 18

Habitat Assessments		
Model	**Description**	**Display Legend**
		🟩 19 🟩 20 (Highest)
Marine shorelines: Average Top 5 Variables	**The Marine Habitats Score – Average of Top 5** presents the average of the top 5 components at each shoreline segment. Some shoreline segments with moderate or low normalized sums (i.e., average values) may be high value sites for a small number of components. The **average of the top 5 components** can be used to identify where that situation occurs. The components were species, species groups, and habitats for which occurrence data were available: eight shellfish species or species groups of commercial/recreational interest, urchins, three forage fish species, eight salmonid species, numerous bird species, pinnipeds, kelp, eelgrass, surfgrass, and wetlands. See volume 2 of the Puget Sound Watershed Characterization Project (A Coarse-scale Assessment of the Relative Value of Small Drainage Areas and Marine Shorelines for the Conservation of Fish and Wildlife Habitats in Puget Sound Basin) for more details.  Details can be found at: ftp://www.ecy.wa.gov/gis_a/PS_PROJECT/Docs/Watershed_Characterization_WDFW_Report_Final_Feb2013.pdf	🟥 1 (Lowest) 🟧 2 🟧 3 🟧 4 🟧 5 🟧 6 🟨 7 🟨 8 🟨 9 🟨 10 🟨 11 🟩 12 🟩 13 🟩 14 🟩 15 🟩 16 🟩 17 🟩 18 🟩 19 🟩 20 (Highest)

Appendix B: Case Studies

Puget Sound Watershed Characterization Case Study

Land Use Planning in the Gorst Watershed (Bremerton, Washington)

The Puget Sound Watershed Characterization Project (the Characterization) is a set of spatially explicit water and habitat assessments that compare areas within a watershed in terms of their relative value for restoration and protection and helps identity the best locations for new development. The Characterization is a coarse-scale assessment that assists in identifying two fundamental questions:

(1) ***where on the landscape*** should management efforts be focused first, be they actions for planning (e.g., protection or additional development) or mitigation (e.g., restoration); and
(2) ***what types of activities and actions*** are most appropriate to that place, be they restoration, protection, conservation, or development?

It is not intended for site-specific application or decision-making at the site scale, including the design of mitigation or restoration projects; finer scale data will be needed for these decisions. This Case Study should only be used as an illustrative example for how to interpret and apply information from the Characterization.

I. Identifying the Issue

The City of Bremerton is preparing a sub-area plan for the Gorst Creek Watershed located in WRIA 15, Kitsap County. Unlike most conventional sub-area plans, the Gorst Creek plan is being developed based on a detailed understanding of watershed processes. The City wants to **identify the best places for development, protection and restoration and use that information to guide future land use decisions**. Working with WA departments of Ecology and Fish and Wildlife, the City assessed water flow and water quality processes and relative habitat value for the 11 square mile area. The intent of the assessment is to lay the ground work to accommodate additional growth while identifying areas within which key ecological processes and habitats that should be restored, protected, and conserved. By identifying the location and extent of natural features that play a key role in controlling the movement of water (e.g. forest cover, wetlands and floodplains, permeability of surface deposits), new development can be located and designed in a manner that results in minimal harm to ecological processes in the Gorst Creek watershed.[4]

The main questions guiding development of the subarea plan are: ***Which areas of the Gorst watershed can best accommodate future development without degrading ecological processes and habitats, which areas should be the highest priority for protection from future development impacts, and which areas would be the highest priority for restoration of ecological processes?***

The Gorst Creek watershed is a tributary to the Puget Sound. The Gorst Creek watershed is partially located within the City of Bremerton's Urban Growth Area (UGA), and partially within Kitsap County

Why Is Gorst Creek Important?

The Gorst Creek watershed is significant for a number of reasons:

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[4] For detailed information on the methods and results used for the Gorst Creek Watersehd sub-area assessment, see the following report:

City of Bremerton. 2012. Gorst Creek Watershed Characterization Report. Washington Department of Ecology and the Washington Department of Fish and Wildlife in collaboration with Parametrix, Bellevue, Washington. May 2012. Available: http://www.ci.bremerton.wa.us/gorstwatershed/

- Public ownership and management of the forest land in the central portion of the watershed has protected water flow processes, which remain in relatively good condition, with respect to other portions of the landscape.
- Gorst Creek and its tributaries, including Sinclair Inlet at the mouth of Gorst Creek, are inhabited by anadromous salmonids and resident trout .
- The Gorst Creek watershed is described as "one of the largest and most productive watersheds in the east WRIA-15 subregion" in the 2003 Kitsap Salmonid Refugia Report (May and Peterson, 2003).
- Jarstad Creek has the greatest value for salmonid conservation in the watershed (May and Peterson, 2003).
- Heins Creek rated 'generally good' habitat conditions (May and Peterson, 2003).
- Gorst Creek, above river mile 1.0, rated 23rd of 95 salmonid refugia areas scored within Kitsap County (May and Peterson, 2003).
- The estuary (Sinclair Inlet) supports waterfowl, shorebirds, great blue herons, bald eagles, and is an important rearing and refuge area for juvenile Chinook salmon.
- The forested area that comprises the north and central portion of the Gorst Creek watershed is publicly owned, and lies within a contiguous area that also contains Green Mountain and Tahuya State Forest. Taken together, this area comprises the largest open-space block in the Puget Trough Ecoregion of the Puget Sound Basin.

The significance of the aquatic habitats identified above indicates that there are important natural features in the Gorst Creek watershed contributing to water flow processes that support and sustain them. If these important features are negatively impacted by future development then processes may be altered to a degree that the aquatic habitats can no longer provide the functions that sustain the aquatic food web. While the Gorst Creek watershed contains significant natural resources, it is also an area which is anticipated to develop over the next several decades.

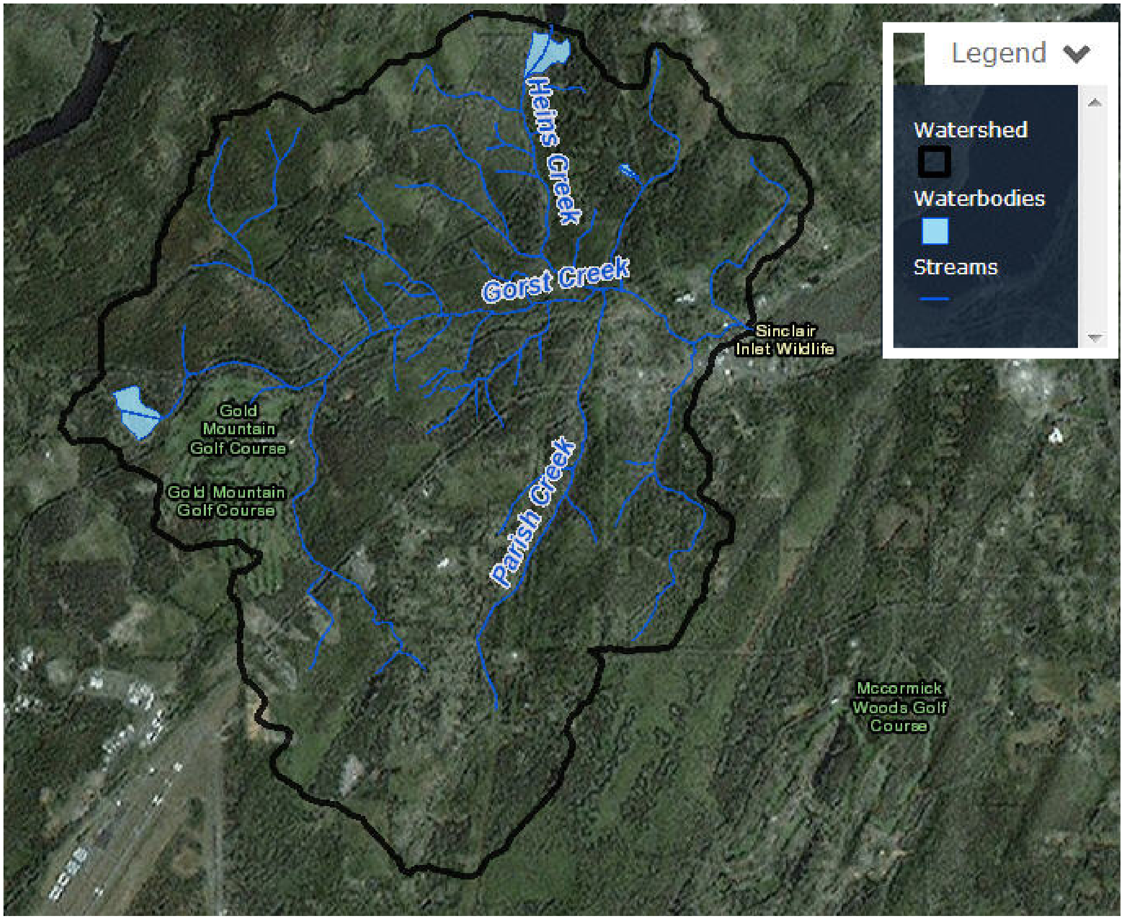
II. Gathering Watershed Based Information

Understanding the Assessment Scale

For any watershed characterization effort, it is important to assess information at the right scale. Since the characterization is a relative comparison of one area of a watershed to another area selecting the right analysis units will help ensure the results appropriate to the management questions being considered.

The City and partners determined that the assessment units (AUs) embedded in the Watershed Characterization results for Gorst Watershed did not provide sufficient detail to address the central planning issues, so local information was used to further divide the watershed into 20 Project AUs.

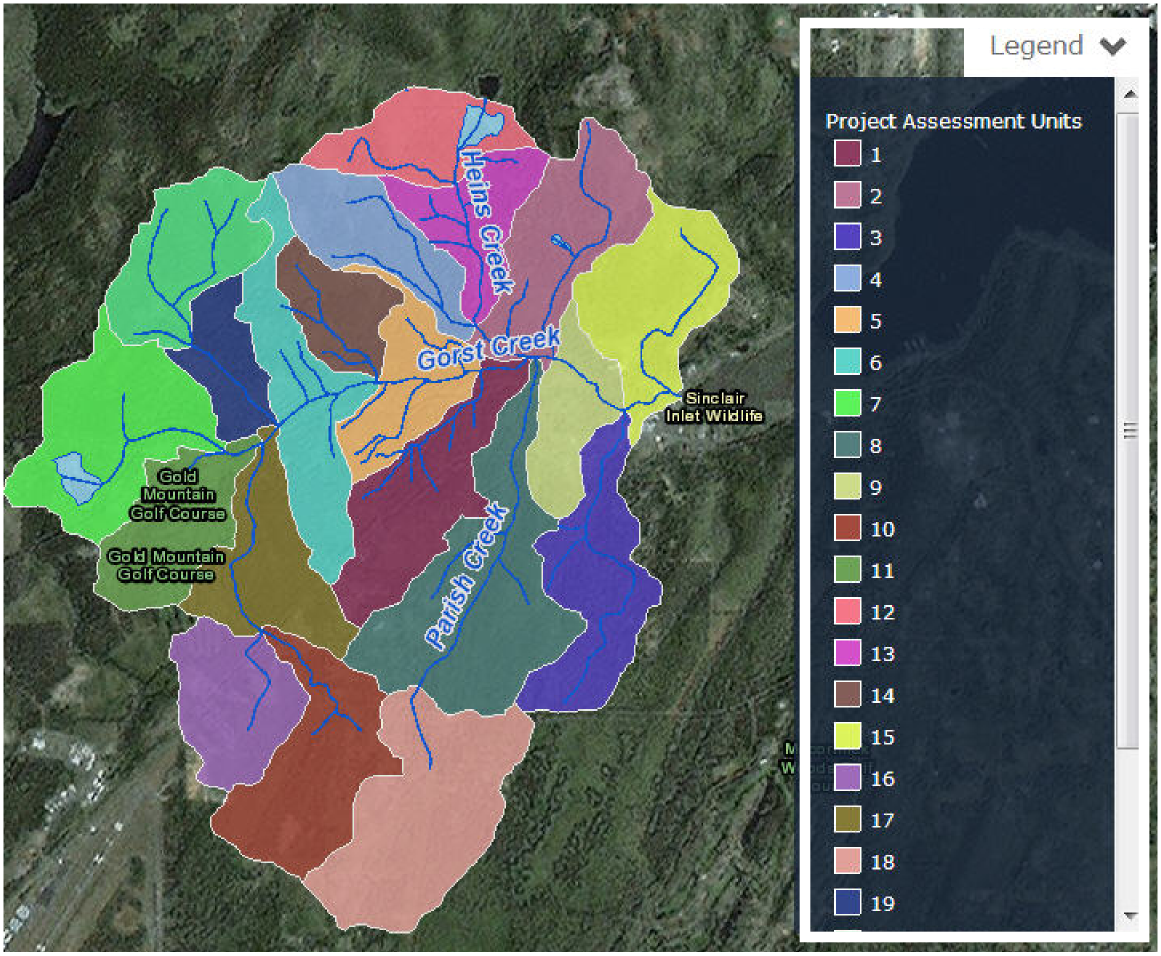
Figure 20. The Gorst Watershed in the City of Bremerton; Gorst Creek and several tributaries drain to Sinclair Inlet (black outline is the project study area).



For this effort, consideration of landscape provided:

- Relative comparison of Watershed Characterization results for only those AUs within the subarea, as opposed to comparison of all AUs across WRIA 15, and
- More precise consideration of physical and biological conditions in the study area.

Figure 21. Gorst Watershed assessment unit boundaries.



Water Flow Assessment Results

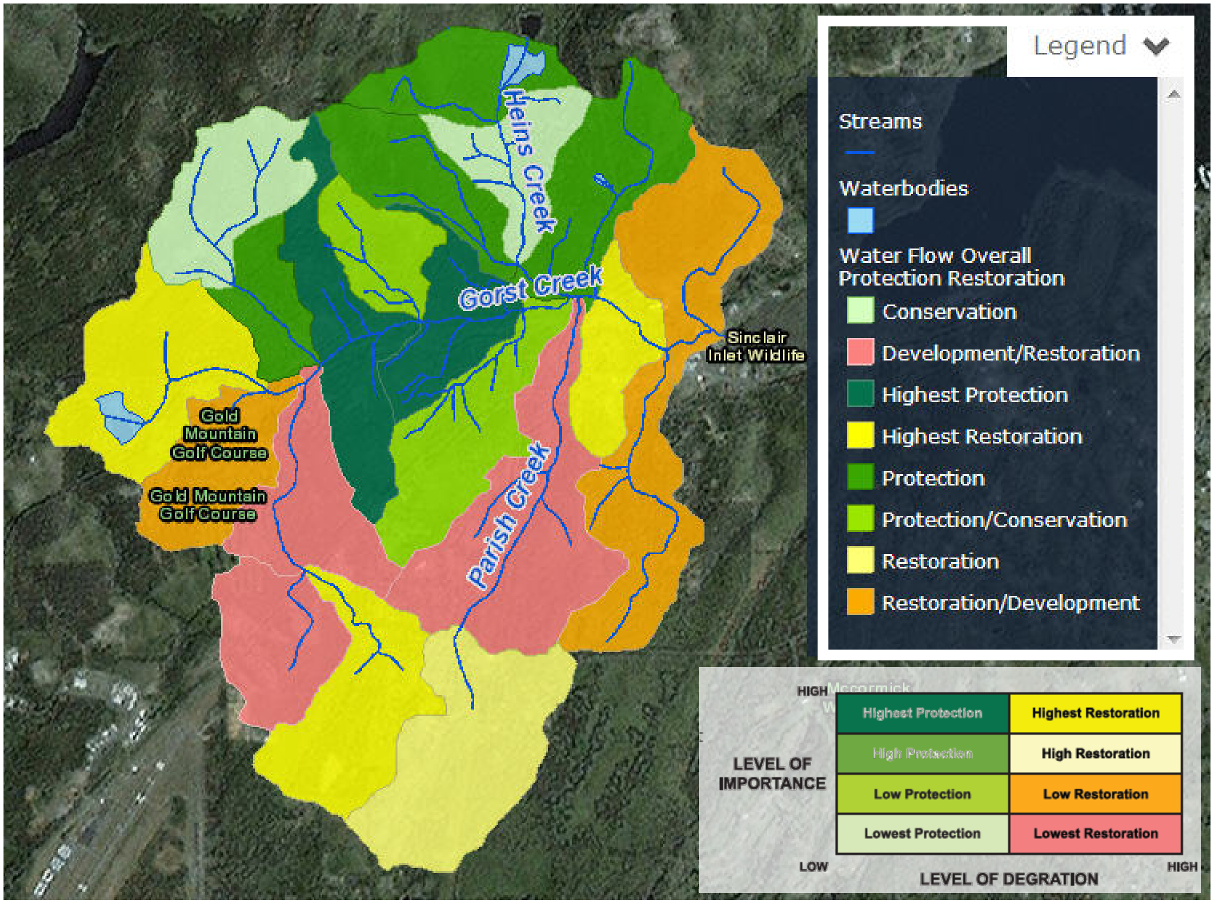
The overall results of the water flow assessment integrate relative rankings of importance and degradation for key water flow processes, and assign a management designation (e.g., protect, restore) to each AU. It is also very important to review the results for the individual components for water flow (delivery, storage, recharge and discharge) since they provide specific information for the type of restoration and protection actions that should be undertaken. For instance, if the overall all results show restoration for an AU, investigation of the individual component models may reveal that storage has the highest restoration ranking relative to the other water flow processes. This would indicate that restoration actions should concentrate on measures that restore wetland storage functions

Green results: The overall water flow results for Gorst Creek showed that the majority of the northern portion of the watershed is of high importance important to water flow processes (delivery, recharge and discharge) and is relatively intact. This suggests that future residential development in these AUs should be avoided or must be designed to protect these processes. This could include limiting development and new impervious surface in areas of high recharge potential, high discharge potential, and extensive forest cover.

Yellow results: Portions of the southwestern watershed are primarily important for surface storage of water and are relatively degraded because of existing residential and recreational development. This suggests the City should seek opportunities to restore and protect wetlands areas in these AUs.

Orange and red results: Compared to other parts of the watershed, development in these areas would likely have less adverse consequences for water flow processes because they are relatively less important in terms of water delivery, storage and recharge/discharge.

Figure 22. Overall water flow assessment results for the Gorst Watershed.



III. Integrating and Applying Other Assessment Results

Integrating Water Quality Assessment Results

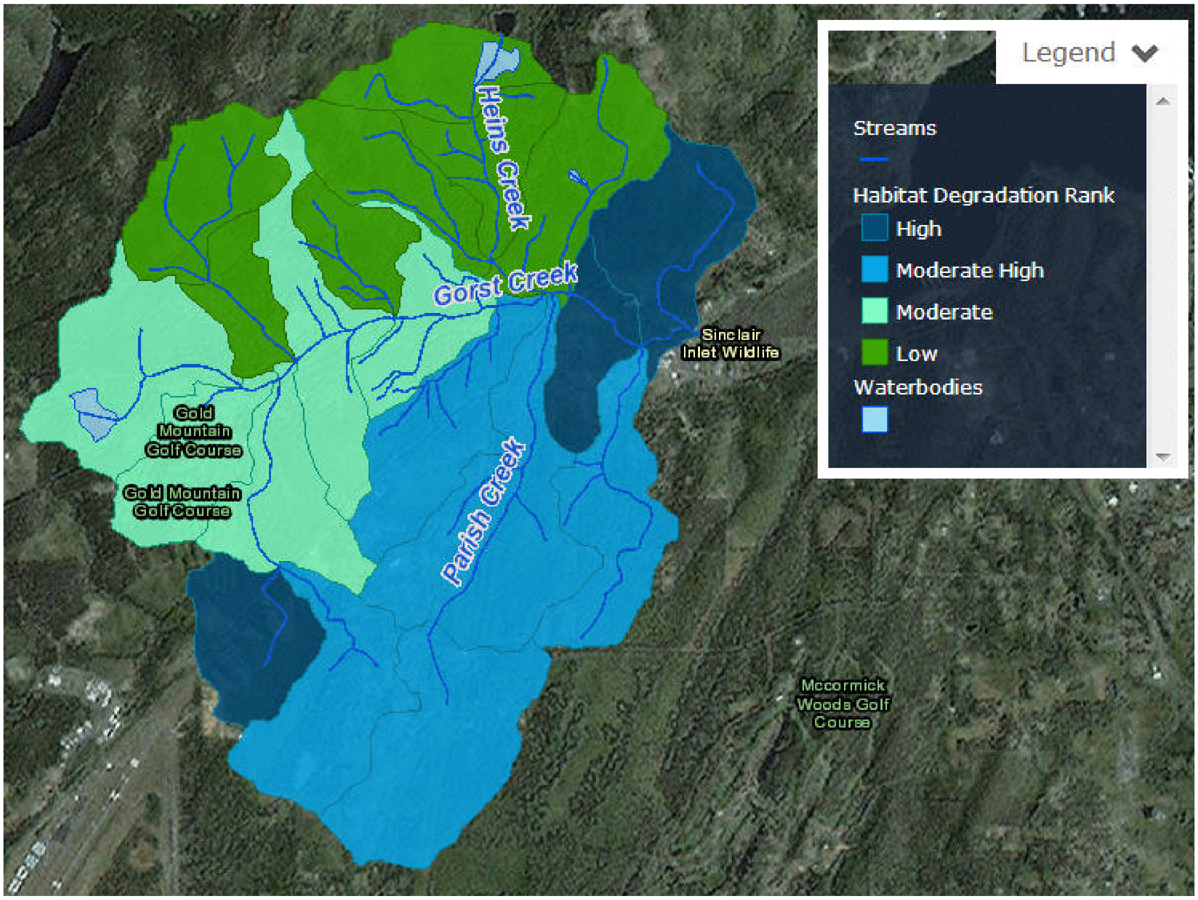
In addition to looking at water flow processes, the Gorst subarea plan is also considering water quality processes – including sediment export potential.

Sediment is of significant concern for the Gorst Watershed due to urbanizing development patterns. For all watershed characterization efforts, landscape and land use patterns should be assessed to identify key water quality concerns.

Highest sediment export potential occurs in areas around the northern and central tributaries, including the south fork of Gorst Creek, Heins Creek, and Parish Creek - areas in brown and dark brown. This result suggests these areas should be prioritized for "protection", as to ensure that sediment export is not increased by development-related disturbances (clearing and grading, increased runoff, etc). Intense development in these areas may not be appropriate given potential for high sediment export. However, the water flow assessment shows this area as appropriate for higher intensity development, leading to an integrated conclusion that would likely modify the final location of most intensive development or else emphasize careful mitigation of potential erosion-causing activities. This could include clustering development to both avoid areas of highest erosion/export and increase natural cover to facilitate infiltration and reduction of overland flow

Lowest sediment export potential occurs primarily in the southern terrace areas (yellow Project AUs); this suggests that these areas may be most appropriate for higher intensity development.

Figure 23. Sediment export potential for the Gorst Watershed.



