JEFFERSON COUNTY
SHORELINE MASTER PROGRAM UPDATE PROJECT
ECOLOGY GRANT # G0600343

Final Shoreline Inventory and Characterization Report – Revised

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Prepared for:

Jefferson County Department of Community Development

Prepared by:

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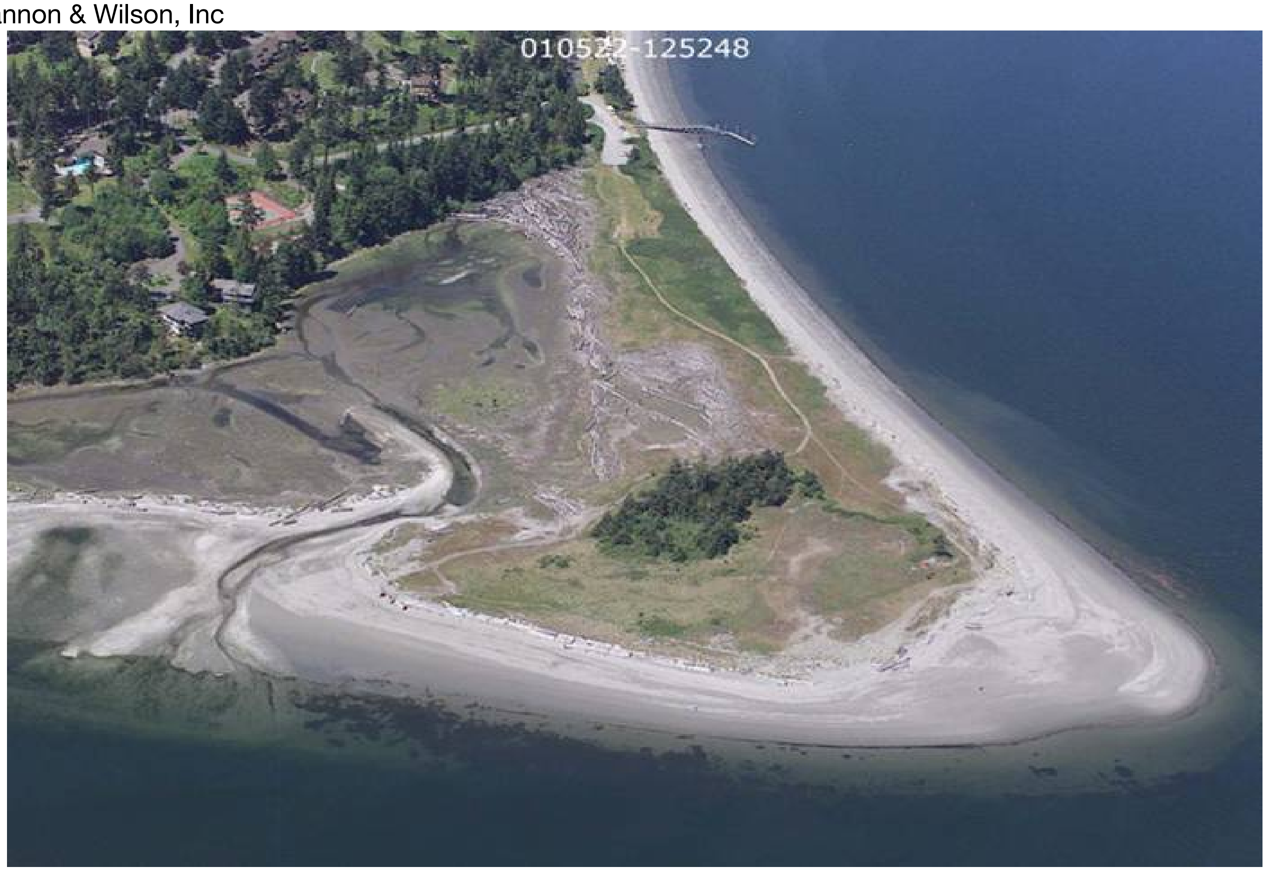

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- Neil Harrington for researching and compiling much of the baseline inventory information for the County's original 2005 Shoreline Inventory and Analysis Report.