Integrating Habitat Assessment Results

A complete watershed characterization requires an assessment of fish and wildlife habitats. Over 70 percent of the Gorst Creek Watershed is forested, and about 4/5 of this forest is managed for timber. These forests are unremarkable except for two characteristics: the large area which they encompass and the ecoregion in which they are located. Two exceptionally large open-space blocks overlap the Gorst Creek watershed. According to the Puget Sound Watershed Characterization, the open-space blocks overlapping the north and south portions of the Gorst Creek Watershed were in the top 10 percent for relative habitat value in the Puget Trough Ecoregion of the Puget Sound Basin. The large, contiguous open-space blocks overlapping the watershed comprise the most important open-space in WRIA 15. The two large open-space blocks are likely to be inhabited by the following priority species: western toad (*Anaxyrus boreas*), Wood Duck (*Aix sponsa*), Sooty Grouse (*Dendragapus fuliginosus*), band-tailed pigeon (*Columba fasciata*), Vaux's swift, (*Chaetura vauxi*), pileated woodpecker (*Dryocopus pileatus*), Keens' long-eared myotis (*Myotis evotis keenii*), big brown bat (*Eptesicus fuscus*), and black-tailed deer (*Odocoileus hemionus columbianus*).

In 2003, Kitsap County commissioned a detailed, in-depth assessment of salmon habitats: the Kitsap Salmonid Refugia Report. Because it was the best available for science for the Gorst Creek Watershed, we used the findings of the Kitsap Salmonid Refugia Report. Gorst Creek is inhabited by Chinook, chum, coho, steelhead, and cutthroat salmon. The Kitsap Salmonid Refugia Report designated Gorst Creek a class C salmonid refugia. Class C refugia have been altered from natural conditions and do not fully support native salmonid populations. The report described the watershed as "one of the largest and most productive watersheds in the east WRIA-15 subregion." According to the Kitsap Salmonid Refugia Report, Jarstad Creek, a tributary of Gorst Creek, has the greatest value for salmonid conservation in the watershed. Habitat conditions in Jarstad and Heins Creeks are "generally good. Finer scale information shows that a landfill covers a portion of Gorst Creek in area 2A (Figure 6) and lower portions of Gorst Creek are channelized (area 2C); both of these alterations impact salmonid habitat and use by resident and migrating populations.

Because Gorst Creek empties in to Sinclair Inlet an assessment of marine shoreline habitats was done. The estuary at the mouth of Gorst Creek contains intertidal wetlands and salt marsh that support shorebird and waterfowl concentrations. A bald eagle nest and territory occur near the south shore. A great blue heron colony was formerly located (circa 2006) near the west end of Sinclair Inlet, and over the past decade two separate great blue heron colonies have existed near the south shore of the inlet. This high concentration of colonies suggests that the estuary is used by herons as foraging habitat. Compared to other shorelines in the Central Puget Sound sub-basin, the two miles of marine shoreline along the Gorst Creek estuary had above average habitat value. These relatively high scores were due to the presence of shorebird and waterfowl concentrations, salt marsh vegetation, and for one of the shoreline segments a nearby great blue heron colony. The marine shoreline assessment supports the need to protect and restore the watershed's water flow and water quality processes which impact these marine resources. Finer scale data show that the mouth of the estuary is currently impacted by older commercial development which has filled a portion of the historic estuary and restricts the historic channel for Gorst Creek.

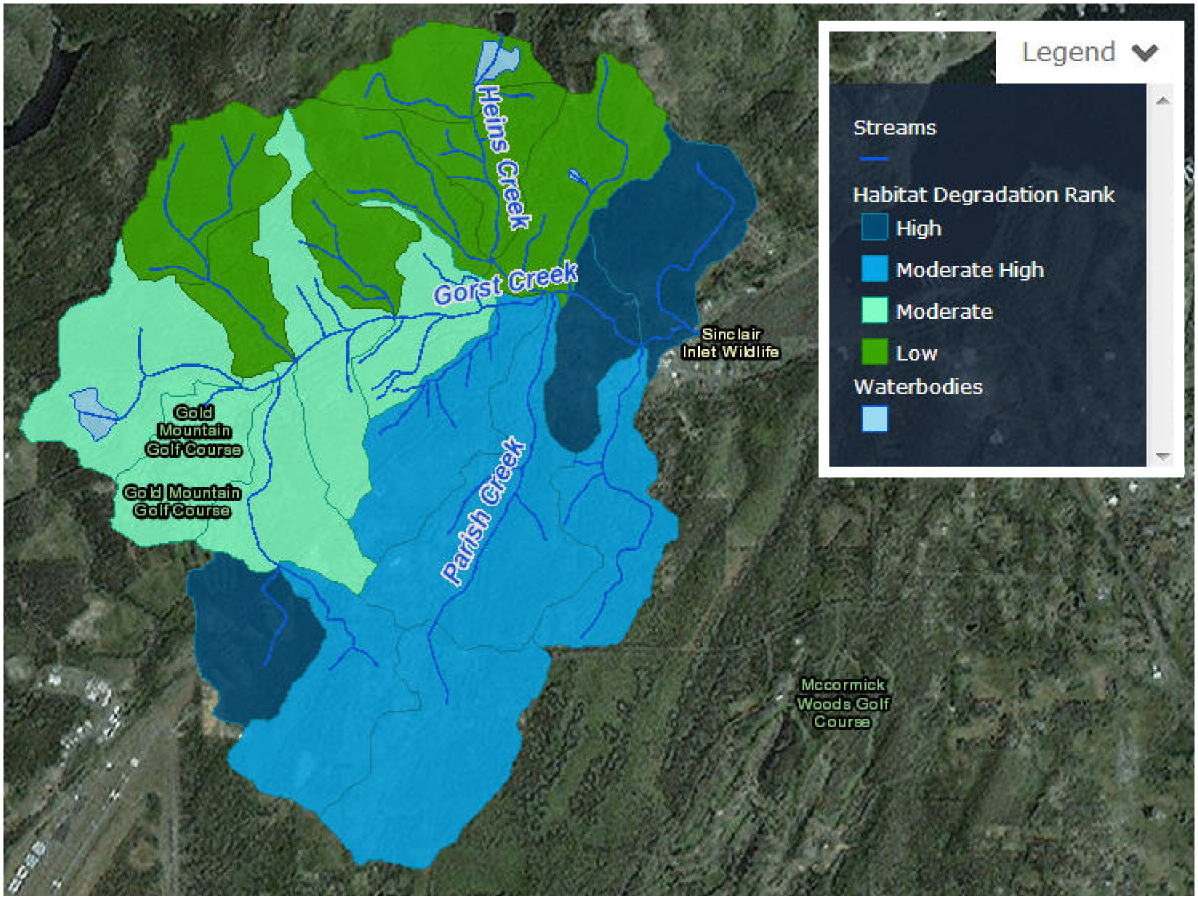
Relative habitat value in the Gorst Creek Watershed can be summarized as follows:

- Headwater AUs in the northern watershed have the **highest local habitat values (dark green)**,
- AUs immediately adjacent to the southwest have a **moderate high local habitat value (light green),** and
- Southern and eastern AUs have a **low to moderate local habitat values (light and dark blue).**

The "protection" areas indicated by overall water flow results for the northern tributaries (yellow border) also have high local habitat scores. The southern and eastern AUs, which according to the water flow results are designated for a combination of development and restoration, have lower local habitat scores.

In contrast, several western-central AUs are designated as appropriate for more intense development by the water flow assessment. This is inconsistent with the local habitat assessment results, which show these AUs as scoring moderately high for local habitat value. Habitat-focused land use management strategies may be especially important if higher intensity uses occur here in the future.

Figure 24. Wildlife habitat values for the Gorst Watershed.



IV. Developing and Implementing Actions

Based on the integration of the assessment results, the City identified three main management zones and a preliminary lists of management actions for each:

Protection Zone (Green areas on Figure 6) – Areas key to recharge, discharge and storage processes for Gorst Greek, as well as significant habitat value. Future land uses should include measures to preserve forest cover and prevent conversion to non-forest uses.

The Protection Zone supports recharge, discharge and storage processes which are critical to sustaining a natural range of flows in Gorst Creek, including adequate low flows during summer and fall. The unique properties of the Gorst Creek recessional outwash deposits are a principal factor in this high rating for hydrologic importance. Because recharge and discharge processes are sensitive to development and would be significantly degraded by impervious surfaces, buildings, roads, and drainage infrastructure, such development should be restricted in this zone.

Restoration Zone (Yellow areas on Figure 6) –Primarily supports storage processes and some recharge/discharge processes. **This zone may be appropriate for development but different actions in areas A, B, and C should be subject to the following provisions:**

Area 2A: This area has moderate to moderate-high importance for storage and discharge and high importance for recharge. The delivery, recharge and discharge processes are degraded. Because of its location at the headwaters of Gorst Creek and importance for recharge, low intensity uses would be appropriate. This low intensity pattern is already set with the golf course, which likely has a lower impact upon recharge processes than higher intensity urban areas. However, restoration actions to improve recharge could be investigated, including infiltration swales or galleries adjacent to the lower permeability fairways and greens. For the discharge process, restoration measures would include re-establishment of the natural hydrology of depressional and slope wetlands. Accomplishing this restoration could involve plugging ditches that either drain these wetlands or re-aligning ditches that intercept upslope water away from wetlands (e.g., roads intercepting shallow groundwater flow), thereby altering water flow processes downstream. The delivery process could be improved through the re-establishment of additional forest cover.

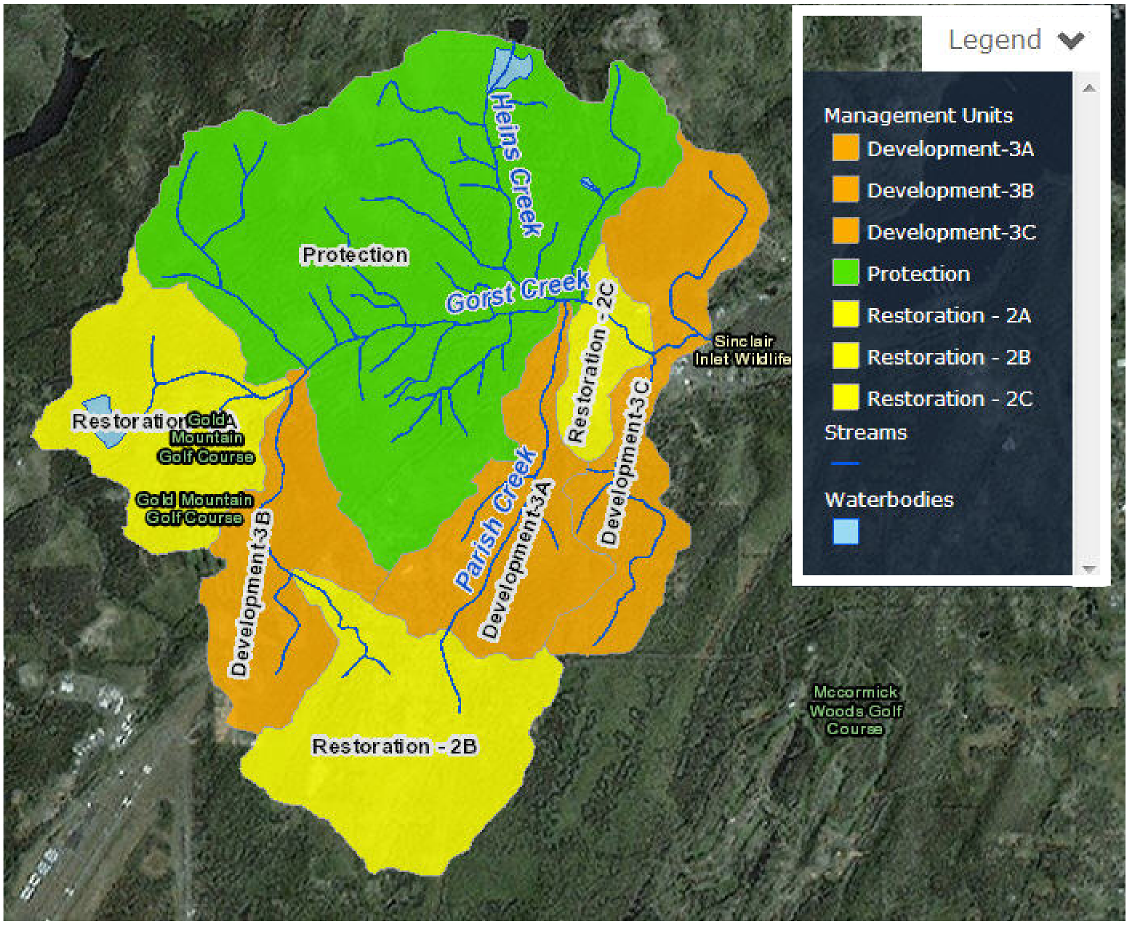
Area 2B: Restoration of storage processes is the highest priority for this area; recharge processes have lower importance due to the presence of till. Higher intensity development would be appropriate provided that storage processes are protected and restored. This effort would include re-establishing the natural hydrology of depressional wetlands by plugging ditches that drain them, removing fill and re-routing natural drainage patterns back into these depressional wetlands. In particular, protection and restoration of wetlands in the Parish Creek AU will protect the mid and lower portions of this watershed from erosion and sediment export.

Area 2C: Located in the lower portion of the watershed, this area is important for its recharge and discharge processes. Given that this area is already developed with urban uses, restoration may be limited to stormwater retrofit actions. However, restoration of in-stream alterations (removal of channel armoring, berms) and re-establishment of natural stream structure (i.e., reducing channelization in the lower reaches of the stream) may be appropriate given that upstream processes for the northern half of the watershed are relatively intact.

Development Zone (Orange areas on Figure 6). Suited for the highest intensity development (such as high density residential or commercial) **provided appropriate measures for protecting streams, wetlands, and water quality are followed**, including those for area 3A and 3B below.

Area 3A: The sediment model indicated that this AU had a high potential for export of sediment which would argue for protecting this area. However, the water-flow assessment shows this area as appropriate for higher intensity development, leading to an integrated measures that would reduce erosion and sediment export through clustering of development, adequate setbacks from steep slopes, restoration of suitable buffers, control of runoff through LID techniques and planting of cover designed to slow and infiltrate overland flows.

Figure 25. Targeted management strategies for different landscape positions within Mukilteo.



Area 3B: The sediment model indicated that this AU had a moderate potential for export of sediment. This area is shown as appropriate for higher intensity development for both the delivery, and surface storage subcomponent models for water flow, although the corridor along Gorst Creek is shown as important for conservation for restoring and protecting surface storage, while the headwaters are shown as important for wetland restoration to protect the surface storage function. This area may be able to accommodate higher intensity development provided that the stream corridor is restored and maintained within the current landfill, development is clustered, and adequate setbacks from steep slopes, appropriately sized buffers, and runoff control as noted in Area 3A are followed.

VI. Additional Resources

City of Bremerton. 2013. Gorst Watershed Planning Website. Available: http://www.ci.bremerton.wa.us/gorstwatershed/

City of Bremerton. 2012. Gorst Creek Watershed Characterization Report. Washington Department of Ecology and the Washington Department of Fish and Wildlife in collaboration with Parametrix, Bellevue, Washington. May 2012. Available through the City Website

Puget Sound Watershed Characterization Case Study

How the Hood Canal Coordinating Council is using watershed characterization data to find mitigation sites for the In Lieu Fee (ILF) mitigation program

The Puget Sound Watershed Characterization Project is a set of spatially explicit water and habitat assessments that compare areas within a watershed in terms of their relative value for restoration and protection and helps identity the best locations for new development. The Characterization is a coarse-scale assessment that assists in identifying two fundamental questions:

(1) ***where on the landscape*** should management efforts be focused first, be they actions for planning (e.g., protection or additional development) or mitigation (e.g., restoration); and
(2) ***what types of activities and actions*** are most appropriate to that place, be they restoration, protection, conservation, or development?

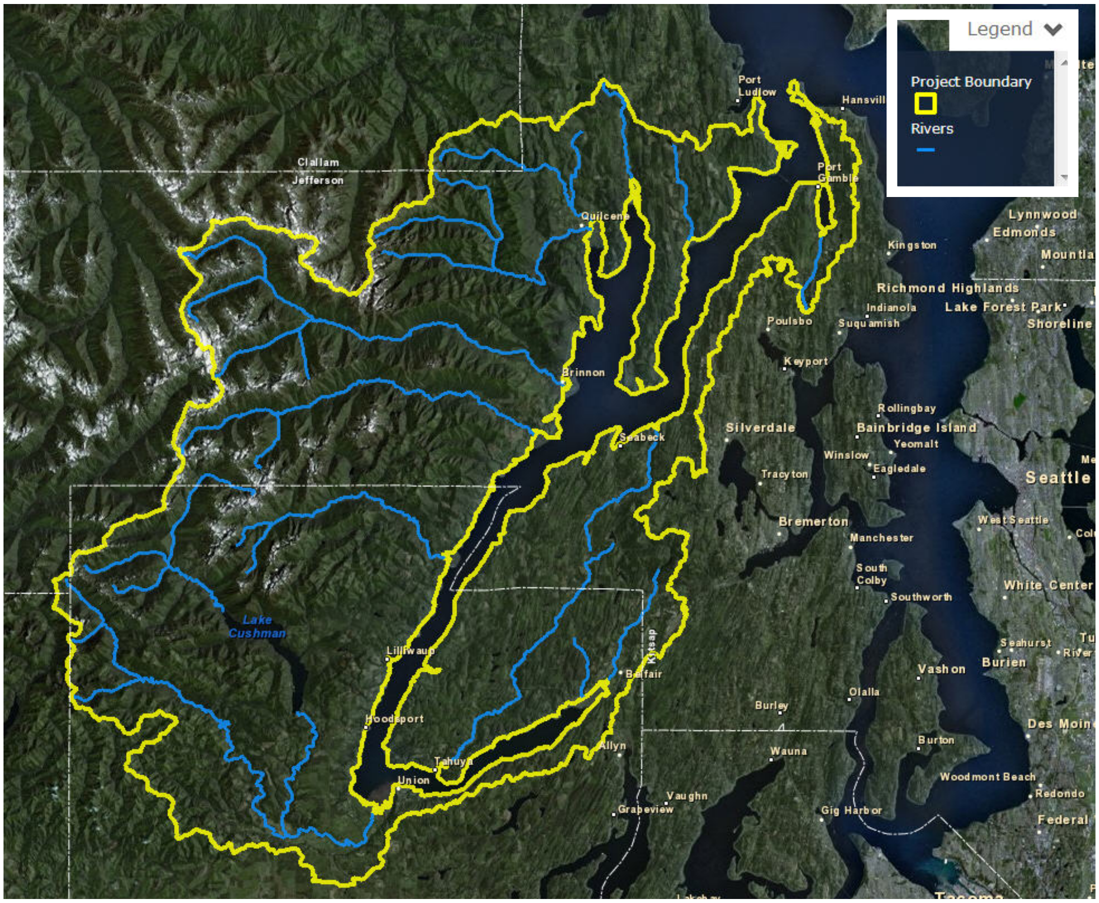
It is not intended for site-specific application or decision-making at the site scale, including the design of mitigation or restoration projects; finer scale data will be needed for these decisions. This Case Study should only be used as an illustrative example for how to interpret and apply information from the Characterization.

I. Identifying the Issue

The Hood Canal Coordinating Council (HCCC) is developing an “In-Lieu Fee” (ILF) mitigation program (HCCC ILF Program) to provide compensatory mitigation opportunities for unavoidable impacts to wetlands, streams, or marine/nearshore habitats in the Hood Canal drainages of Kitsap, Jefferson, and Mason counties, within the Programs service area (Figure 1). Federal rules define an ILF Program as “a program involving the restoration, establishment, enhancement, and/or preservation of aquatic resources through funds paid to a governmental or non-profit natural resources management entity to satisfy compensatory mitigation requirements.” Additional information can be found in Ecology’s *Guidance on In-Lieu Fee Mitigation*.

Similar to a mitigation bank, an ILF Program can sell mitigation credits to permittees whose obligation to provide compensatory mitigation is then transferred to the ILF Program sponsor. Regulatory agencies determine which projects and impacts qualify for the Program. An ILF Program does not necessarily satisfy all federal, state or local permit requirements, but can be a useful tool especially for meeting obligations under section 404 of the Clean Water Act.

Figure 26. The Hood Canal watershed, including drainages of Kitsap, Jefferson, and Mason counties that make up the HCCC ILF Programs service area (yellow outline is the Hood Canal watershed).



As with voluntary restoration actions, watershed-based planning and prioritization can maximize the benefit of compensatory mitigation actions. This case study shows how the characterization data can be used to find restoration areas that are also potentially suitable mitigation receiving areas – where mitigation actions could help restore watershed processes and improve freshwater and nearshore habitats.

As a key aspect of establishing the ILF Program, the HCCC has to determine: ***What are the top priority areas for restoration within the Hood Canal watershed? Which of these areas would make suitable mitigation receiving sites? Which watershed processes would benefit from restoration actions in prioritized areas?***

II. Gathering Watershed Based Information

Understanding the Assessment Scale

The HCCC ILF Program encompasses the entire Hood Canal drainage, which includes four Water Resource Inventory Areas (WRIAs) made up of 285 Assessment Units (AUs). The four WRIAs include:

- WRIA 14b: South Shore Lower Hood Canal
- WRIA 15: Kitsap

- WRIA 16: Skokomish / Dosewallips
- WRIA 17: Quilcene / Snow

The Program also includes the intertidal and shallow sub-tidal marine waters of Hood Canal.

The HCCC ILF Program mitigation projects must be located as close as possible to the impact site, within the same sub-basin whenever feasible, and always within the same WRIA; as such, HCCC is using the Watershed Characterization assessment results to identify the highest priority mitigation receiving areas within the respective WRIAs. Ecology has re-run the Puget Sound Watershed Characterization model specifically for the HCCC ILF Program service area to normalize the results for the portions of WRIAs 15, 16/14b, 17 that are within the program service areas. This allows for comparisons across WRIA boundaries within the service area[5]. Additionally, within each WRIA, AUs are grouped into Watershed Management Units (WMUs). Evaluation of the individual AUs within the context of the WMU as a whole provides an understanding of the integrity of processes within that smaller watershed (see Volume 3, watershed integrity section). A watershed with "greater integrity" is more likely to have success (e.g. meet stated goals and are sustained over time) with proposed restoration actions. Therefore, watershed integrity helps further in identifying the best location for restoration actions

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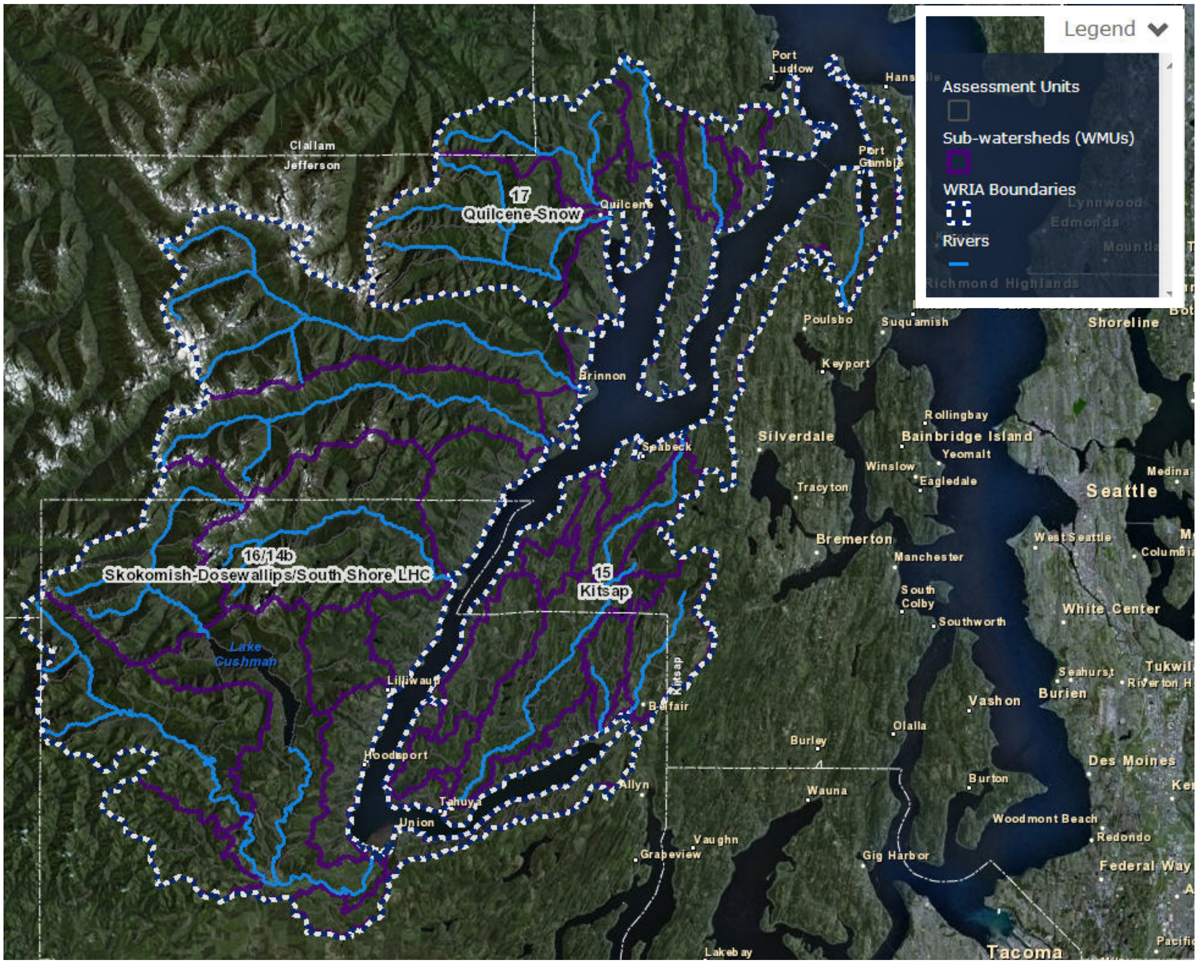
[5] The characterization results for Puget Sound were normalized for only those AUs within their respective WRIAs. This was done because processes driving ecological functions are usually integral to individual WRIAs and thus comparison across WRIAs of results is not always appropriate. However, in the case of the HCCC in-lieu fee program the organizing unit became Hood Canal and identifying the most important restoration areas within watershed draining to it be was the central question to be addressed relative to the health of the Canal. Thus, depending on the planning issue at hand and questions being asked, the boundaries of assessment area can be changed and the characterizatiton model re-run for that area.

Figure 27. The Hood Canal watershed with WRIA, watershed management unit (WMU) and assessment unit (AU) boundaries.



In addition, the Programs service area includes the marine/nearshore waters of Hood Canal that are separately prioritized by the Watershed Characterization model – for more information on how the Puget Sound Watershed Characterization is being used for this effort, please see story map slides on *Finding Priority Areas for Nearshore Mitigation*.

Overall Water Flow Assessment Results

The HCCC is primarily using water flow and freshwater habitat assessment model results to identify priority mitigation receiving areas that are potentially suitable for mitigation actions that restore or maintain key ecosystem processes. For each AU, the Watershed Characterization provides overall results for Water Flow processes, which combines importance and degradation sub-model results for each of the following processes: delivery, surface storage, discharge, and recharge.

Importance represents the relative ability of an AU to contribute to key watershed hydrologic processes. **Degradation** brings human influence into the assessment model. The overall Water Flow model results highlight AUs that should be prioritized for restoration based on the importance of water flow processes and their existing level of degradation. The overall results also depict AUs that are most appropriate for restoration and protection.

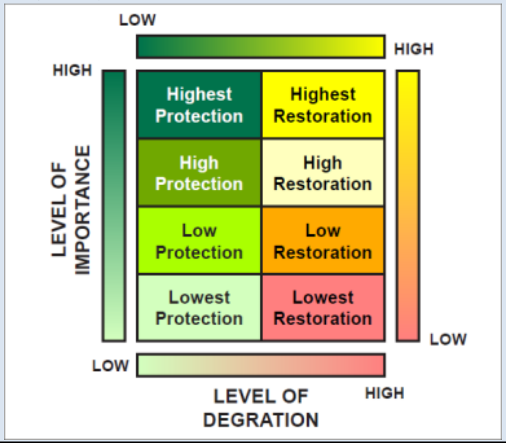
Understanding Water Flow Assessment Results: *Sub-model results are provided for four water flow processes:* ***delivery, surface storage, discharge, and recharge****. Sub-model results combine to produce an overall water flow result.*

AUs where protection is a higher priority (green): *These AUs rate relatively high for importance and have a relatively low level of degradation. Based on model results, these are areas where water flow processes are both of highest importance and most intact.*

AUs where restoration is a priority (yellow): *These AUs have relatively high levels of both importance and degradation. Mitigation actions in restoration AUs will likely provide the most significant benefit to water flow processes and help sustain down gradient aquatic ecosystem.*

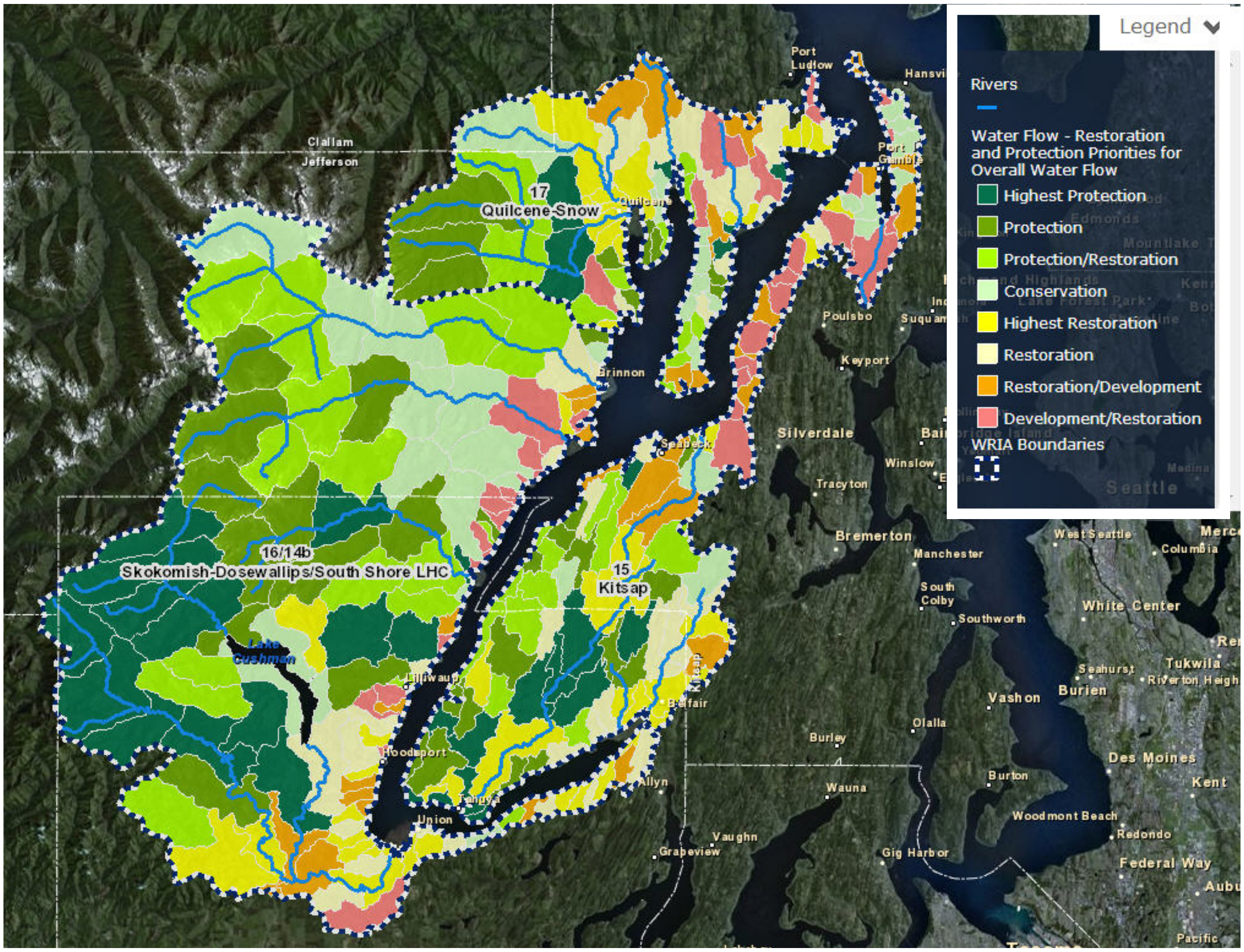
AUs where protection is a lower priority (light green): *These AUs have relatively low importance and degradation, so any proposed land use should minimize impacts to water flow processes.*

AUs that are lower priority for restoration (red): *These AUs have less importance to water flow processes and higher levels of existing degradation, indicating further development may result in relatively limited impacts to water flow processes.*



Assessment units in the upper potions of the Hood Canal WRIAs are typically priorities for protection (green shaded AUs) because, in terms of water flow processes, they have high importance and low degradation (Figure 3). The lower WRIA AUs are also of high importance; but tend to show higher levels of degradation (yellow shaded AUs). Locating mitigation projects in high restoration priority AUs can help repair and improve degraded processes and may be more likely to provide substantial ecological lift.

Figure 28. Overall results for Water Flow processes across the Hood Canal watershed.



To illustrate how the HCCC ILF Program is using the Puget Sound Watershed Characterization at the AU scale, it is helpful to focus on a specific basin with AUs prioritized relatively high for restoration by the overall water flow assessment. The Tahuya River is the largest river on the Tahuya Peninsula in WRIA 15 and drains approximately 45 square miles of land. The mainstem measures roughly 32 miles long and tributaries account for an additional 65 miles. The headwaters of the river are at Tin Mine Creek, Gold Creek and wetlands; the river drains to The Great Bend of Hood Canal. The Tahuya River drainage basin has been extensively modified in the past. Some of the process modifications include:

- Timber harvest in the watershed;
- Residential development adjacent to drainages;
- Culverts and other structures that alter flow regime; and
- Channelization and bank armoring.

For this analysis, the landscape of the Tahuya River is generally divided into the lower, middle, and upper watershed. Each is made up of one to three AUs, with breaks determined based on landscape position and Watershed Characterization model results.

Water Flow Sub-Models: The overall Water Flow results designate the lower and upper watershed yellow (highest restoration priority), while the middle AUs are green (highest protection priority); see Table 1.

Table 6. **Tahuya River Watershed Management Unit - AU identification and water flow assessment prioritization category.**

Watershed	Prioritization Category	Assessment Unit ID
Lower Tahuya River	Highest Restoration (R, R1)	15100
Middle Tahuya River	Highest Protection (P1, P1R)	15095, 15084, 15076
Upper Tahuya River	Highest Restoration (R, R1)	15067, 15055, 15001

Overall water flow results indicate that all Tahuya River AUs are important for one or more Water Flow sub-models; they also show the middle watershed generally has lower levels of Water Flow process degradation.

Freshwater Habitat Assessment Results

The freshwater habitat assessment results consist of three main components: hydrogeomorphic features, local salmonid habitats, and accumulative downstream salmonid habitats. Assessment units with high relative conservation value contain extensive wetlands and undeveloped floodplains, relatively high quality and quantity of salmonid habitats within the AU, and/or relatively high quality and quantity of salmonid habitats downstream from the AU. The assessment provides two indices: a summation of the three components and the maximum of the three components[6].

For this case study, the three components were summed to result in the freshwater habitat conservation score, which ranges from 1 to 10 (the range was normalized from an original 1 to -30 scale), with 10 being the highest score (value). Freshwater habitat model results show that AUs associated with some the major drainages located within the HCCC ILF Program service area, or in close proximity to them, generally have the highest freshwater habitat conservation scores (consistent with salmonid stream use mapping), while AUs located along the Hood Canal shoreline and those located in the mountainous upper watersheds of Jefferson and Mason counties typically have lower freshwater habitat conservation scores.

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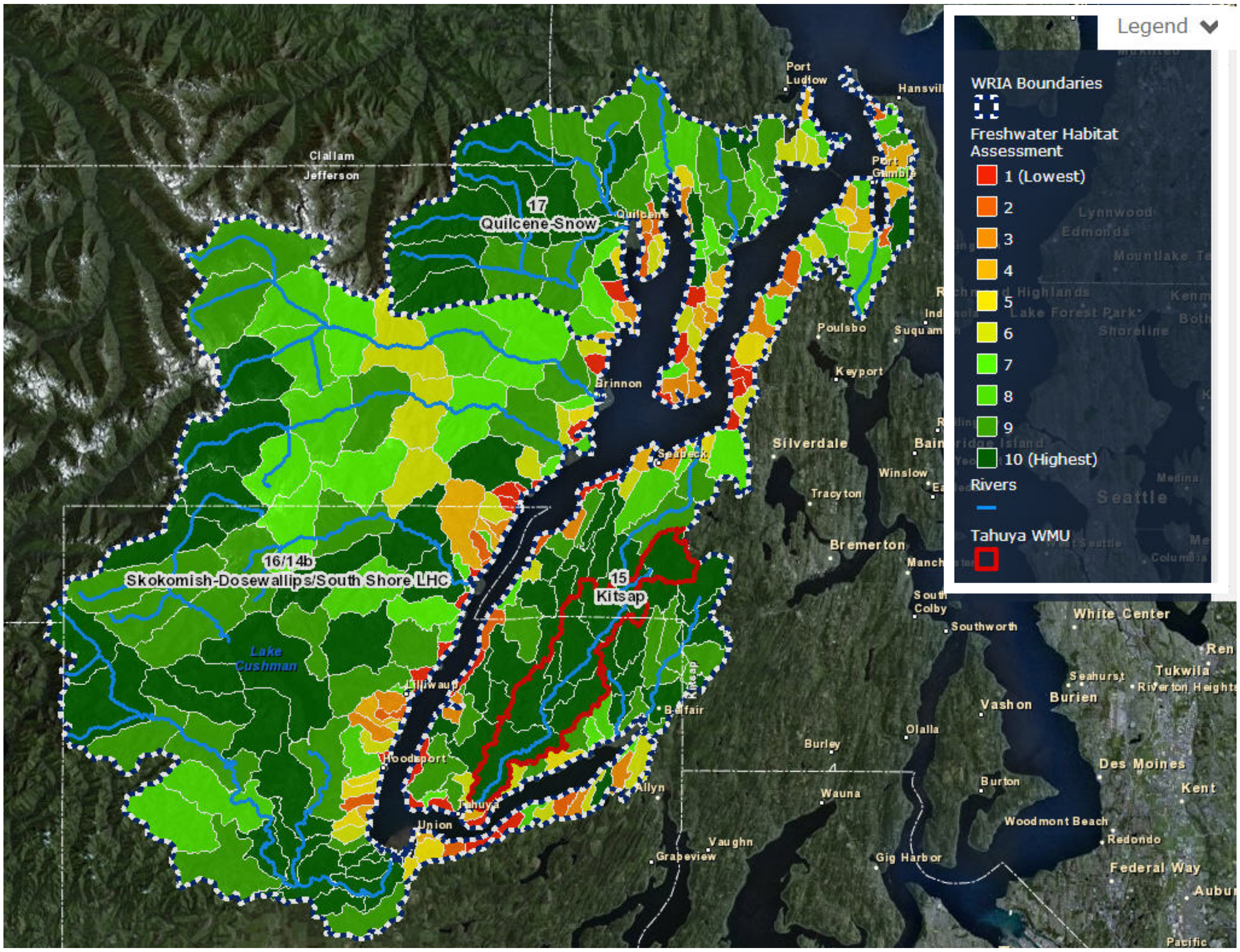
[6] The HCCC ILF Program case study analyzed the sum of the three components, while the story map presents the maximum of the three components.

Figure 29. Overall results for freshwater habitat conservation value across the Hood Canal watershed (Tahuya River WMU outlined by red polygon).



Overlaying the results of the water flow assessment with freshwater (fish) habitat assessment results can help refine the identification of potential mitigation receiving areas. Review of overall Water Flow results identifies many of the same AUs prioritized for Restoration (relatively high importance and degraded) by the water flow assessment are also assigned high freshwater habitat conservation scores.

Freshwater Habitat model results for the Tahuya River WMU indicate all AUs were assigned relatively high freshwater habitat conservation scores (≥7-10, with 10 equal to the highest value); the middle and upper portions of the WMU were scored higher than the lower portions. The middle and upper areas contain extensive depressional wetlands and undeveloped floodplains, relatively high quality and quantity of salmonid habitats within the AU, and/or relatively high quality and quantity of salmonid habitats downstream from the AU. The lower portion of the WMU has had one or more of these features/habitats degraded to a limited extent.

III. Integrating and Applying Other Assessment Results

Water Flow Sub-Model Results

To understand why some AUs are rated as high priorities for restoration of water flow processes, it helps to view the sub-model results for delivery, surface storage and discharge/recharge.

Water Flow sub-model results can be used to better inform appropriate mitigation actions. A summary of water flow processes and potential mitigation goals for the Tahuya River WMU are presented below and in Table 2. As a first step, it is advisable to view the submodel results "side by side" and identify what appears to be the "limiting" issue in the watershed. Table 2 indicates that surface storage has both the highest importance and greatest degree of degradation (i.e. dark yellow) throughout the watershed, which suggests that management actions for restoring surface storage processes are a priority. On the other hand, recharge processes are the least affected throughout the watershed with restoration efforts primarily needed in the upper watershed.

The overall results (column 1 of table 2) can also be used to understand the overall integrity of processes witin a WMU (see volume 3, section of watershed integrity). Watersheds with greater watershed integrity have a greater potential for supporting and maintaining ecological functions. Furthermore, watersheds that have more intact upper watersheds (green colors - less degradation) have a higher degree of integrity. Given that the upper watershed is shown in the overall results as having both a high degree of importance and degradation, suggests that it is the first area to undertake restoration actions, with restoration of storage being the priority.

- **Delivery:** Generally, all parts of the WMU are important for delivery; these areas receive approximately 70 inches of rain a year contributing significant quantities of water to the drainage system. Here again, development and forest loss, due to timber harvest, have impacted the lower and upper portions of the WMU most significantly, suggesting mitigation actions should attempt to remove impervious surfaces and reforest cleared lands. Of note, delivery processes in one AU, ID 15001, were rated Restoration with Development (RD1, RD2), likely due to the relatively low water flow contribution from the AU.

- **Surface Storage:** Results for this sub-model are similar to that of the overall Water Flow assessment, with the lower and upper portions of the WMU rated Highest Restoration (R, R1). Priority and the middle portion of the WMU rated Highest Protection (P1, P1R). This suggests the WMU has extensive areas of depressional wetlands and lakes and/or floodplain storage. The difference between the lower/upper portions of the WMU and that of the middle portion of the WMU results from greater degradation in the lower/upper portions of the WMU due to development (upper and lower) and timber harvest (upper section). The middle portion of the WMU has also been impacted by timber harvest, but to a lesser extent. Mitigation actions in the lower and upper portions of the WMU should focus on providing more areas for surface water storage; this could include wetland restoration or creation, floodplain rehabilitation, reconnecting or creating side channel habitats, and/or setting back informal levees.

- **Recharge and Discharge**: The Tahuya River WMU contains a patchwork of AUs prioritized for protection of recharge and discharge processes, with some restoration priority AUs located in the lower and upper portions of the WMU. These results indicate high importance for recharge and discharge, with generally low degradation, particularly in the middle portion of the WMU;

however, moderately-high degradation to discharge processes has occurred in the lower and upper portions of the WMU (restoration priority AUs). Degradation to recharge occurrs primarily in the upper watershed . This suggests mitigation actions should focus on acquisition of land in the middle portion of the WMU in order to protect these processes, while addressing impacts to discharge processes by reducing road and water well densities in the lower and upper portions of the WMU as well as mitigating for floodplain and slope wetland impacts in these areas.

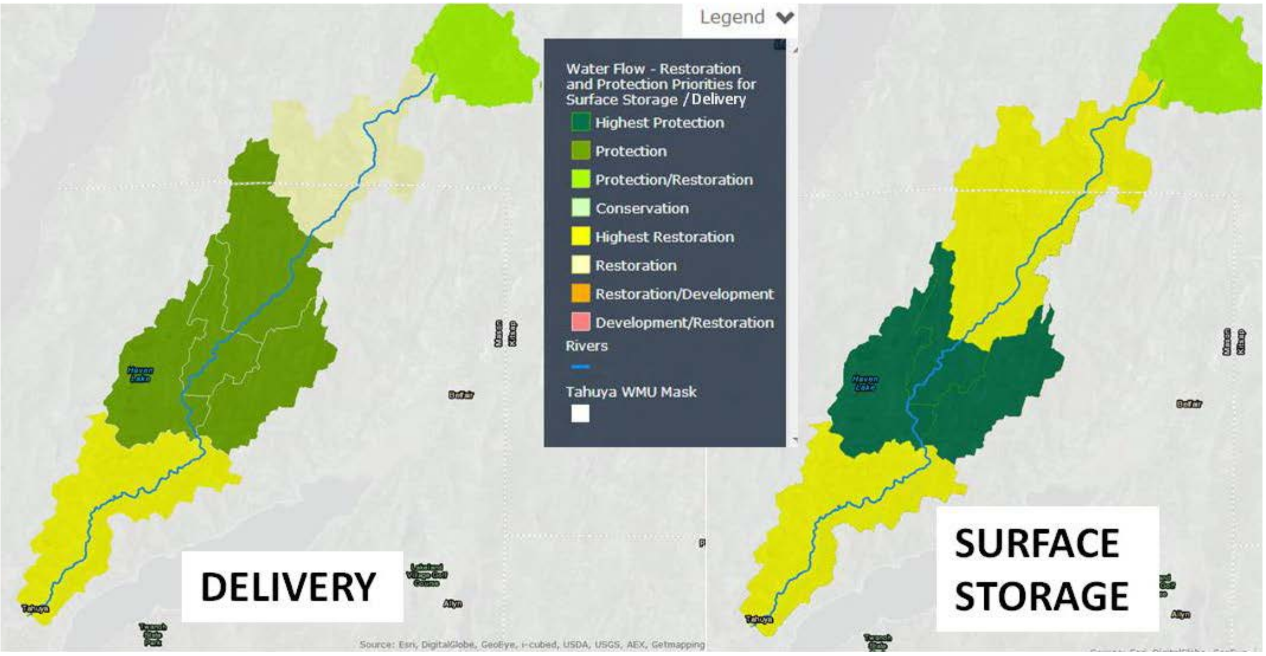
Table 7. Tahuya River WMU: Assessment Unit Prioritization for Water Flow Sub-model Results

Assessment Unit*	Delivery	Surface Storage	Discharge	Recharge
Lower Tahuya River				
15100	R, R1	R, R1	R, R1	P1, P1R
Middle Tahuya River				
15095	P2, P2R	P1, P1R	P3, P3R	P2, P2R
15084	P2, P2R	P1, P1R	P2, P2R	P1, P1R
15076	P2, P2R	R, R1	P3, P3R	P1, P1R
Upper Tahuya River				
15067	R2, R3	R, R1	P1, P1R	P2, P2R
15055	R2, R3	R, R1		R, R1
15001	RD1, RD2	R, R1	R, R1	R2, R3

* All assessment units are part of the lowland landscape group.
R, R1=Highest Restoration Priority
R2, R3=High Restoration Priority
P1, P1R=Highest Protection Priority
P2, P2R=Higher Protection Priority
P3, P3R=Low Protection Priority
RD1, RD2=Low Restoration Priority

For the Tahuya River WMU, water flow processes are generally important throughout the watershed, with most degradation occurring in the lower and upper AUs (Figure 5). For these lower and upper areas, mitigation should be prioritized

Figure 30. Delivery and surface storage results within the Tahuya River WMU.



Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping with mitigation focusing first on surface restoring storage processes in the upper watershed and subsequently in lower AUs of the Tahuya River WMU . This could include mitigation that increases the area and/or function of wetlands (through rehabilitation, re-establishment or enhancement). Restoration of recharge/discharge and delivery processes should be considered next, including restoration of forest lands, removal of impervious surfaces and increase in infiltration in existing and new development through LID measures. Provided upper watershed processes are restored over time, and relatively intact water flow conditions are maintained in the the middle portion of the WMU (green AUs), then mitigation actions in the lower watershed should have a higher likelihood for success. Locating mitigation receiving areas in AUs downstream of AUs with intact processes improves the chances that site- or reach-scale restoration will be successful.

Refining and Informing Results with Finer-scale, Local Information

After results from the Watershed Characterization have been used as an initial filter to identify mitigation receiving areas where projects could be located, additional, higher resolution data about watershed conditions (e.g., riparian cover) can be analyzed to determine which mitigation actions might have the greatest benefits in high restoration priority AUs. When used in combination with Ecology and WDFW Watershed Characterization results and verified by fieldwork, finer scaled data sets such as this can identify site- and reach-scale conditions and inform the selection of management actions that would have the greatest ecological benefits.

Assessment Data and Riparian Inventory: The lower Tahuya River AU is rated as a priority restoration area for water flow processes and is also considered to have high value freshwater habitat. Riparian cover was assessed and mapped in this area by the Point No Point Treaty Council; unlike Watershed Characterization data, this riparian data set was not designed to "prioritize" restoration areas (Figure 6). This riparian land cover data set shows that some portions of the river corridor lack dense riparian cover. Re-vegetation of these riparian areas could have beneficial effects on water flow processes and could improve in-stream habitat for fish by providing shade and organic inputs, including large woody debris. Pairing finer scaled information with characterization results and field verification can help inform the selection of mitigation actions within a given AU.

Figure 31. Riparian cover condition for the lower Tahuya River AU (ID 15100).

IV. Developing and Implementing Actions

Watershed characterization model results suggest that mitigation activities targeting the lower and upper Tahuya River WMU have high potential to significantly improve water flow processes (delivery, surface storage, discharge, and recharge) in addition to habitat that supports freshwater and anadromous fish.

What Management Actions are Appropriate for Mitigation Receiving Areas?

Consideration of Upstream Conditions

In addition to Watershed Characterization results, other factors should be considered in the selection and prioritization of priority AUs and potential mitigation projects. The influence of upstream conditions on a particular AU can be significant. If upstream AUs are highly degraded, downstream mitigation actions may be less successful compared to where the upstream areas have more intact water flow processes and functions. Intact processes in the upper AUs improve the chances that site- or reach-scale restoration in lower AUs will be successful.

Similarly, implementation of mitigation actions within a particular AU will likely have ecological effects (improvement or otherwise) on downstream AUs. The potential ecological lift generated from mitigation actions higher in the watershed may be important in situations where mitigation actions are occurring or are planned lower in the watershed. Therefore these considerations are important for prioritized

AUs in the upper Tahuya River WMU, as well as numerous locations within the HCCC ILF Program service area where upstream mitigation actions will likely improve the success and potential ecological lift of downstream mitigation actions, whether they are underway or planned for the future.

Directly upstream of the lower Tahuya River AU (AU 15100), the middle AUs (IDs: 15095, 15084, and 15076) are rated as highest priorities for protection, indicating these units are of high water flow importance with limited degradation. Assessment units located in the upper portion of the WMU (AU IDs: 15067, 15055, 15001) are rated Highest Restoration (R, R1) signifying high importance and significant degradation; however, impacts to water flow processes in lower AU that stem from high degradation within these upstream AUs may be reduced due to the fact that the river flows through approximately 6 miles of Highest Protection (P1, P1R) Priority AUs before flowing through AU 15100.

Management Actions in the Tahuya River WMU

The lower and upper Tahuya River WMU are potentially well suited for mitigation activities that compensate for impacting projects that occur within the WRIA 15 portion of the HCCC ILF Program service area. Analysis of Watershed Characterization sub-model results highlights specific processes that could be targeted for mitigation (Figure 7).

The Watershed Characterization provides recommendations to support decision making for a variety of key management questions. It is important to make sure that identified management recommendations are relevant to the decisions being made. For example, management recommendations that prioritize mitigation receiving areas should focus on where restoration should occur and what types of restoration actions would have the most benefit. Ultimately, the HCCC ILF Program will identify distinct mitigation sites and actions that provide hydrologic, water quality, and habitat benefits; the following is a preliminary list of management objectives for the Tahuya River WMU.

Preliminary Management Objectives for the Upper Tahuya River WMU:

- Restore areas of surface storage, including depressional wetlands and floodplains.
- Restore, protect and maintain the physical integrity of stream and wetland riparian zones.
- Restore discharge areas, including slope wetlands and high perm floodplains.
- Reduce well density and total groundwater withdrawals.
- Revegetate/reforest and protect forest lands (through land acquisition) that are under threat of future development.
- Decommission and remove unneeded forest roads.

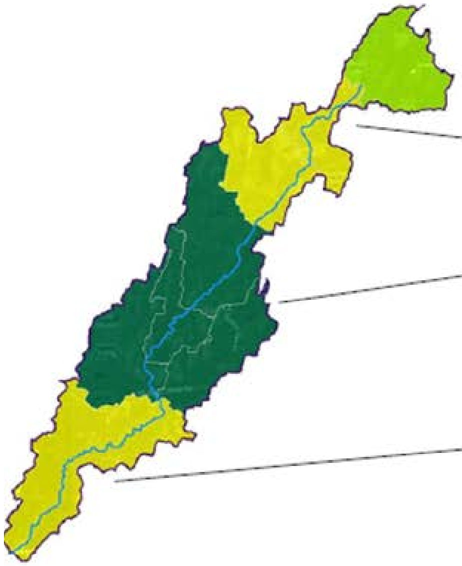
Preliminary Management Objectives for the Lower Tahuya River WMU:

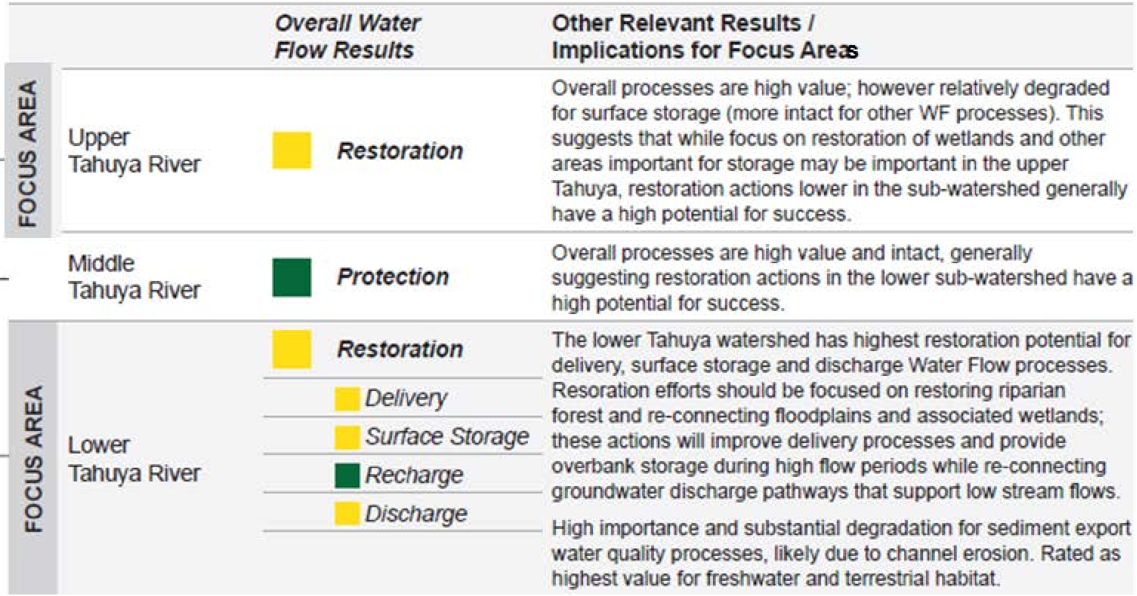
- Revegetate/reforest and protect forest lands (through land acquisition) that are under threat of future development.
- Restore discharge areas, including slope wetlands and high perm floodplains.
- Reduce drainage density of artificial channels.
- Reduce well density and total groundwater withdrawals.
- Restore degraded depressional wetlands, floodplains and/or associated wetlands (reconnect and restore tributary streams, restore side-channel forming processes, reduce channelization).

- Restore/replant riparian zones.

.

Figure 7. Mitigation receiving areas within the Tahuya River WMU.





		Overall Water Flow Results	**Other Relevant Results / Implications for Focus Areas**
FOCUS AREA	Upper Tahuya River	🟨 ***Restoration***	Overall processes are high value; however relatively degraded for surface storage (more intact for other WF processes). This suggests that while focus on restoration of wetlands and other areas important for storage may be important in the upper Tahuya, restoration actions lower in the sub-watershed generally have a high potential for success.
	Middle Tahuya River	🟩 ***Protection***	Overall processes are high value and intact, generally suggesting restoration actions in the lower sub-watershed have a high potential for success.
FOCUS AREA	Lower Tahuya River	🟨 ***Restoration*** 🟨 *Delivery* 🟨 *Surface Storage* 🟩 *Recharge* 🟨 *Discharge*	The lower Tahuya watershed has highest restoration potential for delivery, surface storage and discharge Water Flow processes. Resoration efforts should be focused on restoring riparian forest and re-connecting floodplains and associated wetlands; these actions will improve delivery processes and provide overbank storage during high flow periods while re-connecting groundwater discharge pathways that support low stream flows. High importance and substantial degradation for sediment export water quality processes, likely due to channel erosion. Rated as highest value for freshwater and terrestrial habitat.

Consideration of Existing Local Information

HCCC wants to connect their ILF mitigation efforts to other restoration efforts occurring in the Hood Canal ILF Program service area to supplement these mitigation projects or improve watershed processes in their vicinity.

Locating mitigation receiving areas where there are well-planned or ongoing restoration activities could allow HCCC to leverage watershed investments and make individual projects more sustainable and durable in the long term. The characterization data help assess whether clustering restoration activities in given area makes sense in terms of improving watershed processes.

VI. Additional Resources

Hood Canal Coordinating Council (HCCC). 2011. Hood Canal Coordinating Council (HCCC) In-Lieu Fee (ILF) Program. Available at: http://hccc.wa.gov/In+Lieu+Fee+Mitigation+Program/default.aspx. Accessed: December 2012.

Washington State Department of Ecology (Ecology). 2012. Puget Sound Watershed Characterization Project. Available at: http://www.ecy.wa.gov/puget_sound/characterization/index.html. Accessed: December 2012.

Washington State Department of Ecology (Ecology). 2012. Guidance on In-Lieu Fee Mitigation. Available at: https://fortress.wa.gov/ecy/publications/publications/1206012.pdf. Accessed: February 2013.

Puget Sound Watershed Characterization Case Study

Mukilteo Stormwater Management Strategies Plan

The Puget Sound Watershed Characterization Project (the Characterization) is a set of spatially explicit water and habitat assessments that compare areas within a watershed in terms of their relative value for restoration and protection and helps identity the best locations for new development. The Characterization is a coarse-scale assessment that assists in identifying two fundamental questions:

(1) ***where on the landscape*** should management efforts be focused first, be they actions for planning (e.g., protection or additional development) or mitigation (e.g., restoration); and
(2) ***what types of activities and actions*** are most appropriate to that place, be they restoration, protection, conservation, or development?

It is not intended for site-specific application or decision-making at the site scale, including the design of mitigation or restoration projects; finer scale data will be needed for these decisions. This Case Study should only be used as an illustrative example for how to interpret and apply information from the Characterization.

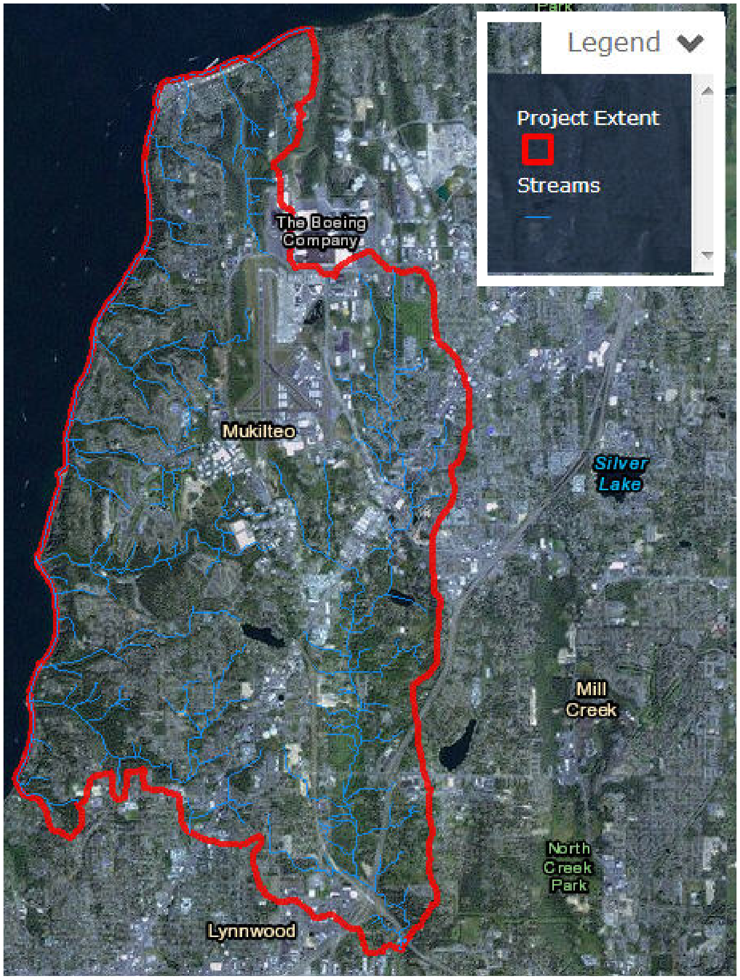
I. Identifying the Issue

The City of Mukilteo, like many urban and urbanizing Puget Sound area cities, is experiencing unnaturally high peak stream flows, erosion in ravines, low summer flows, and decreased water quality associated with increased levels of development, land clearing and impervious surfaces (Figure 1). To address these issues, the City and its project partners (the City of Everett, Paine Field and the Mukilteo School District) have developed a Stormwater Strategy Plan based on data and methods from the Watershed Characterization.

The Stormwater Strategy Plan identifies management strategies to protect and/or restore key watershed processes throughout the study area as well as prioritize opportunities to (1) advance off-site stream and wetland mitigation efforts, (2) identify land acquisition and (3) identify stormwater/low impact development (LID) retrofits consistent with the technical guidance in the 2012 Stormwater Management Manual for Western Washington (SWMMWW).

When thinking about restoring hydrologic processes, a key question for the City is: ***Which areas of the City would benefit most from investments in Low Impact Development, stormwater retrofit, stream and wetland mitigation projects, and/or property acquisition?***

Figure 32. The City of Mukilteo; numerous coastal watersheds drain directly to the Puget Sound, and the east side of the City is part of the upper Swamp Creek watershed (red outline is the project study area).



II. Gathering Watershed Based Information

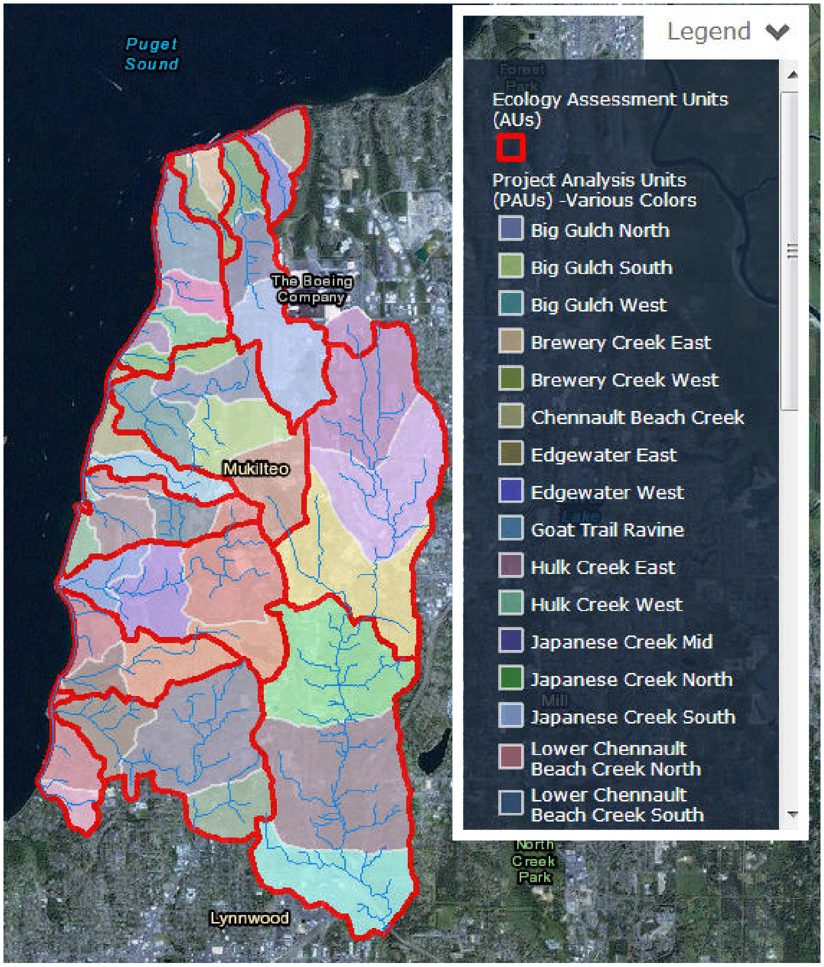
Understanding the Assessment Scale

The Mukilteo study area includes approximately 25.5 square miles and includes portions of the cities of Mukilteo and Everett, Snohomish County, Paine Field and portions of Edmonds and Lynnwood to the south. The northern portion of the study area is located in Watershed Resource Inventory Area (WRIA) 7: Snohomish and the southern portion is located in WRIA 8: Cedar Sammamish. Other than Swamp Creek, which is located in the eastern portion of the study area (part of WRIA 8), all these areas drain directly to Puget Sound.

The Characterization divides the study area into 13 Assessment Units (AUs). The City, however, wanted to compare watershed conditions across their jurisdiction at a more refined scale. For purposes of this analysis, Ecology subdivided these AUs into 38 Project Analysis Units (PAUs) using a combination of high resolution LiDAR digital elevation model (DEM), high resolution stream mapping, and stormwater infrastructure maps.

Mukilteo normalized the results of the watershed analysis relative to the study area only and not at the WRIA scale. That means each PAU is ranked and can be compared to other PAUs in the study area, but not to other AUs in the WRIA. At the WRIA scale, the scores for several watershed processes had little variation within the study area. Normalizing the scores at a finer scale resulted in somewhat more variation and allows for clearer distinctions across the study area.

Figure 33. Mukilteo study area Ecology assessment unit and project analysis unit boundaries.



Up Front Consideration of Local Conditions

In addition to identifying individual PAUs, the City understood that hydrologic conditions in Mukilteo are heavily dependent on the landscape position. The Characterization sorts AUs into three landscape types—mountain, lowland, and coastal—so that similar physiographic areas within the Puget Sound basin can be compared to each other. This is an adequate approach for many characterization efforts; however Mukilteo wanted to capture the range of landscape types present within the study area.

The City decided to evaluate plateaus, ravines, marine bluffs independently of each other, which will enable them to develop general management strategies tailored to these three landscape types.