Cover photo: Kala Point, eatern Jefferson County. Courtesy of the Washington Department of Ecology Shoreline Aeial Photos at http://apps.ecy.wa.gov/shorelinephotos/index.html

ACRONYMNS

BPA	Bonneville Power Administration
DPS	Distinct Population Segment
cfs	cubic feet per second
CGS	Coastal Geologic Services
CMZ	channel migration zone
DEM	Digital elevation model
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ESU	Evolutionarily Significant Unit
°F	degrees Fahrenheit
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
HCMZ	historic channel migration zones
IPCC	Intergovernmental Panel on Climate Change
km	kilometer
LWD	Large Woody Debris
mg/L	milligrams per liter
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MRC	Marine Resources Committee
NOSC	North Olympic Salmon Commission
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NWI	National Wetland Inventory
OHWM	ordinary high water mark
ONP	Olympic National Park
ONF	Olympic National Forest
PAHs	polychlorinated aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PHS	Priority Habitats and Species
PNPTC	Point No Point Treaty Council
RCW	Revised Code of Washington
RM	river mile
ROS	rain-on-snow
SASSI	Salmon and Steelhead Inventory
SCS	Soil Conservation Service
SED	Shoreline Environment Designation
SMA	Shoreline Management Act
SMP	Shoreline Master Program
SSRFB	State Salmon Recovery Funding Board
USFS	United States Forest Service
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources

NRC	Nodal Riparian Corridor
NRCA	Natural Resource Conservation Area
NRCS	Natural Resources Conservation Service
NSE	Nearshore and Estuarine
WDOH	Washington Department of Health
WFPB	Washington Forest Practices Board
WRIA	Water Resource Inventory Area

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1.0 INTRODUCTION

1.1 REPORT PURPOSE

Jefferson County is updating its existing Shoreline Master Program (SMP) to comply with the Washington State Shoreline Management Act (SMA or the Act) requirements (Revised Code of Washington [RCW] 90.58), and its implementing guidelines (Washington Administrative Code [WAC] 173-26, Part III), which were adopted in 2003. The County's SMP includes policies and regulations for managing all fresh and saltwater shorelines of the state in Jefferson County. This report provides background information to be used in updating the existing goals, policies, and regulations for shoreline management.

The purpose of the report is to describe current shoreline conditions and characterize the ecosystem processes (also referred to as watershed processes) that shape and influence shoreline environments. As outlined by the state shoreline guidelines (see WAC 173-26-201(3)), shoreline inventory and analysis are two steps of the multi-step SMP update process. The other required steps are:

- Invite and encourage public participation in the development of shoreline goals and policies;
- Establish shoreline environment designations (SEDs);
- Establish shoreline policies; and
- Prepare shoreline regulations.

The County is in the process of completing all of the required steps in accordance with the terms and conditions of a grant agreement (Grant # G0600343) with the Washington State Department of Ecology (Ecology) (Appendix A). The County has also prepared a cumulative impact analysis and a shoreline restoration plan as required by the state shoreline guidelines. The cumulative impacts analysis and restoration plan were prepared as separate documents.

1.2 BACKGROUND AND LIMITATIONS

This report is based on published and unpublished literature pertaining to Jefferson County shorelines and shoreline management in general. Much of the information was derived from aerial photography, including the 2001 and 2006 shoreline oblique photos provided by Ecology (available at: http://apps.ecy.wa.gov/shorephotos/), and existing Geographic Information Systems (GIS) data compiled and collected primarily by Jefferson County Department of Community Development. This report updates the May 2007 and September 2006 Draft Shoreline Inventory and Characterization Reports (SICRs)(ESA Adolfson et al., 2007; Adolfson et al., 2006) as well as the County's previous shoreline inventory report titled *Jefferson County Shoreline Master Program Update: Shoreline Inventory and Analysis Report, CZM306 Grant G0400080*, prepared by Neil Harrington in October 2005. Much of the text from the Harrington report is included here verbatim, and maps referenced in that report are provided in Appendix B. Readers are advised that the numbering convention for the maps used here (for the 2008 Inventory) differs from the numbering used in the Harrington (2005) report.

Although the scope of this effort did not include field verification of shoreline conditions, considerable effort was put forth to ensure that the information presented is complete and accurate as of the date of publication. This included soliciting information from numerous reliable sources and requesting peer review from local, state, and federal agency representatives, tribes, and non-governmental organizations with knowledge of the local shoreline conditions. Department of Ecology Staff and the County's Planning and other Department staff provided pertinent reference materials and reviewed the May 2007 STAC Draft Inventory and Characterization Report for accuracy and completeness. In addition, members of the County's Shoreline Technical Advisory Committee (STAC, see Acknowledgements section for a list of members) previously provided pertinent reference materials and reviewed the September 2006 Draft Inventory and Characterization Report. This final report addresses comments and suggestions provided by the Department of Ecology, County staff, and STAC members and incorporates new information brought to light by committee members, as well as previous STAC-requested revisions that could not previously be accommodated due to schedule and/or budget limitations.

This report provides a general inventory description of existing conditions along approximately 250 miles of marine shoreline and approximately 22 miles of lakeshore on 14 lakes that are designated as shorelines of the state in Jefferson County. In addition, this report provides a general inventory of more than 742 'river miles' of stream and river shoreline, of which approximately 238 river miles are within County-regulated (non-federal and non-tribal) lands (based on 20 cubic feet per second [cfs] mapping from USGS, 1998). It also characterizes, in a general manner, the ecosystem processes that shape and influence conditions along each reach of the County's shoreline. A goal of the watershed or landscape-scale analysis is to determine which of the key shoreline-influencing processes have been altered or impaired, even if the factors contributing to the impairment occur outside or beyond the jurisdiction of the SMA. The intent of the shoreline reach-scale analysis is to identify how existing conditions at or near the shoreline have responded to watershed alterations, and how the alterations have affected the functions and values of the SMA-regulated shorelines.

While this report provides a basis for updating the policies and regulations contained in the County's SMP, it does not provide a complete blueprint for managing each individual shoreline parcel or property over time. Readers are reminded that much of the information presented herein (concerning water quality, protected/priority habitats and species, land cover, etc.) is from government-maintained databases, which are frequently updated to reflect changing conditions. Furthermore, some of the shoreline characteristics described or mapped in this report are ephemeral or seasonal. For example, eelgrass beds can change in response to changing weather or circulation patterns, and forage fish can commence spawning in areas where they have not previously been known to spawn. In many cases, decisions on how or whether specific shoreline areas should be used, developed, or restored will require additional, site-specific/time-specific data and/or analyses.

Finally, this report is not intended as a full evaluation of the effectiveness of the SMA or County's existing shoreline policies or regulations. Alterations and impairments described in this report could be the result of actions that occurred prior to the adoption of the SMP, actions that are exempt from SMP regulation as dictated by the Act, illegal actions, and/or actions that occurred outside shoreline jurisdiction. That said, the inventory and characterization information can serve as a valuable tool for determining how future use and development might affect shoreline resources, where there are opportunities to restore or rectify past impacts, and where there are valuable or unaltered areas that need protection.

1.2.1 Mapping

Accompanying this text is an electronic map folio depicting some of the pertinent watershed-scale and reach-scale information described herein[1] (Appendix C). The maps were generated from a project-specific GIS database maintained by Jefferson County and updated throughout development of this report. The GIS database includes myriad datasets from a variety of sources. Using the GIS database, it is possible to plot and map virtually any shoreline attribute at any scale. Plotting all of the attributes at a fairly refined scale (e.g., 1:24,000 or larger) would require hundreds of maps. Because of the expense and logistical challenges associated with producing such a large quantity of maps, the map folio focuses on key features of interest for SMA-regulated shorelines.

In some cases, the report authors have consolidated information in the database to facilitate depiction of key information at a reasonable scale. For example, the project-specific database includes data from a recent study by the Point No Point Treaty Council (PNPTC) on the *Historical Changes to Estuaries, Spits, and Associated Tidal Wetland Habitats in the Hood Canal and Strait of Juan de Fuca Regions of Washington State* (Todd et al., 2006). Some of the data from this study were aggregated to create the maps in Appendix C (see Maps 26 and 27 for the PNPTC information). Readers are encouraged to review the map folio in conjunction with the text for better understanding, recognizing that the maps are only a subset of the data used to compile this analysis.

The County is divided into three general areas for purposes of displaying maps: southeast, northeast and west. For some attributes (e.g., aquatic vegetation, shoreline modifications, etc.), complete data layers are only available for eastern Jefferson County. In general, characteristics of the Pacific Coast shore and some of the major west coast tributaries (i.e., the Queets River) may not be fully represented on maps since they are outside County shoreline jurisdiction.