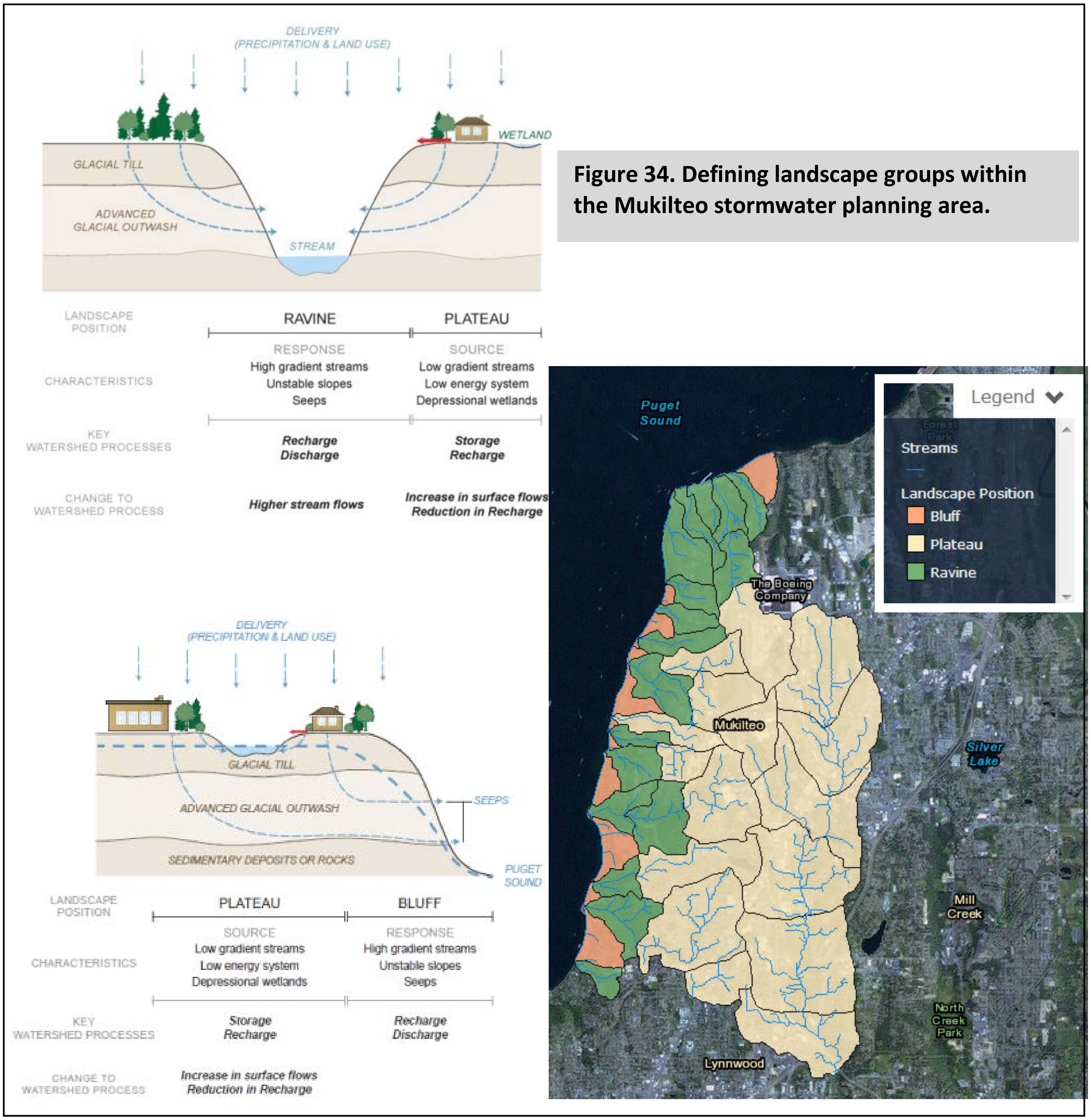


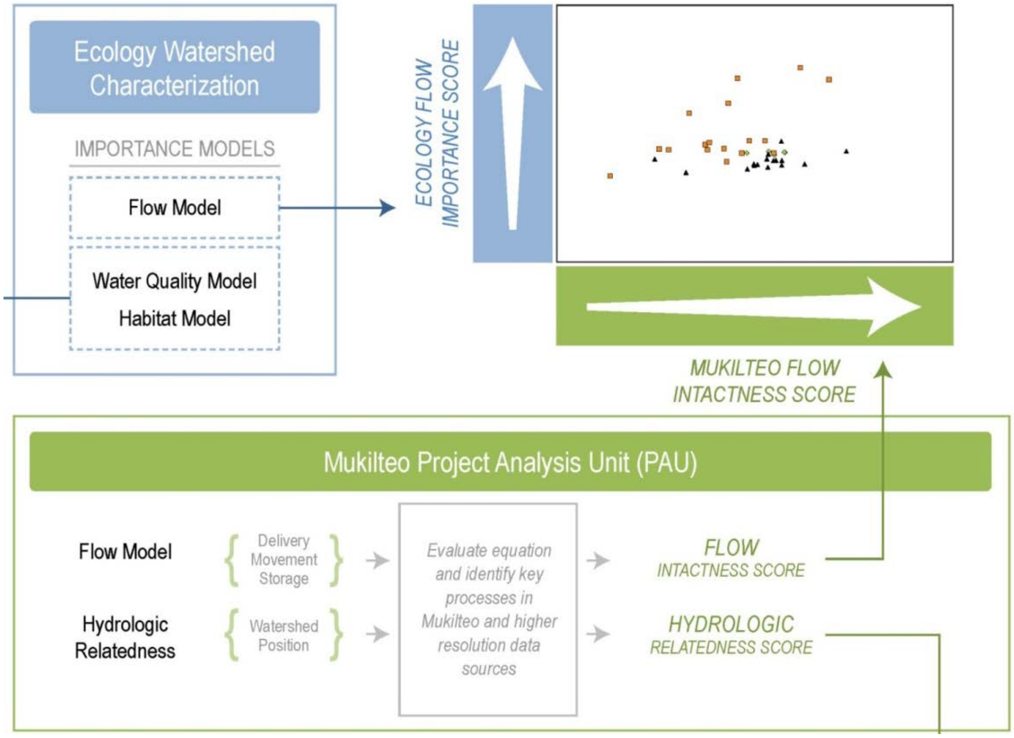
Figure 34. Defining landscape groups within the Mukilteo stormwater planning area.

Water Flow Assessment Results

The Characterization compares watersheds in terms of their priority for restoration, conservation, and protection. Each watershed is divided into AUs that are ranked based on their degree of importance and their level of degradation. The water flow model provides overall results that are the summary of the submodel results for delivery, surface storage, recharge, and discharge, which can also be analyzed individually.

Mukilteo used the water flow assessment importance scores (normalized relative to the study), and also developed a project-specific intactness score for water flow within the study area. The intactness score is essentially the inverse of the characterization's water flow degradation score (available for all AUs) — it assigns a higher score to PAUs that have lower levels of degradation to key water flow processes (Figure 4). The intactness score was developed using detailed stormwater infrastructure density and land use data available within the study area.

Figure 35. Mukilteo's approach to integrating water flow importance scores with project-specific assessment completed for each PAU.



The importance and intactness scores were integrated for each PAU to form the basis for prioritization and management categories (discussed later in this Story).

Relevant Sub-Model Results

Delivery

In general, there is little variation in the importance of delivery within the study area. This result is primarily due to the relatively uniform distribution of precipitation. However, the intactness of delivery processes, represented by impervious cover, does vary throughout the study area. PAUs within the study area range from 8 to 63 percent impervious cover and delivery processes are impaired to some extent within all of the PAUs. Most of the development is located in the plateau PAUs, which largely form the headwaters of the small stream systems.

Storage

Surface water storage processes are important primarily in the plateau landscape position (Figure 5). In general, PAUs in bluff and ravine landscape positions scored low for importance and intactness, which is expected because PAUs in this landscape position naturally do not have a high density of depressional wetlands. Although storage is an important process within plateau PAUs, most of these PAUs received low storage intactness scores due to high levels of development. The PAU that scored high relative to the study area included the golf course due to the high density of wetlands; it is unknown if this PAU represents an appropriate reference condition for undisturbed areas throughout the region.

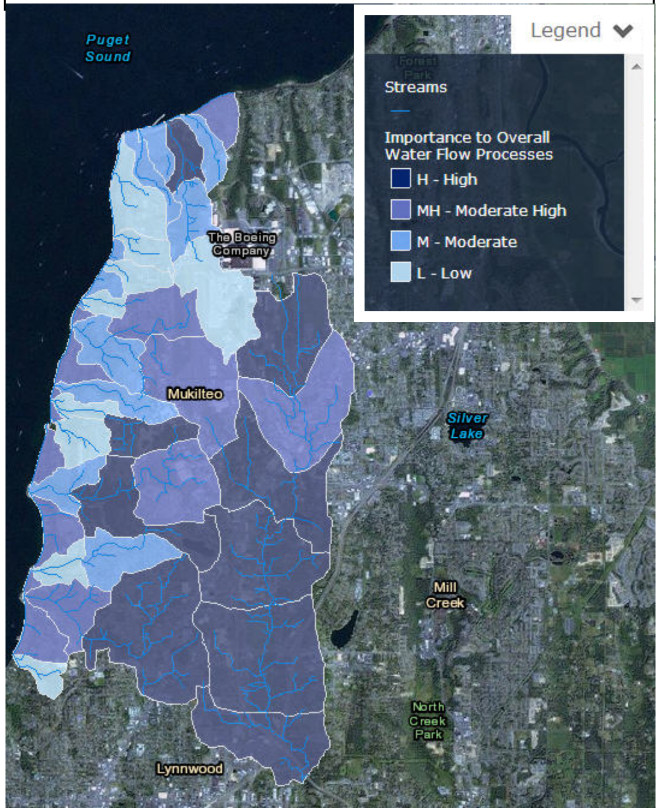
Discharge

According to the Characterization results, discharge is generally not an important process throughout the study area, except in a few plateau PAUs. This result is expected because the study area does not have extensive floodplains or areas where hydric soils are intercepted by slopes. The intactness of discharge process varies throughout the study area; and is lowest in PAUs with high levels of devlopement and surface water infrastructure.

Recharge

Although most of the study area is located on a low permeability plateau, recharge is an important process throughout the study area. Recharge is most important in the ravine and bluff landscape positions where advanced outwash deposits are exposed and is less important relative to other processes in the plateau PAUs. In addition, based on this analysis the recharge process is mostly intact, except for a few isolated plateau PAUs with very high levels of intense development.

Figure 36. Importance map for water flow surface storage.



III. Integrating and Applying Other Assessment Results

Integrating Water Quality, Freshwater (Fish) Habitat, and ‘Hydrologic Relatedness Results

Mukilteo developed an integrated score to quantify the importance of secondary processes within the study area. This score was developed to represent the importance of water quality, fish habitat, and hydrologic relatedness.

Water Quality (Sediment)

The water quality score used the results of Sediment Export Potential and Degradation model to indicate PAUs with a relatively higher risk for sediment export; which is a known problem throughout the study area. Given concerns about stream channel and bank erosion in Mukilteo, it is important to look at the water quality sub model results including the sediment export sub-model. The results show that PAUs in the ravine and bluff landscape positions have relatively high risk for sediment export.

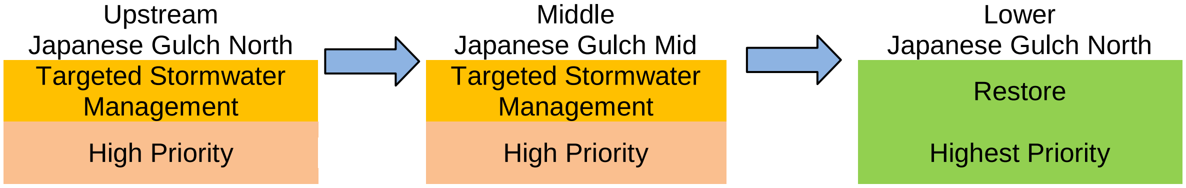
Habitat

In Mukilteo, each PAU also received a secondary score based on its habitat conditions. The integrated results for habitat show that larger watersheds have the highest value habitat and the smaller watersheds have lower value habitat. These scores prioritize PAUs with good in-stream habitat.

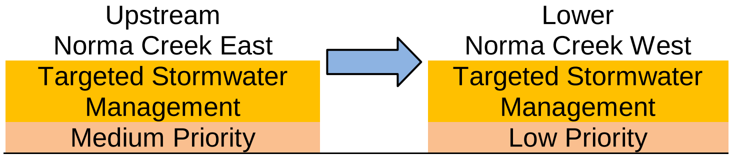
Hydrologic Relatedness

Mukilteo developed the hydrologic relatedness score to place a higher priority on PAUs located upstream of other resources.

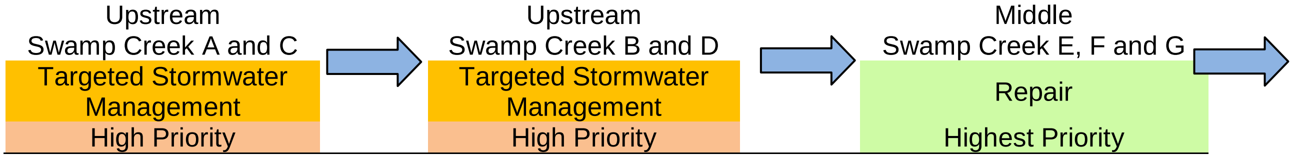
Japanese Gulch –Overall Results



Norma Creek–Overall Results



Swamp Creek –Overall Results

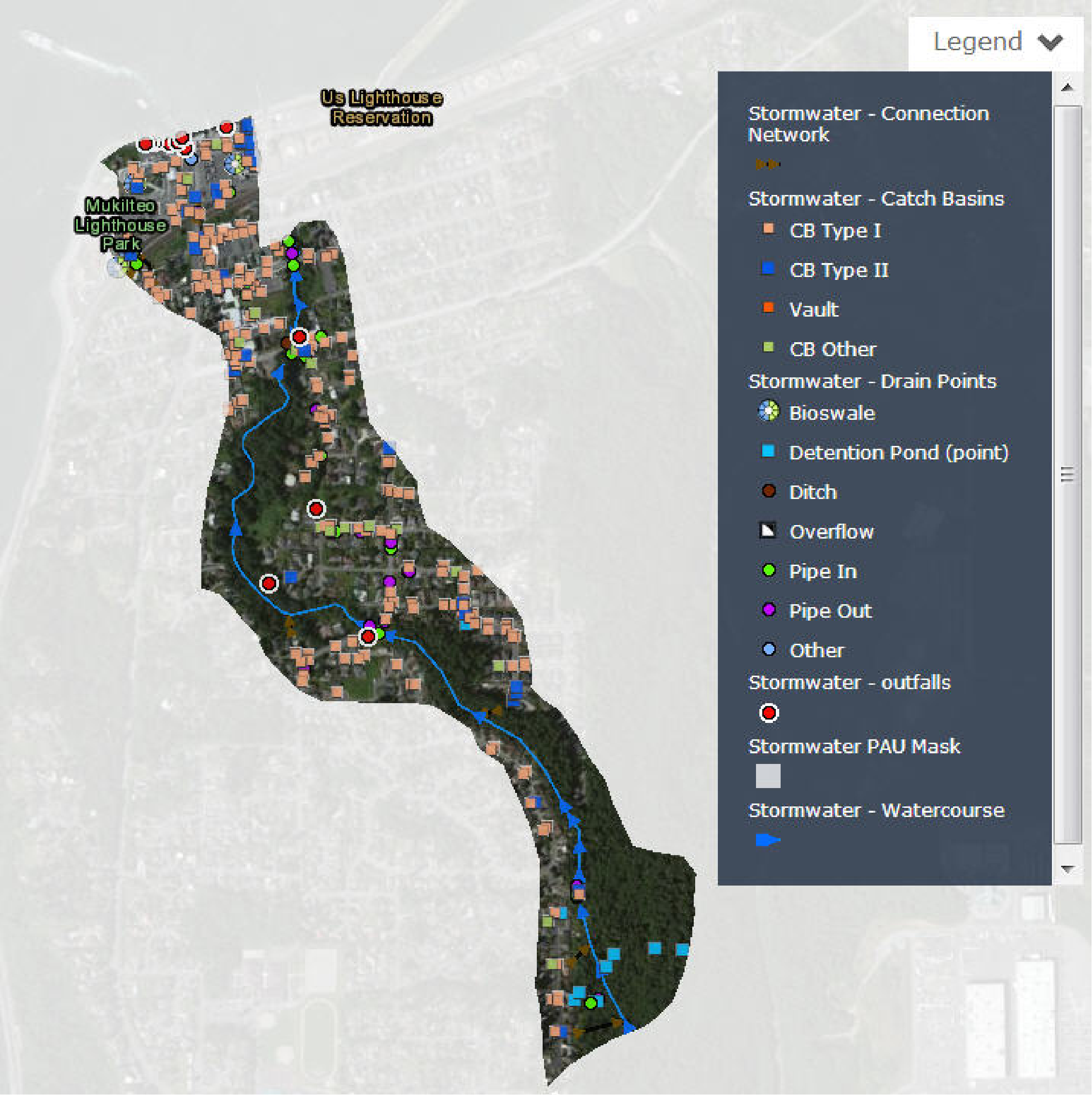


Refining and Informing Results with Finer-scale, Local Information

By using additional local information and data, the City is refining its understanding of watershed conditions and will be able to implement management strategies for specific projects within each PAU. For example, Mukilteo performed a detailed survey of the stormwater infrastructure system located within the city (Figure 6). They used the data to evaluate the intactness of discharge processes, and identify locations within the city with high effective impervious area.

During development and implementation of the stormwater plan, this detailed information will help the City to identify management actions consistent with the priority for each PAU.

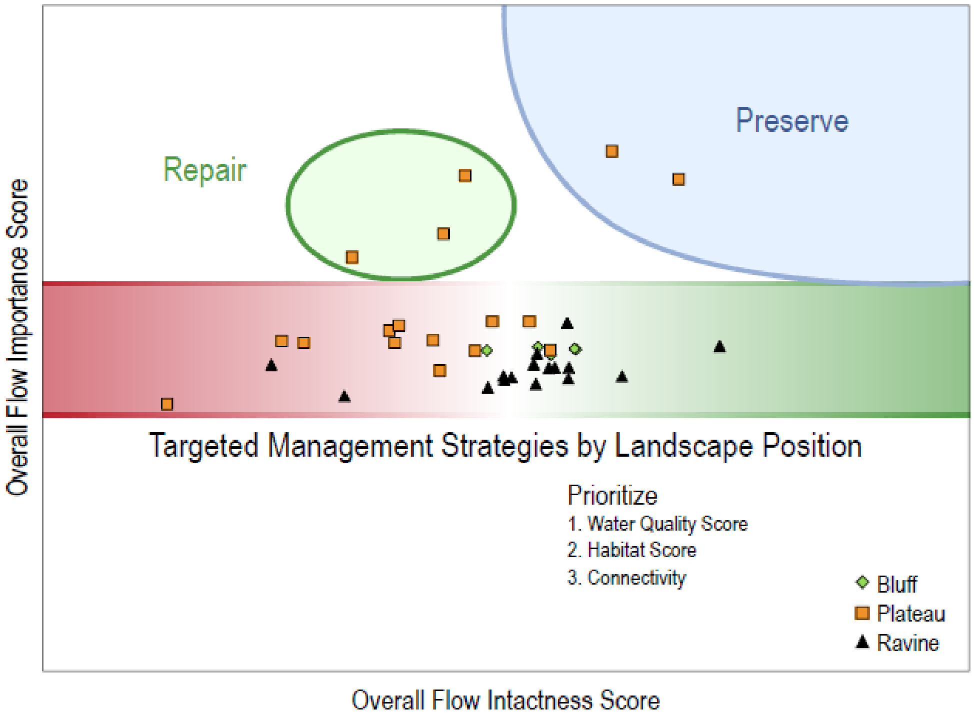
Figure 37. Stormwater infrastructure mapping in the northwest corner of Mukilteo.



IV. Developing and Implementing Actions

The overall flow importance and flow intactness scores were plotted. Most of the PAUs are located in the middle of the graph indicating relatively uniform overall importance. This result was expected because of the realtively uniform distribution of geology, soils, stream type, and PAU area. This analysis predicts more variation in overall intactness of flow proceses, with PAUs in ravines and bluffs generally scoring higher indicating that they are more intact.

Figure 38. Targeted management strategies for different landscape positions within Mukilteo.



Based on the results of this analysis, three distinct management strategies were identified:

- **Preserve**: PAUs with relatively high importance and intactness scores
- **Repair**: PAUs with relatively high importance scores, but lower intactness scores
- **Targeted Stormwater Strategies**: PAUs with similar relative importance scores and a range of intactness scores

Based on this methodology, efforts should focus on PAUs in the Preserve and Repair PAUs first, following that work should be performed in PAUs within the Targeted Stormwater Strategies management category based on the secondary scores.

The integrated secondary score was used as a method for prioritizing implementation of stormwater strategies in PAUs with similar levels of flow importance. PAUs with higher total scores were generally given higher priority. However, the methodology is only intended to provide a framework for decision making, Mukilteo also plans to use existing opportunities and feasibility criteria to make final decisions about implementation.

Management Strategies - Overview

Mukilteo used the results of this analysis to develop a suite of strategies and provide a framework for prioritization, decision making and implementation of stormwater and land use strategies that (1) target key impaired processes within each PAU, (2) are cost effective, feasible, and (3) are consistent with other Stakeholder Plans. These strategies are also intended to focus on off-site mitigation, retrofit, and capital projects that would not be covered by the 2012 Ecology Stormwater Management Manual; which would address new development and significant redevelopment projects.

Table 1. Summary of Key Study Area Management Strategies

Targeted Stormwater Management Strategy	**Key Watershed Process**			
	Delivery	**Surface Storage**	**Recharge**	**Water Quality**
Regional Engineered Strategies				
detention/retention pond		**X**		**X**
constructed wetlands		x		**X**
Restore depressional wetlands		x		**X**
Cisterns		x		
Permeable pavement	**X**		X	**X**
Engineered Bioretention	x	x	X	**X**
Bioretention Swale	**X**		X	**X**
On-Site Strategies				
Soil amendment/restoration	**X**		x	x
Plant trees	**X**	x		x
Rain Gardens	**X**	x	**X**	**X**
Vegetated filter strips	**X**		x	**X**
Disconnect downspouts	**X**		**X**	**X**
Additional Strategies				
Protect/acquire open space	**X**			**X**
Restore upland vegetation	**X**	x		**X**
Restore buffer vegetation	**X**	x		**X**
Education				

X indicates Best Management Practice (BMP) primarily benefits key watershed process

Although many of the strategies recommended in this plan are feasible throughout the study area; some strategies are more important based on landscape position and land ownership. Strategies such as detention and retention ponds, constructed wetlands, and restoration of depressional wetlands is significantly more feasible in PAUs in the plateau landscape position because (1) surface storage is an important and in many cases impaired process, (2) topography is generally flat so extensive grading would not be required, and (3) working in the headwater would have the added benefit of addressing problems downstream.

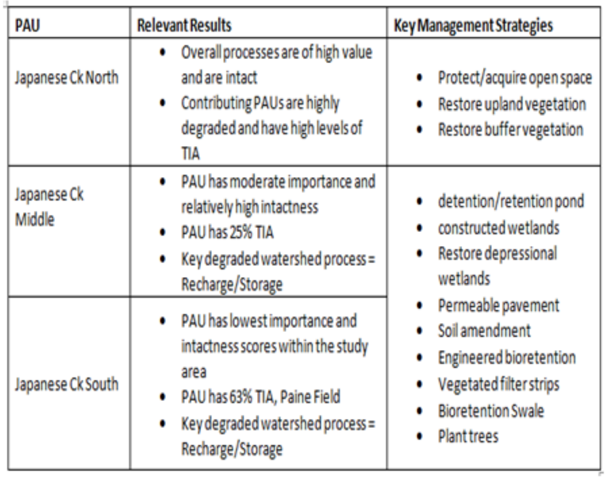
In addition, the land acquisition and buffer restoration projects would be most feasible in PAUs where parks and open spaces already existing and could be enhanced or increases in size by additional acquisition and would be less feasible in PAUs and locations with extensive existing development.

Japanese Gulch Watershed: Recommended Stormwater Management Strategies

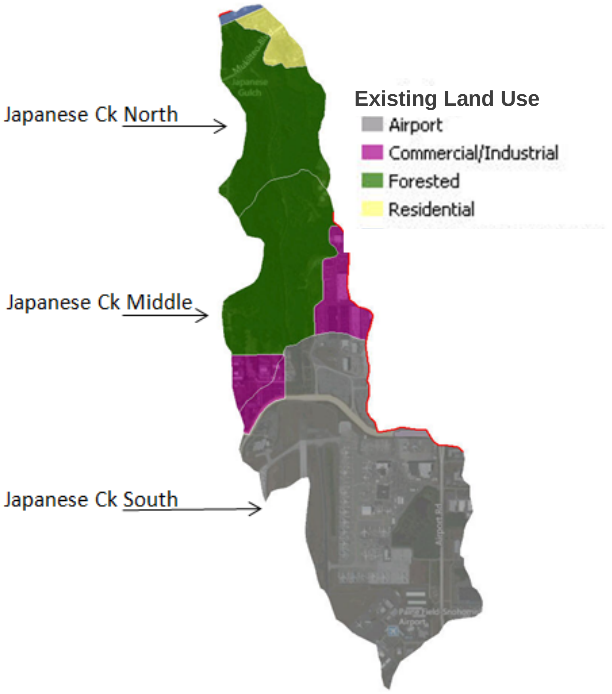
Mukilteo has also developed specific strategies for each PAU based on the results of this analysis, known limitations such as steep slopes, known problems, opportunities identified by other studies, landscape position, and feasibility.

Based on the results of this analysis, Mukilteo identified the Japanese Gulch as having highest priority for preservation (Japanese Creek North), and high priority for targeted stormwater management (Japanese Creek Middle and Upper) (Figure 8).