As a final reminder, the information presented in this report is not necessarily accurate to the parcel or property boundary scale. For this reason, **this report makes no representation as to the exact ownership (public or private) of specific areas of the County shoreline or adjacent tidelands, except for noting the general location of public parks and other public access points.** Similarly, the maps included here were prepared for planning purposes only. The regulatory extent of “shoreline jurisdiction” (described below) at any one location or property will require site-specific, field-based investigation.

[1] All of the referenced maps are contained in Appendix C. Figures are included in the body of the text.

1.3 REGULATORY OVERVIEW

Washington's Shoreline Management Act was passed by the State Legislature in 1971 and adopted by the public in a referendum. The SMA was created in response to a growing concern among residents of the state that unplanned and uncoordinated development was causing serious and permanent damage to shorelines. The purpose of the SMA is to "…provide for the management of the shorelines of the state by planning for and fostering all reasonable and appropriate uses[2]." Ecology administers the Act, but gives primary permitting authority for shoreline development to local governments.

Local governments also have responsibility for developing SMPs in accordance with Ecology's guidelines. The guidelines give local governments discretion to adopt master programs reflecting local circumstances and to develop other local regulatory and non-regulatory programs related to the goals of shoreline management as provided in the policy statements of RCW 90.58.020, WAC 173-26-176, and WAC 173-26-181.

Shoreline Master Programs balance and integrate the objectives and interests of local citizens and address the full variety of conditions on the shoreline. They have a planning function as well as a regulatory function. The planning function may take into account areas outside the territorial limits of the shorelines of the state. The regulatory function is limited to the areas subject to shoreline jurisdiction as defined by the Act (RCW 90.58.030(2)).

1.3.1 Jefferson County Shoreline Master Program

Jefferson County adopted its existing SMP in 1989 and amended it most recently in 1998. The SMP provides both policies and regulations to govern development and use of the County shorelines. The SMP is codified as Chapter 18.25 of the Jefferson County Code (JCC). The UDC regulates shoreline development by requiring shoreline substantial development permits, variances, conditional use permits, or statement of exemption according to the criteria established by the Act (RCW 90.58.140).

Local SMPs establish a system to classify shoreline areas into specific "environment designations." The purpose of shoreline environment designations (SEDs) is to provide a uniform basis for applying policies and use regulations within distinctly different shoreline areas. In a regulatory context, SEDs function similarly to zoning overlay districts. That is, they provide an additional layer of policy and regulation that applies, in conjunction with other development standards, to lands and waters within shoreline jurisdiction. Generally, environment designations are based on biological and physical capabilities and limitations of the shoreline, existing and planned development patterns, and a community's vision and objectives for future development.

The environment designations in the County's current SMP were developed based on land use patterns, biophysical capabilities and limitations of the shorelines, and input from local citizens as well as the County comprehensive land use plan and Ecology guidelines as they existed at the time. The environment designations have not been updated since they were originally adopted.

[2] RCW 90.58.020

Five environment designations are currently in effecting Jefferson County: Aquatic, Natural, Conservancy, Suburban, and Urban.

All of the County's river and lake shorelines currently have a Conservancy designation. More intensively developed marine shorelines near Port Townsend, Port Ludlow and Port Hadlock are designated Urban. Other marine shores are generally designated Conservancy or Suburban or a combination of the two, with scattered areas designated as Natural. The Aquatic designation applies only to areas waterward of the ordinary high water mark (OHWM). As noted in Section 1.1, part of the SMP update process involves revisiting and revising these designations in accordance with the new state criteria and standards in WAC 173-26- 211. Preliminary recommendations for revised SEDs are provided in Chapter 5 of this report.

A variety of other regulatory programs, plans, and policies work in concert with the County's SMP to manage shoreline resources and regulate development near the shoreline. The Comprehensive Plan establishes the general land use pattern and vision of growth and development the County has adopted for areas both inside and outside the shoreline jurisdiction. The County development standards and use regulations for environmentally critical areas are particularly relevant to the SMP. Designated environmentally critical areas including wetlands, aquifer recharge areas, frequently flooded areas, fish and wildlife habitat conservation areas, and geologically hazardous areas are found throughout County shoreline jurisdiction. The County recently adopted a new critical areas ordinance (JCC 18.22) to meet the Washington Growth Management Act mandates.

1.3.2 Shoreline Jurisdiction and Definitions

SMA jurisdiction includes all *shorelines of the state* as defined in RCW 90.58.030. Shorelines of the state include the total of all *shorelines* and *shorelines of statewide significance*. Shorelines means all of the water areas of the state, including reservoirs, and their associated *shorelands*, together with the lands underlying them, except:

- Shorelines on segments of streams upstream of a point where the mean annual flow is 20 cubic feet per second (cfs) or less and the wetlands associated with such upstream segments; and
- Shorelines on lakes less than 20 acres in size and the wetlands associated with such small lakes.

1.3.2.1 County Shorelines

Rivers and streams in Jefferson County that are designated shorelines are shown on Maps 1A and 1B in Appendix C and include: Goodman Creek, numerous tributaries to the Hoh River, Mosquito Creek, Cedar Creek, Snahapish River, numerous tributaries to the Clearwater River, Solleks River and portions of the Salmon River and Matheny Creek in the west side of the County. In the eastern part of the County, rivers and streams that are designated shorelines: Salmon Creek, Snow Creek, Chimacum Creek, Little Quilcene River, Big Quilcene River, Dosewallips River, Duckabush River, and Fulton Creek (revised from WAC 173-20-200 to include all rivers and streams below 20 cfs limits determined by USGS, 1998). Map 1C documents shoreline planning areas for rivers and streams showing the current upstream limits of shoreline jurisdiction based on the WAC and the proposed limits as derived from the 1998 USGS 20 cfs mapping (USGS, 1998).

Jefferson County lakes that meet the size threshold for shorelines are also shown on Maps 1A and 1B in Appendix C and include: Anderson, Crocker, Gibbs, Leland, Lords, Peterson, Sandy Shore, Tarboo, Wahl, Beausite, Teal, Rice, and one unnamed lake (Ludlow Lake) in Section 16, Township 30N, Range 1W[3].

Jefferson County marine shorelines include the waters of Puget Sound and Strait of Juan de Fuca and their underlying lands between the ordinary high water mark and extreme low tide.

1.3.2.2 Shorelands

Shorelands means those lands extending landward for 200 feet in all directions as measured on a horizontal plane from the OHWM; floodways and contiguous floodplain areas landward 200 feet from such floodways; and all wetlands and river deltas associated with such streams, lakes, and tidal waters.

In context of SMA, *associated wetlands* means wetlands that are in proximity to shorelines or that influence or are influenced by waters subject to the Act (WAC 173-22-030 (1)). These typically include wetlands that physically extend into the shoreline jurisdiction, and wetlands that are functionally related to the shoreline through a hydrologic connection or other factors. *Associated river deltas* include those lands formed as aggradational features at the mouths of streams where the streams enter a quieter body of water. The upstream extent of a river delta is where it no longer forms distributary channels.

A local jurisdiction may include all of the 100-year floodplain in its master program, or a portion thereof as long as such portion includes, at a minimum, the floodway and the adjacent land extending landward 200 feet within the floodplain.

1.3.2.3 County Shorelines of Statewide Significance

Freshwater shorelines of statewide significance include rivers with mean annual flow of 1,000 cfs or greater[4], and freshwater lakes 1,000 acres or larger. In Jefferson County, this includes portions of the Bogachiel, Clearwater, Hoh, Queets, Elwha and Quinault Rivers all located in western Jefferson County. The Queets River passes completely within Olympic National Park (ONP) and Tribal lands and the Elwha River passes completely within the ONP. None of the County's lakes are designated shorelines of statewide significance. Marine shorelines of statewide significance include: the area from the ordinary high water mark to the western boundary of the state on the west side of the County (excluding lands under federal or tribal ownership), the areas of Puget Sound and Strait of Juan de Fuca seaward of extreme low tide, and the areas of Hood Canal between ordinary high water mark and extreme low tide.

In general, federal/tribal actions on federal/tribal lands do not require shoreline permits, even if they are conducted within the shoreline area. However, non-federal/tribal actions on shorelines within federal/tribal lands are generally subject to the Act. This can include fee ownership in-

[3] Kah Tai Lake, which is also a shoreline of the state, is within the city of Port Townsend's municipal boundary and under city jurisdiction. Mill Pond is not a natural lake.