Figure 39. Japanese Gulch Watershed – relevant results and key management strategies.



PAU	Relevant Results	Key Management Strategies
Japanese Ck North	• Overall processes are of high value and are intact • Contributing PAUs are highly degraded and have high levels of TIA	• Protect/acquire open space • Restore upland vegetation • Restore buffer vegetation
Japanese Ck Middle	• PAU has moderate importance and relatively high intactness • PAU has 25% TIA • Key degraded watershed process = Recharge/Storage	• detention/retention pond • constructed wetlands • Restore depressional wetlands • Permeable pavement • Soil amendment • Engineered bioretention • Vegetated filter strips • Bioretention Swale • Plant trees
Japanese Ck South	• PAU has lowest importance and intactness scores within the study area • PAU has 63% TIA, Paine Field • Key degraded watershed process = Recharge/Storage	



The management strategies for each PAU are consistent with existing land cover and use patterns. Protecting native forest / riparian vegetation through targeted land acquisition and easements is the primary focus for Japanese Ck North; and restoring wetlands (primarily Japanese Ck Middle), retrofitting commercial / industrial areas with infiltration BMPs are the primary focus for upper PAUs of Japanese Creek.

VI. Additional Resources

City of Mukilteo Public Works Department. 2011. City of Mukilteo Stormwater Facilities Atlas. Prepared by ESA. Available: http://www.ci.mukilteo.wa.us/Page.asp?NavID=250

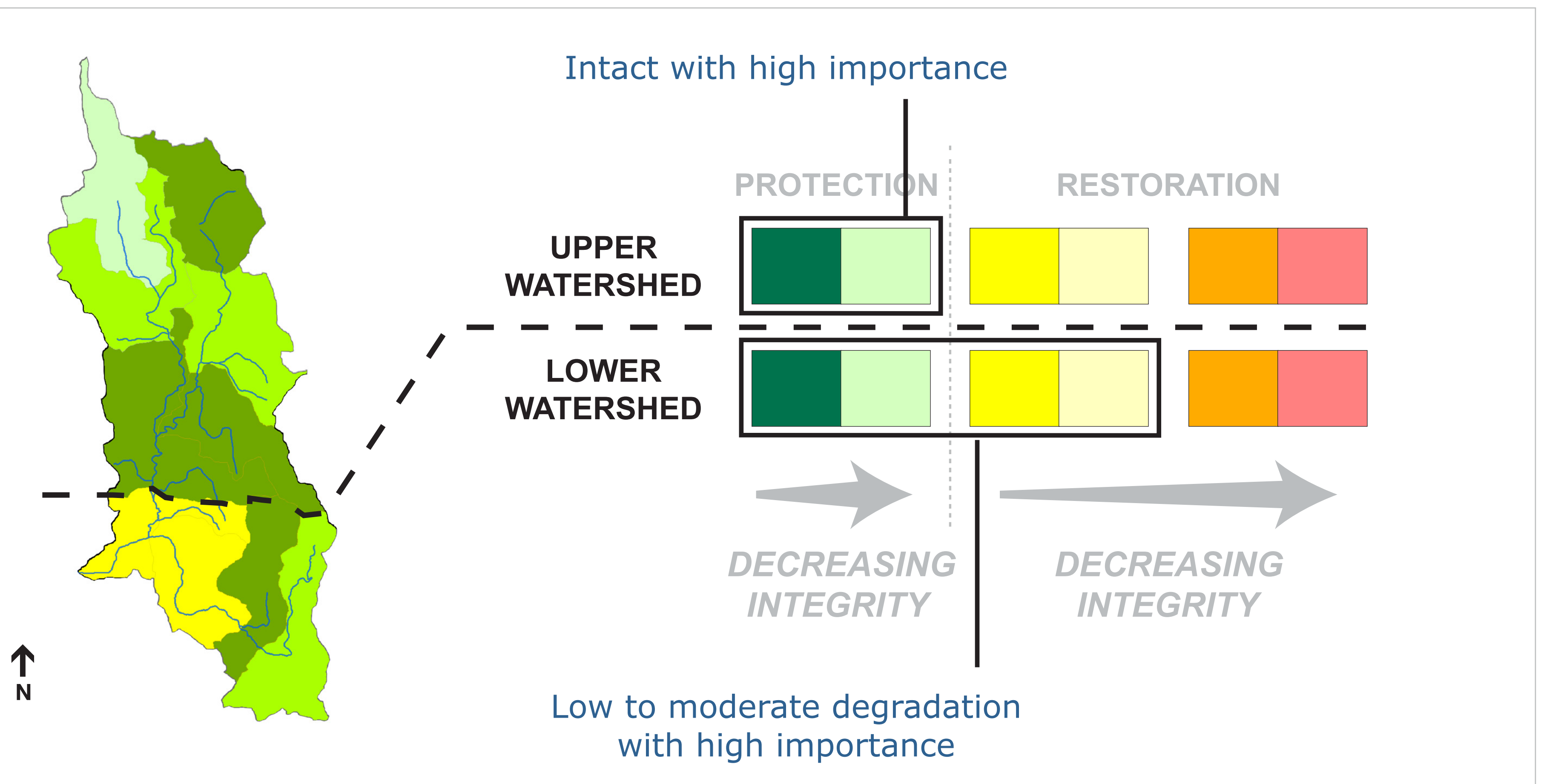
Appendix C: Common Puget Sound Landscape Scenarios and Associated Watershed-Based Management Strategies

Management Considerations

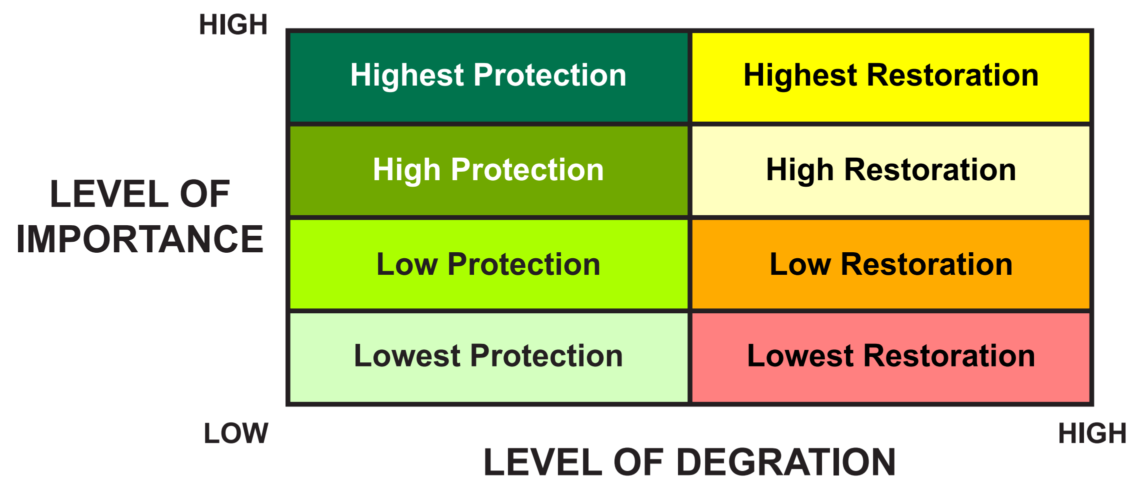
The watershed characterization results can help you make management decisions, but you need to look at individual AUs in the context of the entire watershed management unit. The Watershed Management Index presents a set of common watershed scenarios occurring across the Puget Sound. Each watershed scenario reflects a general pattern of upstream and downstream conditions within a WMU as well as well as the general patterns of land use.

STEP 1

You will need to consider upstream and downstream conditions occurring within your watershed. To start, use **overall restoration and protection results for water flow** to identify conditions in the upper and lower AUs (patterns of dark and light green, yellow, orange, and pink). Based on these results, generally divide your area in half (based on the dominant color or color combinations in the upper versus the lower watershed areas).



Example:
Green AUs in the upper watershed of Bear / Evans Creek (suggesting intact conditions for water flow processes) drain to **a mix of yellow and green AUs in the lower watershed** (areas with low to moderate degradation and high importance).



Highest Protection	Highest Restoration
High Protection	High Restoration
Low Protection	Low Restoration
Lowest Protection	Lowest Restoration

STEP 2

Review the **Watershed Management Index** to identify and select the watershed management scenario with greatest parallels to the upper and lower watershed dominant colors for your area. The Index also highlights common land use (open space, forestry, rural, agricultural, suburban, urban) and landscape (lowland, coastal & lowland, lowland & mountainous, and mountainous) patterns that occur for each respective scenario; also consider these patterns when identifying the scenario with most similarities to your area.

STEP 3

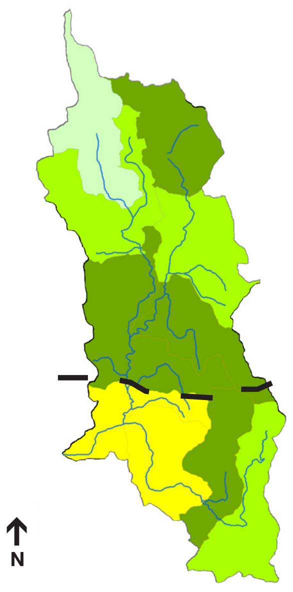
Explore additional management recommendations through the **Watershed Management Matrix**.

STEP 4

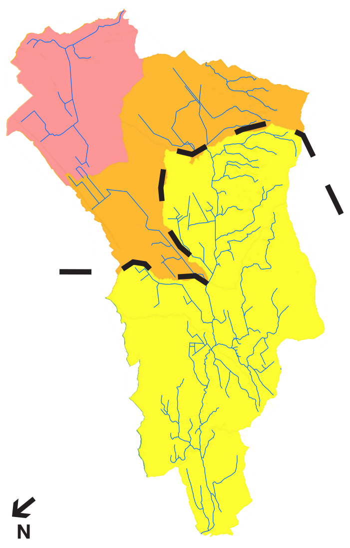
Consider other **Ecology and WDFW guidance information** for watershed management.

Watershed Management Index

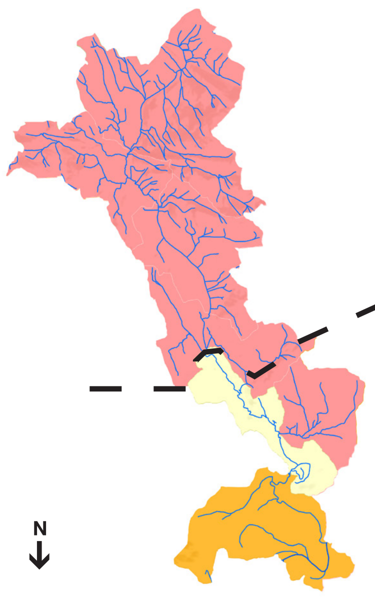
Use this Index to identify the watershed management scenario with greatest parallels to the WMU(s) within your area. Click the appropriate scenario to learn more, including general management strategies appropriate to each. See Step 1 above, and **Getting Started** content for more information.

Watershed Management Scenario			*General Condition*
LOWLAND: Moderate density residential/ open space *upstream of* urban areas EXAMPLE AREA: Bear/Evans Creek (WRIA 8)		Upper Watershed	Intact with high importance • Land use: moderate density residential use and open space (surrounding stream corridors and wetlands) • Intact water flow processes are of moderate to high importance
		Lower Watershed	Mixed degradation with generally high importance • Land use: predominantly urban, with some open space (around stream corridors and wetlands) • All lower watershed AUs of moderate to high importance for water flow processes, even where degraded

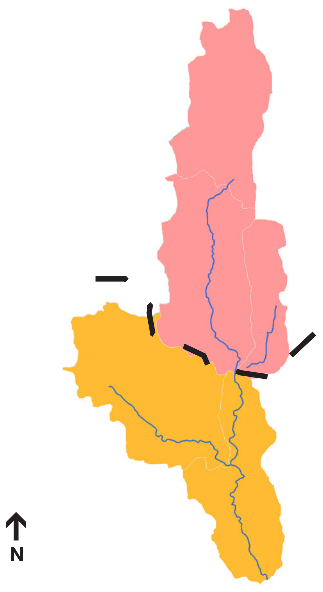
Learn more

Watershed Management Scenario			*General Condition*
LOWLAND: Rural residential and agriculture throughout; limited urban development in upper watershed and significant open space in the mid and lower watershed EXAMPLE AREA: California Creek (WRIA 1)		Upper Watershed	Moderate to high degradation with low importance • Land use: Predominantly rural residential and agriculture, with limited urban development • Upper watershed, while moderately to highly degraded, is of less relative importance to water flow processes
		Mid & Lower Watershed	High degradation with high importance • Land use: Predominantly rural residential and agriculture, with some open space • All lower watershed AUs of high importance for water flow processes, even though highly degraded

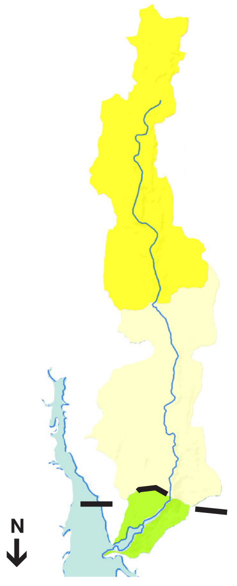
Learn more

Watershed Management Scenario			*General Condition*
LOWLAND: Commercial forest lands/rural *upstream of* agriculture and moderate density and rural residential EXAMPLE AREA: Nookachamps (WRIA 3)		Upper Watershed	High degradation with low importance • Land use: predominantly commercial forest land with some rural residential • Upper watershed, while highly degraded, is of less relative importance to water flow processes
		Lower Watershed	High degradation with low to moderate importance • Land use: predominantly agriculture with limited areas of moderate density residential • Importance to water flow processes varies between AUs in the lower watershed; however all areas are highly degraded

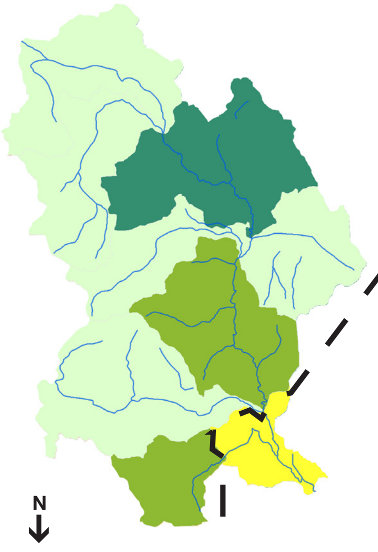
Learn more

Watershed Management Scenario			*General Condition*
LOWLAND: Predominantly urban and moderate density development *throughout* WMU EXAMPLE AREA: Swamp Creek (WRIA 8)		Upper Watershed	High degradation with low importance • Land use: predominantly urban (commercial / high density residential) and moderate density residential • Upper watershed is highly degraded and is of less relative importance to water flow processes
		Lower Watershed	High degradation with moderate importance • Land use: predominantly urban (commercial / high density residential) and moderate density residential • Lower watershed is highly degraded and is of moderate relative importance to water flow processes

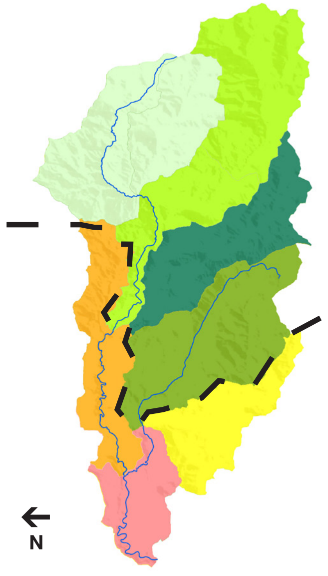
Learn more

Watershed Management Scenario			*General Condition*
COASTAL & LOWLAND: Urban *upstream of* rural residential and forest EXAMPLE AREA: Woodard Creek (WRIA 13)		Upper & Mid Watershed	High degradation with moderate to high importance • Land use: predominantly urban (commercial / high density residential) and moderate density residential • Upper watershed is highly degraded, however is relatively important to water flow processes
		Lower Watershed	Low degradation with moderate importance • Land use: predominantly rural residential, forested • Lower watershed has relatively low degradation and is of moderate relative importance to water flow processes

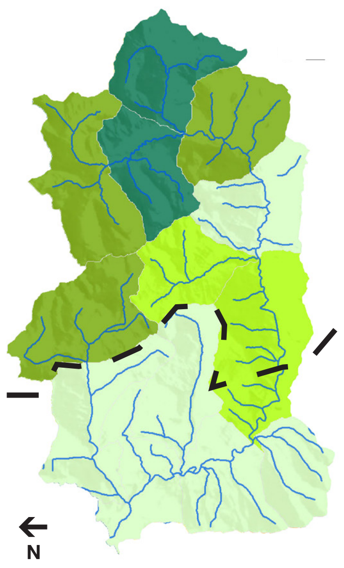
Learn more

Watershed Management Scenario			*General Condition*
LOWLAND & MOUNTAINOUS: Protected forest lands and some residential *upstream* of urban areas EXAMPLE AREA: Issaquah Creek (Tiger WMU) (WRIA 8)		Upper & Mid Watershed	Low degradation with mixed importance • Land use: predominantly protected forest land, with some residential • Upper and mid watershed is relatively intact, with areas of low, moderate, and high importance to water flow processes
		Lower Watershed	High degradation with high importance • Land use: predominantly urban (commercial / high density residential) • Lower watershed AU has relatively high degradation, however is also of high importance to water flow processes

Learn more

Watershed Management Scenario			*General Condition*
LOWLAND & MOUNTAINOUS: Forest lands *upstream of* urban areas, residential and some agriculture EXAMPLE AREA: Mashel River (WRIA 11)		Upper Watershed	Low degradation with mixed importance • Land use: predominantly commercial forest lands, some protected forest • Upper and mid watershed is relatively intact, with areas of low, moderate, and high importance to water flow processes
		Lower Watershed	High degradation with mixed importance • Land use: predominantly urban and suburaban / rural, with some agriculture • Lower watershed is relatively highly degraded, with mixed relative importance to water flow processes

Learn more

Watershed Management Scenario			*General Condition*
MOUNTAINOUS: Predominantly protected forest lands *upstream of* forest lands and agriculture EXAMPLE AREA: Nooksack River (WRIA 1)		Upper Watershed	Low degradation with moderate to high importance • Land use: predominantly urban (commercial / high density Land use: predominantly protected forest, some commercial forest • Upper watershed is relatively intact, generally with moderate to high importance
		Lower Watershed	Low degradation with low importance • Land use: predominantly commercial forest lands and agriculture, some protected forest • Lower watershed is relatively intact, with lower relative importance to water flow processes

Learn more

After you have reviewed relevant Management Scenarios, explore additional management strategies through the **Watershed Management Matrix**. Additionally, consider other **Ecology and WDFW guidance information** for watershed management.

LOWLAND: Suburban Residential/ Open Space *Upstream of* Urban Areas

Common Problems for this WMU scenario:

- Alteration of hydro-periods from forest loss and impervious cover (potential for more extreme high and low flow events)
- Loss of wetlands and floodplains (surface storage); especially in impacted areas of urban development
- Reduced stream/wetland biodiversity and habitat fragmentation

Understanding implications of watershed integrity:

Water flow processes are relatively intact for upper and mid watershed, and are relatively important for these processes. This suggests these areas should be high priorities for protection.

Lower watershed AUs are relatively more degraded, however are also relatively important for flow processes (yellow AUs). Intact upper AUs suggest that restoration actions in the lower watershed whould have a higher likelihood of success.

General Management Recommendations

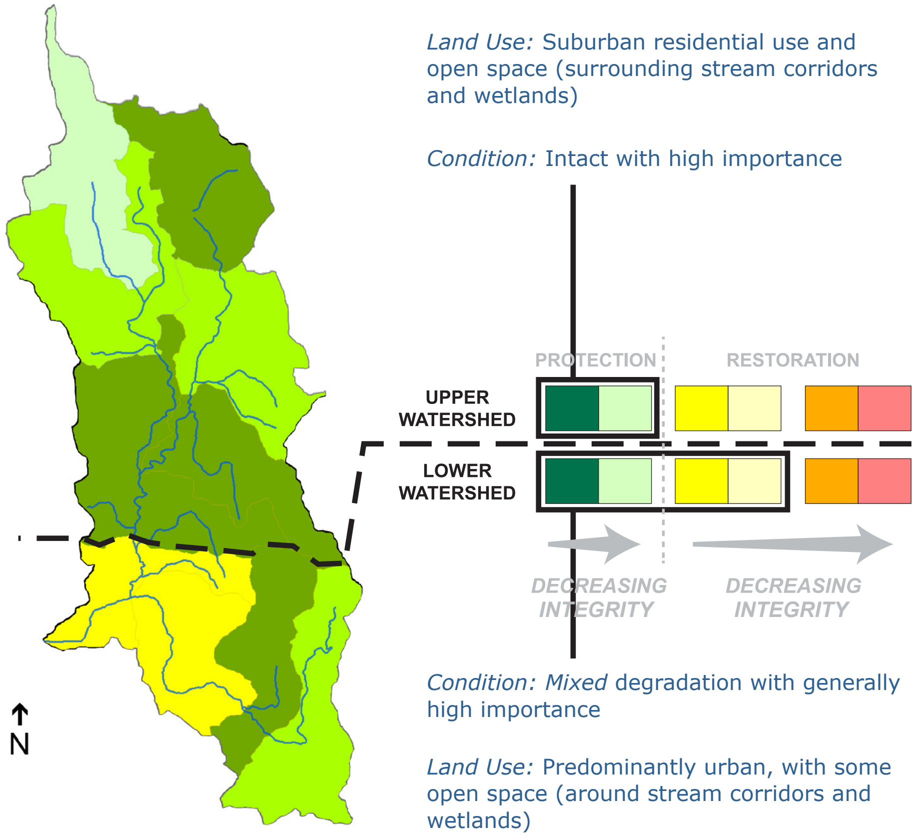
Upper Watershed (Green AUs prioritized for Protection)

- Protect existing forest cover (acquisition, easements)
- Cluster new development, minimize impervious cover
- Apply LID to new and redevelopment where feasible

Lower Watershed (Yellow AU prioritized for Restoration):

- Retrofit existing urban areas (stormwater retrofits + reforest)
- Restore water flow process alteration (see submodel results to assess)
- Habitat restoration at site/reach scale OK

Bear/Evans Creek (WRIA 8)

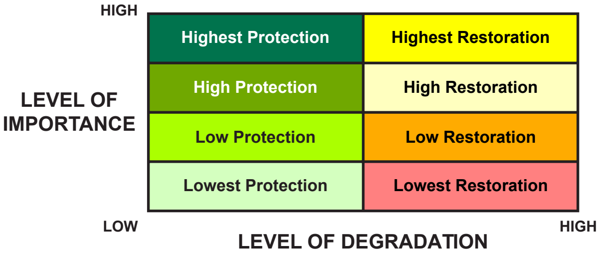


Land Use: Suburban residential use and open space (surrounding stream corridors and wetlands)

Condition: Intact with high importance

Condition: Mixed degradation with generally high importance

Land Use: Predominantly urban, with some open space (around stream corridors and wetlands)



LEVEL OF IMPORTANCE	LOW → HIGH LEVEL OF DEGRADATION	
HIGH	🟩 Highest Protection	🟨 Highest Restoration
	🟩 High Protection	🟨 High Restoration
	🟩 Low Protection	🟧 Low Restoration
LOW	🟩 Lowest Protection	🟥 Lowest Restoration

Click here to review other potential management strategies.