[4] For rivers west of the Cascade Range crest.

holdings (private property surrounded by national forest or other federal lands) or partial ownership such as mining claims. Applicability of the shoreline program within various federal land ownerships needs to be considered on a case-by-case basis. For some federal land holdings, the federal government has invoked "exclusive jurisdiction." For example, in Olympic National Park (ONP), the federal government has invoked exclusive jurisdiction over all lands and activities within the boundaries. The situation is variable with land under tribal ownership. Another type of exclusive federal status may be military installations where no non-federal activity is allowed, such as Indian Island.

For cities and counties updating their SMP maps, Ecology's general rule is to include shorelines of the state within federal lands in SMP maps except where exclusive federal or tribal jurisdiction is documented. Ecology cautions: "While SMP mapping within exclusive federal jurisdiction areas will not change any legal status of the lands, it could lead to confusion regarding applicability of the SMA." Map 1C (Appendix C) depicts rivers and streams within federal lands that would be jurisdictional under the SMA if a situation in which non-federal/tribal actions were to take place.

1.3.2.4 Potential Shorelines Not Designated by WAC 173-18 or 173-20

Following the passage of the Act in the early 1970s, Ecology developed a list of all known streams and lakes meeting the criteria for shorelines of the state[5]. The lists, which were codified in WAC 173-18 and 173-20, had not been updated since their initial development. Recently, Ecology revised the list of shoreline streams using data from several regional flow studies conducted by the U.S. Geological Survey (USGS 1998)[6]. The results of the USGS study showed that numerous streams that are not currently designated as shorelines of the state may actually meet the 20 cfs mean annual flow criterion and should be regulated as state shorelines. In other cases, the USGS study relocated the upstream boundary of the 20 cfs point further upstream or downstream from its WAC-designated location. In many cases the new stream flow data show the 20 cfs points in headwaters areas on federal lands, which may or may not be subject to County SMP jurisdiction. The revised list of streams in Jefferson County meeting the 20 cfs mean annual flow criterion is provided in Table 1-1. Mapping of rivers and streams depicted on Maps 1A and 1B in Appendix C have been updated to account for the USGS (1998) study, with most revisions to the codified list of WAC 173-18 and 173-20 occurring on streams located in the western portion of Jefferson County. For comparative purposes, Map 1C depicts shorelines of the state as designated by WAC 173-18 and 173-20 with the updated mapping of shorelines using the USGS 1998 information. All maps in Appendix C depicting the shoreline planning area associated with shorelines of the state include mapping updated per the 20 cfs information USGS (1998).

Bahls et al. (2006) initiated a similar effort to assess potential errors in state shoreline designation for lakes in Washington. The study attempted to estimate the error rate in current lake designation and develop a reliable and cost-effective method for local governments to use in identifying lakes that meet the 20-acre size threshold. The investigators used a three-phased approach to identify

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[5] The original U.S. Geological Survey stream flow report used by Ecology in the 1970s did not include streams above the first federal land boundary.

[6] The revised list has not been codified, but Ecology is currently in the process of revising state jurisdiction regulations to allow for incorporation of new data during the local SMP amendment process.

lakes equal to or greater than 20 acres throughout the state. The first phase involved GIS analysis, the second phase involved aerial photo interpretation, and the final phase included field assessment of a small subset of the lakes analyzed. The study identified several currently undesignated lakes in Jefferson County that appear to meet the criteria for shorelines of the state (indicated by shading in Table 1-2). Not all lakes within the County were assessed.

As a result of Bahls et al., 2006 and additional analysis done for this report, four additional lakes (Beausite, Teal, Rice, and Ludlow Lakes) have been determined to be shorelines of the state (in addition to the ten lakes included within the County's 1998 SMP). These lakes are believed to meet the 20-acre size threshold.

The additional potential shoreline streams and lakes are identified herein so that they can be included in the County's SMP if they occur on County-controlled lands (outside federal/tribal jurisdiction).