Click here to consider other WDFW and Ecology guidance.

LOWLAND: Rural Residential and Agricultural Throughout; Limited Urban in Upper and Open Space in Lower

Common Problems for this WMU scenario:

- Extensive degradation of land cover, ditching of wetlands reduces storage and increases overland flow and downstream flooding and erosion
- Rapid transport of pollutants (fecals and nutrients) to marine waters
- Low flows and high temps in aquatic areas during dry months
- Location of urban area in headwaters can greatly increase all of these problems
- Low permeability and terrace topography results in widespread ponding and storage of surface waters (particular to this example; may apply in similar lowland scenarios

Understanding implications of watershed integrity:

Water flow processes are not intact for both the upper and lower watersheds. Restoration of aquatic habitat will have a lower likelihood of success unless process degradation is addressed.

General Management Recommendations

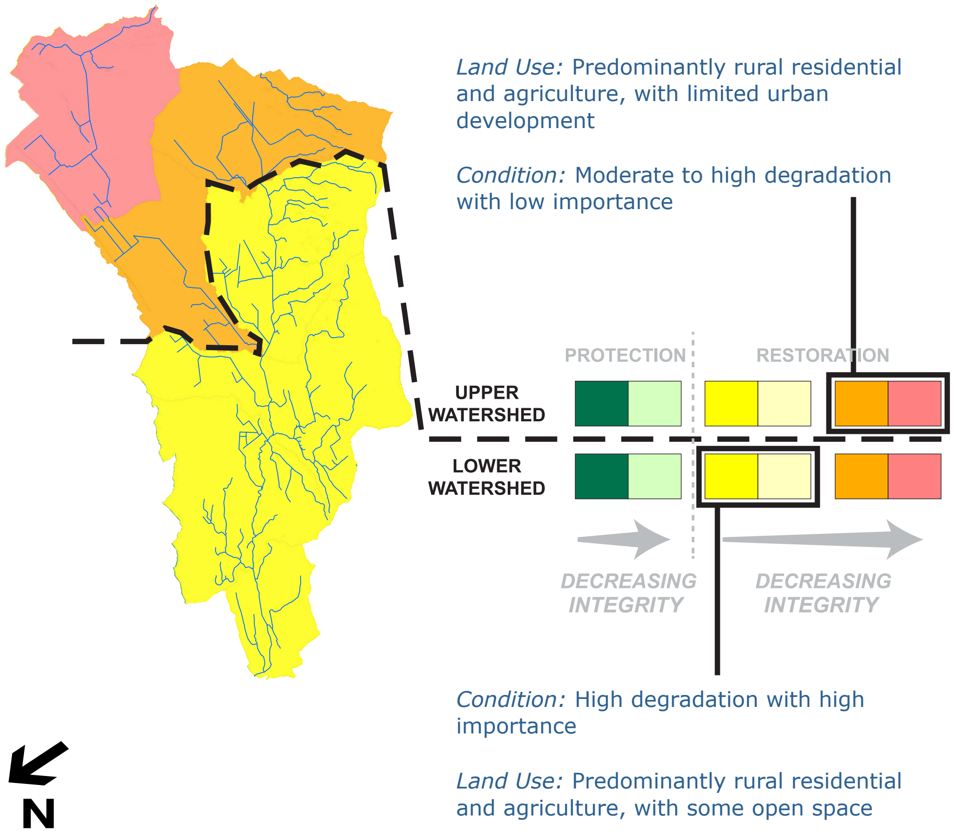
Upper Watershed (Orange AUs prioritized for Restoration)

- Restore Storage in Urban Areas: retrofit urban areas and increase retention and infiltration of surface waters through rain gardens, storage ponds, and other LID measures

Lower Watershed (Yellow AUs highly prioritized for Restoration):

- Restore depression wetland and/or increase storage during winter periods on agricultural parcels
- Cluster new development, minimize impervious cover, increase forested cover especially along riparian corridors

California Creek (WRIA 1)

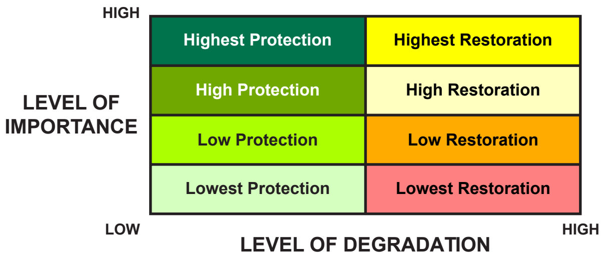


Land Use: Predominantly rural residential and agriculture, with limited urban development

Condition: Moderate to high degradation with low importance

Condition: High degradation with high importance

Land Use: Predominantly rural residential and agriculture, with some open space



Highest Protection	Highest Restoration
High Protection	High Restoration
Low Protection	Low Restoration
Lowest Protection	Lowest Restoration

Click here to review other potential management strategies.

Click here to consider other WDFW and Ecology guidance.

LOWLAND: Commercial Forest/Rural *Upstream of* Agriculture; Suburban and Rural Uses

Common Problems for this WMU scenario:

- Upper basins – forestry management measures can lead to sedimentation and increased stream discharge
- Lower basin – channelization (ditching) of runoff and lack of floodplain storage

Understanding implications of watershed integrity:

Water flow processes are not intact for both the upper and lower watersheds. Restoration of aquatic habitat will have a lower likelihood of success unless process degradation is addressed.

General Management Recommendations

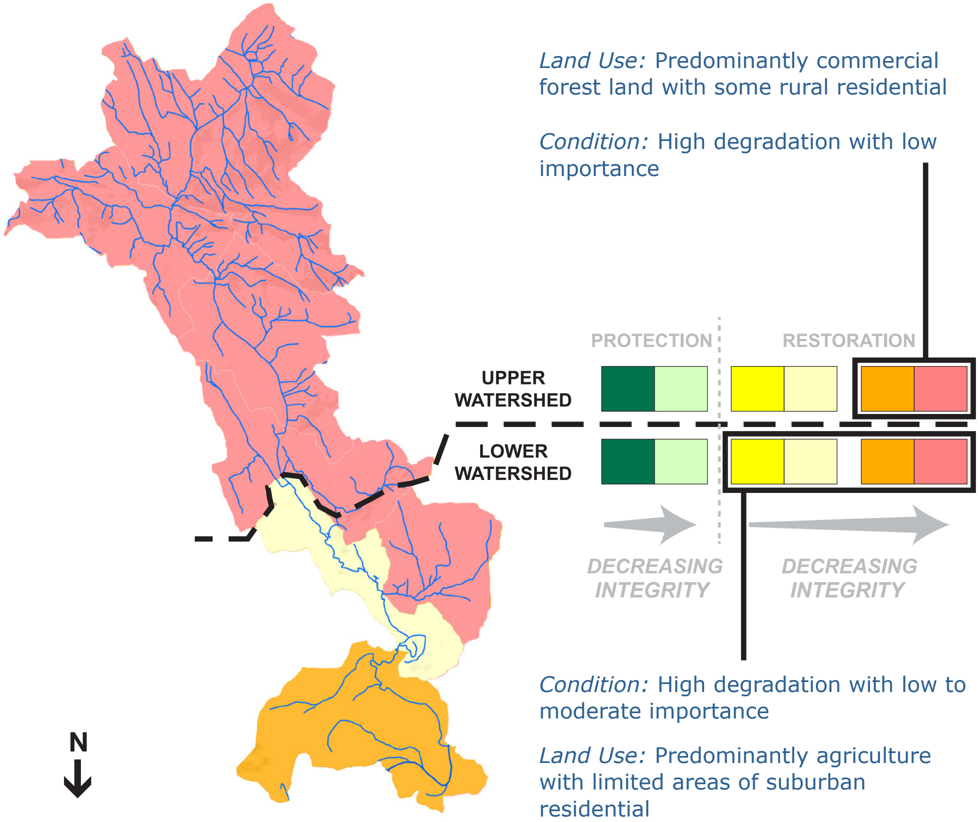
Upper Watershed (Red AUs prioritized for Restoration)

- Employ forestry practices that maximize cover and minimizes roads and erosion
- Cluster new development, minimize impervious cover, increase forested cover especially along riparian corridors

Lower Watershed (Light yellow AUs higher prioritized for Restoration):

- Restore depression wetland and/or increase storage during winter periods on agricultural parcels
- Urban areas – Manage stormwater using LID measures to reduce surface discharge

Nookachamps (WRIA 3)



Land Use: Predominantly commercial forest land with some rural residential

Condition: High degradation with low importance

Condition: High degradation with low to moderate importance

Land Use: Predominantly agriculture with limited areas of suburban residential

LEVEL OF IMPORTANCE (HIGH to LOW)

Highest Protection	Highest Restoration
High Protection	High Restoration
Low Protection	Low Restoration
Lowest Protection	Lowest Restoration

LEVEL OF DEGRADATION (LOW to HIGH)

Click here to review other potential management strategies.

Click here to consider other WDFW and Ecology guidance.

LOWLAND: Predominantly Urban and Suburban Development *throughout WMU*

Common Problems for this WMU scenario:

- Residential development throughout the watershed results in loss of forest cover and increased overland flow and peak flows in streams
- Stream hydrology is flashy with increased peak flows, rapid increases and decreases in flow rate, and reduced base flows
- Channels tend to widen and incise through bank erosion and bed scour

Understanding implications of watershed integrity:

Water flow processes are not intact for both the upper and lower watersheds. Restoration of aquatic habitat will have a lower likelihood of success unless process degradation is addressed.

General Management Recommendations

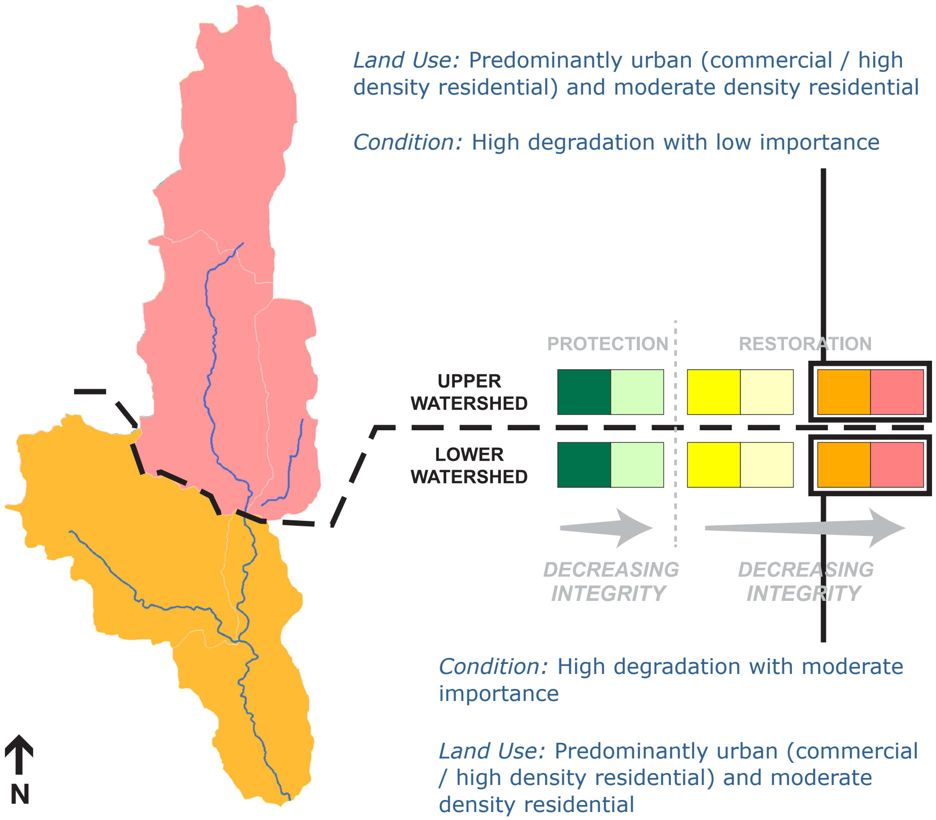
Upper Watershed (Red AUs prioritized for Restoration)

- Manage stormwater using LID measures to reduce surface discharge
- Restore/protect remaining wetlands

Lower Watershed (Orange AUs prioritized for Restoration):

- Manage stormwater using LID measures to reduce surface discharge
- Restore/protect floodplains

Swamp Creek (WRIA 8)

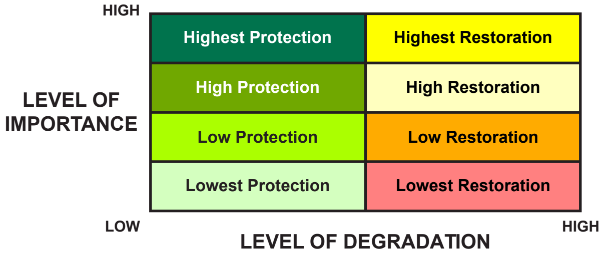


Land Use: Predominantly urban (commercial / high density residential) and moderate density residential

Condition: High degradation with low importance

Condition: High degradation with moderate importance

Land Use: Predominantly urban (commercial / high density residential) and moderate density residential



HIGH

LEVEL OF IMPORTANCE

Highest Protection	Highest Restoration
High Protection	High Restoration
Low Protection	Low Restoration
Lowest Protection	Lowest Restoration

LOW

HIGH

LEVEL OF DEGRADATION

COASTAL & LOWLAND: Urban *Upstream of Rural Residential and Forested*

Common Problems for this WMU scenario:

- Development in the upper watershed results in loss of forest cover and increased overland flow and peak flows in streams
- Stream hydrology is flashy with increased peak flows, rapid increases and decreases in flow rate, and reduced base flows
- Channels tend to widen and incise through bank erosion and bed scour

Understanding implications of watershed integrity:

Water flow processes are not intact in upper watershed, and are marginal in the lower watershed. Restoration of aquatic habitat will have a lower likelihood of success unless process degradation is addressed.

General Management Recommendations

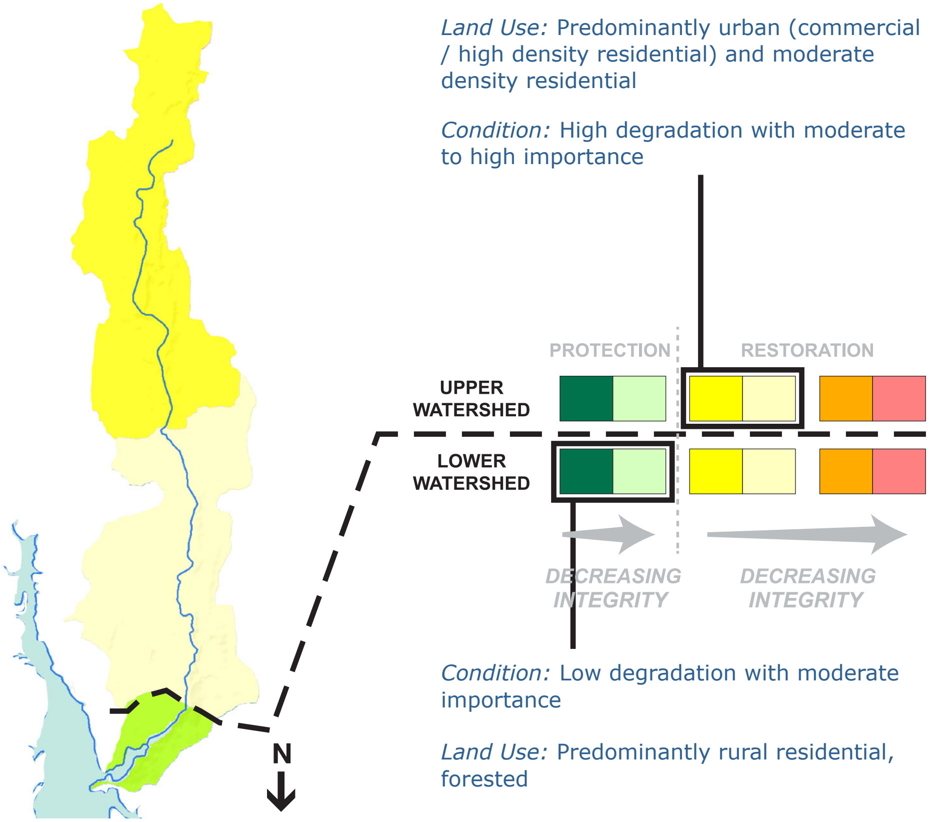
Upper and Mid Watershed (Yellow AUs prioritized for Restoration)

- Manage stormwater using LID measures to reduce surface discharge
- Restore/protect remaining wetlands
- Cluster new development, minimize impervious cover, increase forested cover especially along riparian corridors

Lower Watershed (Light green prioritized for Protection)

- Protect forested riparian zone
- Cluster new development, minimize impervious cover, increase forested cover especially along riparian corridors

Woodard Creek (WRIA 13)

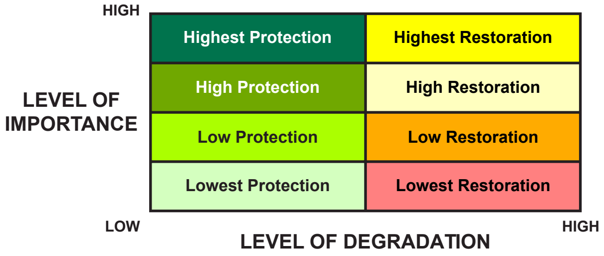


Land Use: Predominantly urban (commercial / high density residential) and moderate density residential

Condition: High degradation with moderate to high importance

Condition: Low degradation with moderate importance

Land Use: Predominantly rural residential, forested



Highest Protection	Highest Restoration
High Protection	High Restoration
Low Protection	Low Restoration
Lowest Protection	Lowest Restoration

Click here to review other potential management strategies.

Click here to consider other WDFW and Ecology guidance.

LOWLAND & MOUNTAINOUS: Protected Forest Lands *Upstream of Urban Areas*

Common Problems for this WMU scenario:

- Encroachment by rural residential development into intact areas outside of urban growth boundaries result in loss of forest cover and increased overland flow and peak flows in streams
- Higher potential for downstream flooding, and sediment export due to steep slopes, higher precipitation and rain-on-snow areas
- Extensive channelization in lower watershed in urban areas is typically present, resulting in higher velocity flows and erosion

Understanding implications of watershed integrity:

Water flow processes are relatively intact for upper and mid watershed. Restoration of aquatic habitat will have a higher likelihood of success, even in areas of higher degradation in lower watershed – yellow AUs.

General Management Recommendations

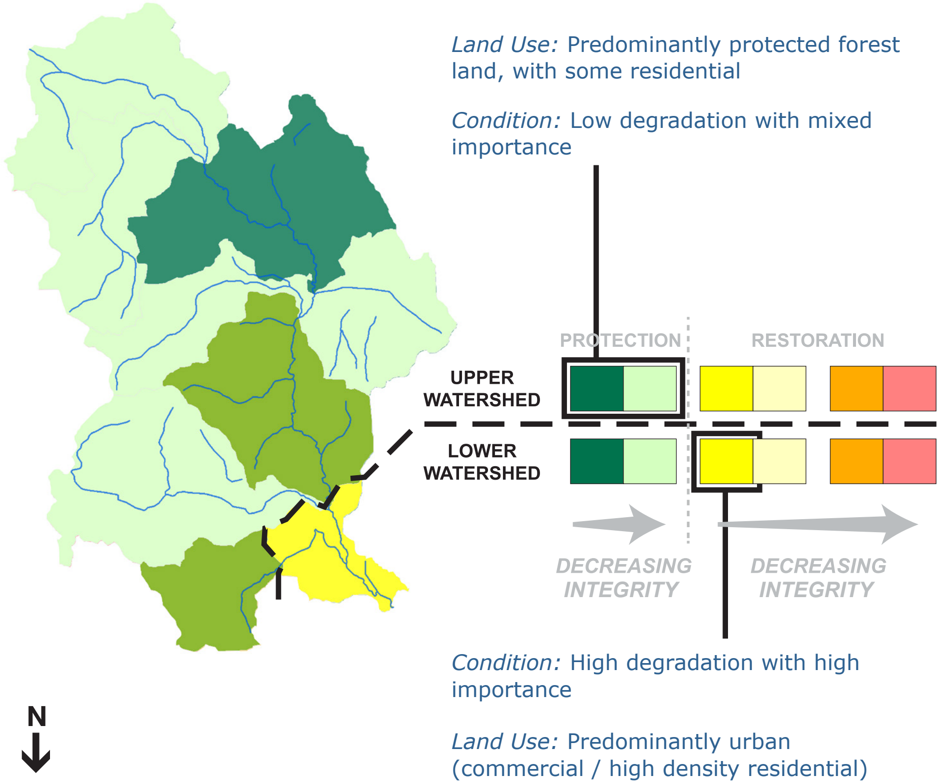
Upper Watershed (Green AUs prioritized for Protection)

- Maintain protected status and employ forestry practices that maximize cover and minimizes roads and erosion

Lower Watershed (Yellow AU prioritized for Restoration):

- Restore reach scale water flow processes (e.g. reconnect stream to floodplain)

Issaquah Creek (Tiger WMU) (WRIA 8)

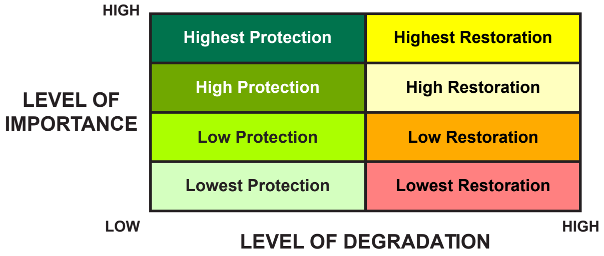


Land Use: Predominantly protected forest land, with some residential

Condition: Low degradation with mixed importance

Condition: High degradation with high importance

Land Use: Predominantly urban (commercial / high density residential)



	LOW → HIGH: LEVEL OF DEGRADATION	
LEVEL OF IMPORTANCE (HIGH)	Highest Protection	Highest Restoration
	High Protection	High Restoration
	Low Protection	Low Restoration
LEVEL OF IMPORTANCE (LOW)	Lowest Protection	Lowest Restoration

Click here to review other potential management strategies.

Click here to consider other WDFW and Ecology guidance.

LOWLAND & MOUNTAINOUS: Forest Lands Upstream of Agriculture and Urban

Common Problems for this WMU scenario:

- Upper Basins – Forestry practices in upper watershed can cause increased surface runoff and sediment delivery
- Lower Basins – Urban and residential development in the lower basins results in loss of forest cover and increased peak flows to tributary streams. Lack of floodplain storage in lower watershed due to channel confinement
- Lower Basins - Stream hydrology is flashy with increased peak flows, rapid increases and decreases in flow rate, and reduced base flows. Channels tend to widen and incise through bank erosion and bed scour

Understanding implications of watershed integrity:

Processes are not intact in the lower watershed due to confinement of the river channel and lack of floodplain processes. Processes are generally intact in the mountainous upper watershed. Restoration efforts in the lower watershed will have a higher chance of success.

General Management Recommendations

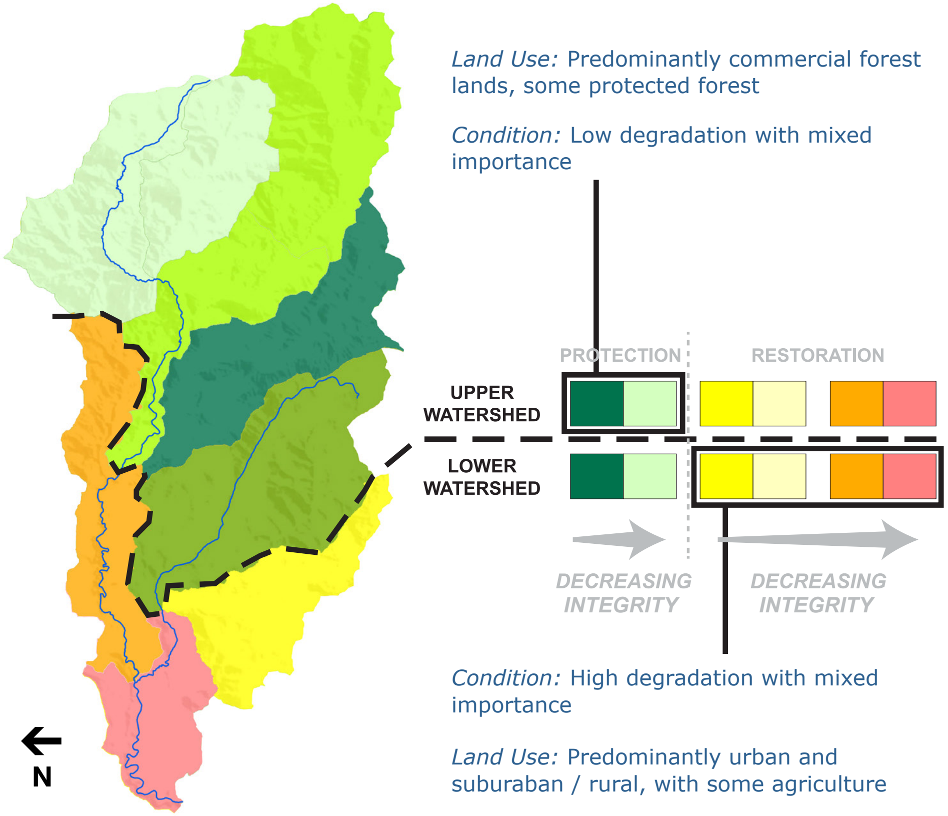
Upper Watershed (Green AUs prioritized for Protection)

- Employ forestry practices that maximize cover and minimizes roads and erosion
- Minimize/reduce channel and floodplain constrictions

Lower Watershed (Red and orange [prioritized lower for Restoration] and yellow [prioritized higher for Restoration]):

- Restore floodplain processes (e.g. reconnect river to floodplain)
- Urban and rural areas restore reach scale processes (e.g. reconnect stream to floodplain)

Mashel River (WRIA 11)

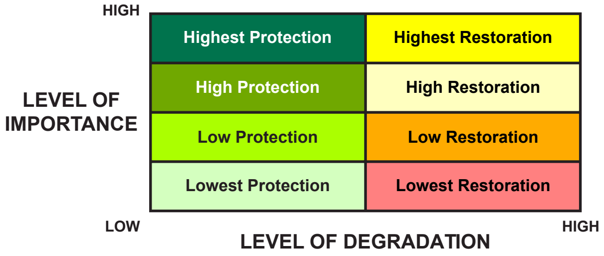


Land Use: Predominantly commercial forest lands, some protected forest

Condition: Low degradation with mixed importance

Condition: High degradation with mixed importance

Land Use: Predominantly urban and suburaban / rural, with some agriculture



Highest Protection	Highest Restoration
High Protection	High Restoration
Low Protection	Low Restoration
Lowest Protection	Lowest Restoration

Click here to review other potential management strategies.

Click here to consider other WDFW and Ecology guidance.

MOUNTAINOUS: Forest Lands *Upstream of Forest Lands and Agriculture*

Common Problems for this WMU scenario:

- Upper basins: forestry management measures can lead to sedimentation and increased stream discharge
- Lower basins: Rivers are often disconnected from their floodplains due to dikes and levees, reducing surface storage and increasing in-channel velocities and flood water elevations

Understanding implications of watershed integrity:

Water flow processes are intact in upper watershed and in the lower watershed. Restoration of aquatic habitat will have a higher likelihood of success.

General Management Recommendations

Upper Watershed (Green AUs highly prioritized for Protection)

- Employ forestry practices that maximize cover and minimizes roads and erosion

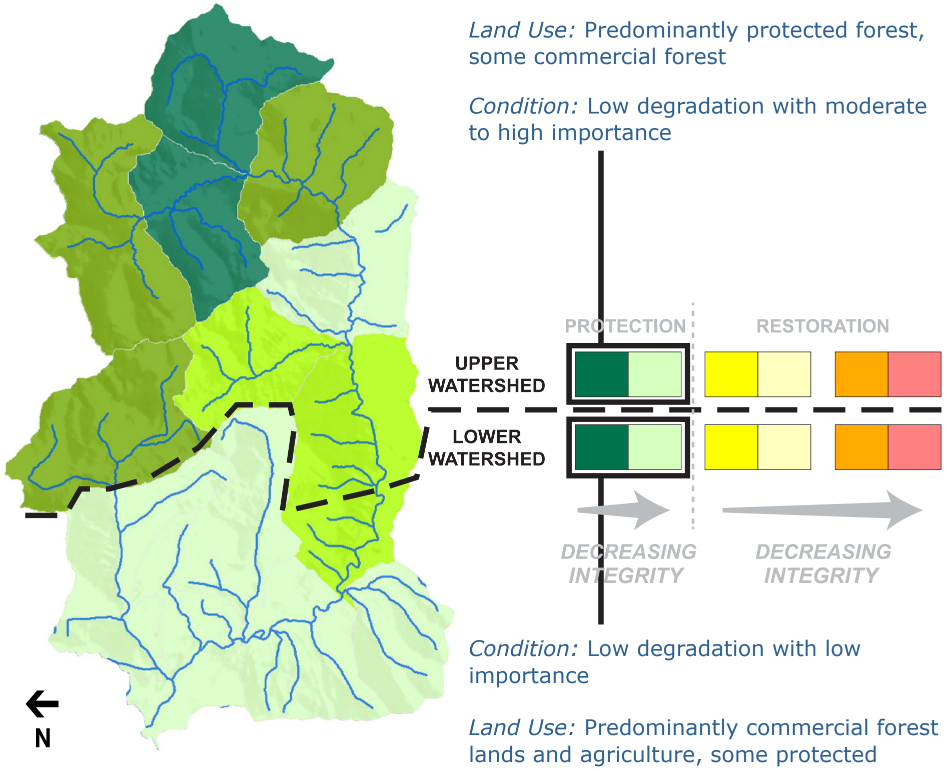
Lower Watershed (Light green AUs prioritized for Protection):

- Protect forested riparian zone and active floodplain

S.F. Nooksack River (WRIA 1)

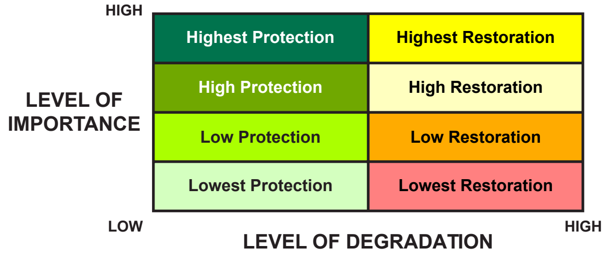
Land Use: Predominantly protected forest, some commercial forest

Condition: Low degradation with moderate to high importance



Condition: Low degradation with low importance

Land Use: Predominantly commercial forest lands and agriculture, some protected forest



HIGH

LEVEL OF IMPORTANCE		
	Highest Protection	Highest Restoration
	High Protection	High Restoration
	Low Protection	Low Restoration
	Lowest Protection	Lowest Restoration

LOW HIGH

LEVEL OF DEGRADATION

Click here to review other potential management strategies.

Click here to consider other WDFW and Ecology guidance.

Appendix D: Matrix of Potential Management Actions

Water-flow processes addressed by management objectives: “DE” = Delivery, “SS” = Surface Storage, “RD” = Recharge/Discharge.

Management Objective	Management Recommendations	Regulatory Driver(s)	Applicable Land Use(s)				Water Flow Assessment - Overall Protection & Restoration Result				Water Flow Processes Addressed		
			Forest Lands	Rural Lands	Agricultural	Urban and Suburban	Higher Protection	Higher Restoration	Lower Protection	Lower Development	Delivery	Surface Storage	Recharge / Discharge
Maintain stream and wetland physical structure and ecological functions (DE, SS, RD).	Review and update (as needed) Critical Areas Ordinance based on Best Available Science to provide protection for wetlands and streams, and to require buffers sufficient to protect riparian zones. Use current use property tax incentive programs to encourage conservation. Acquire property or easements to provide permanent protection.	**Local:** Critical Areas Ordinance, Shoreline Master Program	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Protect and restore floodplains (reconnect streams, reduce channelization) (SS, RD)	Consider implementing all or portions of FEMA's model land use ordinance to protect floodplain functions. Update local regulations including critical areas ordinances, drainage, grading and filling regulations, zoning regulations and land use regulations to restore floodplain functions for new and redevelopment. Use current use property tax incentive programs to limit floodplain development and encourage restoration. Acquire property or easements to restore and provide permanent protection.	**Local:** Shoreline Master Program, Critical Areas Ordinances, drainage, grading and filling regulations, zoning regulations and other land use controls. **State:** Ecology manages floodplains through Chapter 86.16 RCW (floodplain management). Ecology has the authority to “examine, approve or reject designs and plans for any structure or works, public or private, to be erected or built or to be reconstructed or modified upon the banks or in the channel or over and across the floodway of any stream or body of water in the State. (RCW 86.16.025). Ecology has authority to influence federal actions that occur in floodplain wetlands via Section 401 of the Federal Clean Water Act, and authority to approve or disapprove a local government’s Shoreline Master Program. The Department of Fish and Wildlife regulates activities that could impair fish life through the State’s Hydraulic Code (Ch. 77.55 RCW). **Federal:** NFIP administered by FEMA is a potential regulatory tool for controlling land use actions that negatively affect floodplain functions. FEMA issued a model land use ordinance for adoption by local governments in response to NMFS Biological Opinion (BiOp) pursuant to Section 7 of the Endangered Species Act in January 2012. New land use standards for flood plains set by FEMA will be required elements of continuing in the NFIP for local governments.	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑
Reduce surface-water diversions (RD)			☑	☑	☑	☑	☑	☑	☑	☑			☑
Protect and restore depressional wetlands and their adjacent riparian zones	Prepare or update a Watershed Management Plan that includes restoration and enhancement projects. Update Shoreline Master Program Restoration Plan to include wetland and riparian restoration that would benefit the shoreline jurisdiction. Institute a mitigation program as part of local Critical Areas Ordinance with suggested prioritized projects.	**Local:** Critical Areas Ordinance Shoreline Master Program Watershed Management plan	☑	☑	☑	☑	☑	☑	☑	☑		☑	☑

Water-flow processes addressed by management objectives: “DE” = Delivery, “SS” = Surface Storage, “RD” = Recharge/Discharge.

Management Objective	Management Recommendations	Regulatory Driver(s)	Applicable Land Use(s)				Water Flow Assessment - Overall Protection & Restoration Result				Water Flow Processes Addressed		
			Forest Lands	Rural Lands	Agricultural	Urban and Suburban	Higher Protection	Higher Restoration	Lower Protection	Lower Development	Delivery	Surface Storage	Recharge / Discharge
Protec t and restore/replant riparian zones (RD)	Prepare or update a Watershed Management Plan that includes riparian restoration and enhancement projects. Update Shoreline Master Program Restoration Plan to include riparian restoration in the shoreline jurisdiction. Institute a mitigation program as part of local Critical Areas Ordinance with suggested prioritized projects.	**Local:** Critical Areas Ordinance Shoreline Master Program Watershed Management plan	☑	☑	☑	☑	☑	☑	☑	☑			☑
Identify and protect aquifer recharge areas (DE, RD)	Update Critical Areas Ordinance based on Best Available Science to protect aquifer recharge areas. Institute a septic training and inspection program. Institute a pollutant source tracking program. Update stormwater regulations to avoid infiltrating stormwater where it could adversely impact aquifer recharge.	**Local:** Critical Areas Ordinance Stormwater Management Regulations	☑	☑	☑	☑	☑	☑	☑	☑	☑		☑
Reduce number of stream crossings by roads (SS)		**Local:** Critical Areas Ordinance Shoreline Master Program **State:** Forest Practices Act Ch. 76.09, RCW	☑				☑	☑	☑	☑		☑	
Reduce interception of shallow GW in channels and road ditches (RD)			☑				☑	☑	☑	☑			☑
Replant deforested areas (DE)		**State:** Forest Practices Act Ch. 76.09, RCW	☑				☑	☑			☑		
Ensure zoning is consistent with long-term protection of resources (e.g., large parcel size; stable urban growth boundary) (DE, SS, RD)	Update Comprehensive Plan	**Local:** Comprehensive Plan	☑				☑	☑			☑	☑	☑
Decommission and remove unneeded forest roads (SS, RD)			☑				☑	☑				☑	☑
Increase size of protected areas around streams/wetlands (DE, SS, RD)	Update Critical Areas Ordinance to meet Best Available Science recommendations. Acquire property or conservation easements. Allow for native growth protection easements in local land use regulations.	**Local:** Critical Areas Ordinance	☑				☑	☑			☑	☑	☑
Require [properly functioning] septic systems (RD)				☑			☑	☑	☑	☑			☑

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Management Objective	Management Recommendations	Regulatory Driver(s)	Applicable Land Use(s)				Water Flow Assessment - Overall Protection & Restoration Result				Water Flow Processes Addressed		
			Forest Lands	Rural Lands	Agricultural	Urban and Suburban	Higher Protection	Higher Restoration	Lower Protection	Lower Development	Delivery	Surface Storage	Recharge / Discharge
Emphasize dispersive/infiltrative stormwater management (DE, RD)	Update Stormwater Management Plans to include low impact development measures Encourage and/or require use of LID approaches and techniques to better manage stormwater for new development, redevelopment and retrofit projects. This includes: limit land clearing, retain and, where necessary, restore native vegetation and soils, minimize site disturbance and development footprints, limit impervious surfaces through use of permeable pavement or other techniques, create graded swales and rain gardens to disperse and infiltrate stormwater runoff on site, and utilize rainwater catchment for landscaping irrigation.	**Local:** Stormwater Management Regulations		☑			☑	☑	☑	☑	☑		☑
Ensure zoning is consistent with long-term protection of resources (e.g., clustered development, stable urban growth boundary) (DE, SS, RD)	Update Comprehensive Plan	**Local:** Comprehensive Plan		☑			☑	☑			☑	☑	☑
Increase size of protected areas around streams/wetlands, as needed to meet Best Available Science (DE, SS, RD)	Update Critical Areas Ordinance to meet Best Available Science recommendations. Acquire property or conservation easements. Allow for and incentivize native growth protection easements in local land use regulations.	**Local:** Critical Areas Ordinance, Development / Zoning regulations		☑			☑	☑			☑	☑	☑
Reduce drainage density of artificial channels (SS, RD)				☑			☑	☑				☑	☑
Revegetate upland areas (DE, SS)		**Local:** Critical Areas Ordinance **State:** Forest Practices Act Ch. 76.09, RCW		☑			☑	☑			☑	☑	
Reduce GW withdrawals (RD)				☑			☑	☑					☑
Reduce interception of shallow GW in channels and road ditches (RD)				☑			☑	☑					☑
Replant deforested areas (DE)		**Local:** Critical Areas Ordinance **State:** Forest Practices Act Ch. 76.09, RCW		☑			☑	☑			☑		
Set back dikes/levees in key areas to restore overbank flooding (SS)		Local:		☑				☑				☑	

Water-flow processes addressed by management objectives: “DE” = Delivery, “SS” = Surface Storage, “RD” = Recharge/Discharge.

Management Objective	Management Recommendations	Regulatory Driver(s)	Applicable Land Use(s)				Water Flow Assessment - Overall Protection & Restoration Result				Water Flow Processes Addressed		
			Forest Lands	Rural Lands	Agricultural	Urban and Suburban	Higher Protection	Higher Restoration	Lower Protection	Lower Development	Delivery	Surface Storage	Recharge / Discharge
Restore stream reaches, floodplains, or wetlands to recover lost processes and functions (SS, RD)	Prepare or update a Watershed Management Plan that includes restoration and enhancement projects. Update Shoreline Master Program Restoration Plan to include such projects that would benefit the shoreline jurisdiction. Institute a mitigation program as part of local Critical Areas Ordinance with suggested prioritized projects.	**Local:** Critical Areas Ordinance Shoreline Master Program Watershed Management plan		☑				☑				☑	☑
Apply source controls for nitrogen and pathogens (SS)					☑		☑	☑	☑	☑		☑	
Allow greater residence time of water on fields and ditches outside of growing season (SS, RD)					☑		☑	☑	☑	☑		☑	☑
Encourage [properly functioning] septic systems (RD)					☑		☑	☑	☑	☑			☑
Ensure zoning is consistent with long-term protection of agriculture and resources (e.g., large parcel size; stable urban growth boundary) (DE, SS, RD)	Update Comprehensive Plan Provide property tax incentives for protection of farmland. Obtain farmland protection grants for acquisition of property and easements.	**Local:** Comprehensive Plan, Land Use Regulations, Current Use Taxation Programs			☑		☑	☑		☑	☑	☑	☑
Reduce GW withdrawals (RD)					☑		☑	☑					☑
Reduce drainage density of artificial channels (SS, RD)					☑		☑	☑				☑	☑
Establish buffers for water-quality improvement in strategic areas (DE, RD)	Update Critical Areas Ordinance to meet Best Available Science recommendations. Acquire property or conservation easements. Allow for native growth protection easements in local land use regulations.				☑		☑	☑			☑		☑
Reduce interception of shallow GW in channels and road ditches (RD)					☑		☑	☑					☑
Revegetate upland areas (DE, SS)					☑		☑	☑			☑	☑	
Set back dikes/levees in key areas to restore overbank flooding (SS)		**Local and Regional:** Flood authorities, County flood control districts, Public Works			☑			☑				☑	

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Management Objective	Management Recommendations	Regulatory Driver(s)	Applicable Land Use(s)				Water Flow Assessment - Overall Protection & Restoration Result				Water Flow Processes Addressed		
			Forest Lands	Rural Lands	Agricultural	Urban and Suburban	Higher Protection	Higher Restoration	Lower Protection	Lower Development	Delivery	Surface Storage	Recharge / Discharge
Restore degraded stream reaches, floodplains, or wetlands to recover lost processes and functions (SS, RD)	Prepare or update a Watershed Management Plan that includes restoration and enhancement projects. Update Shoreline Master Program Restoration Plan to include such projects that would benefit the shoreline jurisdiction. Institute a mitigation program as part of local Critical Areas Ordinance with suggested prioritized projects.				☑			☑				☑	☑
Restore highly infiltrative soils (RD)					☑			☑					☑
Emphasize dispersive/infiltrative stormwater management (DE, SS, RD)	Update Stormwater Management regulations to require LID for new and redevelopment	**Local:** Stormwater Management Regulations				☑	☑	☑	☑	☑	☑	☑	☑
Increase retention of surface water using LID stormwater measures (SS, RD)	Update Stormwater Management regulations to require LID for new and redevelopment	**Local:** Stormwater Management Regulations				☑				☑		☑	☑
Ensure zoning is consistent with long-term protection of natural resources (e.g., clustered development, minimize impervious area) (SS, RD)	Update Comprehensive Plan	**Local:** Comprehensive Plan				☑	☑	☑		☑		☑	☑
Increase widths of protected wetland, stream, and marine riparian zones (DE)	Update Critical Areas Ordinance to meet Best Available Science recommendations. Update Shoreline Management Program to provide adequate protection to Shorelines of the State. Acquire property or conservation easements. Allow for native growth protection easements in local land use regulations.	**Local:** Critical Areas Ordinance				☑	☑	☑			☑		
Reduce GW withdrawals (RD)						☑	☑	☑					☑
Reduce interception of shallow GW in channels and road ditches (RD)						☑	☑	☑					☑
Revegetate upland areas (DE, SS)						☑	☑	☑			☑	☑	
Retrofit structures and roads for greater infiltration (DE, RD)	Update land use regulations and/or stormwater management regulations to address infiltration requirements for redevelopment.	**Local:** Stormwater Management regulations				☑		☑			☑		☑

Water-flow processes addressed by management objectives: “DE” = Delivery, “SS” = Surface Storage, “RD” = Recharge/Discharge.

			Applicable Land Use(s)				Water Flow Assessment - Overall Protection & Restoration Result				Water Flow Processes Addressed		
Management Objective	**Management Recommendations**	**Regulatory Driver(s)**	Forest Lands	Rural Lands	Agricultural	Urban and Suburban	Higher Protection	Higher Restoration	Lower Protection	Lower Development	Delivery	Surface Storage	Recharge / Discharge
Construct stream reaches or constructed wetlands to recover lost processes and functions if/as feasible (SS, RD)	Prepare or update a Watershed Management Plan that includes restoration and enhancement projects. Update Shoreline Master Program Restoration Plan to include such projects that would benefit the shoreline jurisdiction. Institute a mitigation program as part of local Critical Areas Ordinance with suggested prioritized projects.	Local: Critical Areas Ordinance, Shoreline Master Program				☑		☑				☑	☑

Recommedations from Volume 1: Water Resources Assessment (Water Flow and Water Quality), April 2012 - available: http://www.ecy.wa.gov/services/gis/data/pugetsound/characterization.htm

Content from Volume 1 'Solutions Templates' tables not included in EXCEL MATRIX
ALL LANDS - For relevant literature see: http://www.ecy.wa.gov/biblio/wetlands.html

FOREST LANDS - Common issues: widespread loss of vegetative cover, particularly in high-elevation snow and rain-on-snow areas, high in watersheds and so affecting many reaches downstream. Creation of new impervious surfaces rare, although a dense forest road network can greatly alter flow paths and sediment production.

RURAL LANDS - Common issues: Rural land use can drain key headwater wetlands, with potentially great effect on downstream flooding and erosion. Septic systems can be a source of nutrients and pathogens. Forest clearing increases overland flows, affecting stream/wetland structure and function. Groundwater withdrawal in rural residential areas can affect downstream discharge areas.

RURAL LANDS - For relevant literature see: http://www.ecy.wa.gov/biblio/wq.html

AGRICULTURAL LANDS - Common issues: Extensive drainage system reduces residence time of water on landscape and increases downstream delivery of water; also compromises water-quality functions of wetlands and floodplains. Potential source of nutrients, pathogens and sediment that impact downstream aquatic area; lack of vegetated buffers increases delivery and transport. Floodplains disconnected from overbank flooding and tidal processes. Groundwater withdrawals and diversions can significantly affect low-flow regimes and wetland hydrology.

URBAN AND SUBURBAN LANDS - Common issues: Areas of impervious surface impair multiple water-flow processes, resulting in simplification of habitat structure and functions, and compromising effective restoration of structure and function of aquatic habitat. Significant transport of pollutants generated by urban uses to aquatic areas. Note that development regulations will preempt/supersede some of these recommendations.