Table 1-1. Ecology's Updated List of Streams/Rivers Meeting the Definition of Shorelines of the State in Jefferson County

Stream or River *** indicates shoreline of statewide significance.** B = Branch; E = East; F = Fork; M = Middle; N = North; P = Prong; S = South; T = Tributary; U = Unnamed; W = West	**USGS 7.5 Minute Series Map where Point is Located**	**Currently Designated in WAC 173-18?**	**Total River Miles of Stream or River**	**River Miles on Federal Lands**	**20 cfs Upstream Limit on Federal Land?**
Alder Creek	Winfield Creek	No	1.7	0	No
Alta Creek	Kimta Peak	No	3.8	3.8	Yes
Alta Creek, U T	Bob Creek	No	0.6	0.6	Yes
Alta Creek, U T	Kimta Peak	No	0.4	0.4	Yes
Anderson Creek	Anderson Creek	No	1.5	0.5	Yes
Big Creek	Bunch Lake	No	12	11.5	Yes
Big Creek, U T	Bunch Lake	No	1.8	1.8	Yes
Big Quilcene River	Mount Townsend	Yes	15	11.5	Yes
Blue Glacier	Mount Olympus	No	No information	No information	Yes
Bob Creek	Bob Creek	No	1.9	1.9	Yes
Bogachiel River - Entire length in Jefferson County is a Shoreline	Indian Pass	Yes	9	4.6	Yes
Braden Creek	Kalaloch Ridge	No	0.7	0	No
Buckinghorse Creek	Chimney Peak	No	3.2	3.2	Yes
Cabin Creek	Eldon	No	1.3	1.3	Yes
Cameron Creek	Wellesley Peak	No	0.6	0.6	Yes
Cannings Creek - Entire length in Jefferson County is a Shoreline	Bunch Lake	No			Yes
Canoe Creek	Finley Creek	No	1.3	1.3	Yes
Cedar Creek	Kalaloch Ridge	Yes	2.4	0	No
Chimacum Creek	Center	Yes	5.4	0	No

Stream or River * indicates shoreline of statewide significance. B = Branch; E = East; F = Fork; M = Middle; N = North; P = Prong; S = South; T = Tributary; U = Unnamed; W = West	USGS 7.5 Minute Series Map where Point is Located	Currently Designated in WAC 173-18?	Total River Miles of Stream or River	River Miles on Federal Lands	20 cfs Upstream Limit on Federal Land?
Christmas Creek	Christmas Creek	Yes	6.4	0	No
Clearwater River - From confluence with U T	Kloochman Rock	Yes	35	1.4	Yes
Clearwater River *	Christmas Creek	Yes		0	No
Clearwater River, U T	Kloochman Rock	No	0.9	0	Yes
Clearwater River, U T	Kloochman Rock	No	No information	No information	Yes
Crazy Creek	Mount Steel	No	2.9	2.9	Yes
Cream Lake Creek	Mount Queets	No	2	2	Yes
Deception Creek	Christmas Creek	No	1.2	1.2	No
Delabarre Creek	Chimney Peak	No	3.1	3.1	Yes
Delabarre Creek, U T	Mount Christie	No	0.9	0.9	Yes
Dosewallips River	Wellesley Peak	Yes	26.1	19.1	Yes
Dosewallips River, W F	Mount Steel	No	No information	No information	Yes
Dowans Creek	Anderson Creek	No	1.4	0	No
Duckabush River	Mount Steel	Yes	24.3	20.7	Yes
Duckabush River, U T	The Brothers	No	0.8	0.8	Yes
Dungeness River	Mount Deception	No	5.1	5.1	Yes
Elip Creek	Kimta Peak	No	1.7	1.7	Yes
Elk Creek	Queets	No	4.6	1	No
Elk Lick Creek	Mount Steel	No	0,6	0.6	Yes
Elkhorn River	Mount Queets	No	2	2	Yes
Elwha River	Mount Queets	No	17.8	17.8	Yes
Elwha River, U T	Mount Queets	No	0.3	0.3	Yes
Finley Creek	Finley Creek	No	5.2	5.2	Yes
Finley Creek, U T	Finley Creek	No	2.1	2.1	Yes
Fletcher Canyon - Entire length in Jefferson County is a Shoreline	Bunch Lake	No	0.5	0	No
Fox Creek	Bunch Lake	No	1.2	1.2	Yes
Fulton Creek	Brinnon	Yes	1	0	No
Geoduck Creek	Mount Christie	No	1.9	1.9	Yes
Geoduck Creek, U T	Mount Christie	No	0.6	0.6	Yes
Godkin Creek	Chimney Peak	No	6.9	6.9	Yes
Godkin Creek, U T	Chimney Peak	No	1	1	Yes
Godkin Creek, U T	Chimney Peak	No	1.4	1.4	Yes
Goldie River	Mount Queets	No	7.4	7.4	Yes
Goldie River, U T	Mount Queets	No	1.6	1.6	Yes
Goldie River, U T	Mount Queets	No	1.5	1.5	Yes
Goldie River, U T	Mount Queets	No	3.1	3.1	Yes
Goldie River, U T	Mount Queets	No	1.7	1.7	Yes
Goodman Creek	Anderson Creek	Yes	9.9	9.9	No
Graves Creek	Mount Hoquiam	No	5.2	5.2	Yes
Gray Wolf River	Wellesley Peak	No	1.2	1.2	Yes

Stream or River *** indicates shoreline of statewide significance.** B = Branch; E = East; F = Fork; M = Middle; N = North; P = Prong; S = South; T = Tributary; U = Unnamed; W = West	**USGS 7.5 Minute Series Map where Point is Located**	**Currently Designated in WAC 173-18?**	**Total River Miles of Stream or River**	**River Miles on Federal Lands**	**20 cfs Upstream Limit on Federal Land?**
Hades Creek	Winfield Creek	No	1.4	1.4	Yes
Harlow Creek - Entire length in Jefferson County is a Shoreline	Salmon River West	No	7.6	7.6	Yesw
Hayes River	Chimney Peak	No	8.0	8.0	Yes
Hee Haw Creek	Kimta Peak	No	3.8	3.8	Yes
Hee Haw River	Kimta Peak	No	No information	No information	Yes
Hell Roaring Creek, E F	Anderson Creek	No	No information	No information	Unclear
Hoh River	Mount Olympus	No	58.3	30.5	Yes
Hoh River *	Owl Mountain	Yes	No information	No information	Yes
Hoh River, S F	Mount Olympus	Yes	14.9	14.9	Yes
Hoh River, S F, U T	Bob Creek	No	0.3	0.3	Yes
Hoh River, S F, U T	Kloochman Rock	No	1.8	1.8	Yes
Hoh River, S F, U T	Mount Olympus	No	0.3	0.3	Yes
Hoh River, S F, U T	Mount Tom	No	2.5	2.5	Yes
Hoh River, S F, U T	Mount Tom	No	No information	No information	Yes
Hoh River, U T	Mount Queets	No	1.1	1.1	Yes
Hoh River, U T	Mount Tom	No	0.8	0.8	Yes
Hoh River, U T	Mount Tom	No	3.0	3.0	Yes
Hoh River, U T	Owl Mountain	No	0.5	0.5	Yes
Hoh River, U T	Owl Mountain	No	No information	No information	Yes
Hook Branch Creek	Matheny Ridge	No	2.3	2.3	Yes
Howe Creek - Entire length in Jefferson County is a Shoreline	Bunch Lake	No	No information	No information	Yes
Hungry Creek	The Brothers	No	0.7	0.7	Yes
Hurst Creek	Salmon River West	Yes	4.3	0	No
Ice River	Mount Olympus	No	1.6	1.6	Yes
Irely Creek	Bunch Lake	No	0.2	0.2	Yes
Jackson Creek	Owl Mountain	No	3.5	3.5	Yes
Jeffers Glacier	Mount Olympus	No	No information	No information	Yes
Jemrod Creek	Mount Olympus	No	0.8	0.8	Yes
Kalaloch Creek	Kalaloch Ridge	Yes	6.2	0	No
Kalaloch Creek, E F	Kalaloch Ridge	No	No information	No information	Yes
Kimta Creek	Kimta Peak	No	3.0	3.0	Yes
Kunamakst Creek	Stequaleho Creek	No	0.8	0.0	Yes
Lena Creek	The Brothers	No	2.5	2.5	Yes
Litchy Creek	Mount Hoquiam	No	3.5	3.5	Yes
Litchy Creek, U T	Mount Hoquiam	No	0.5	0.5	Yes
Little Quilcene River - Entire length in Jefferson County is a Shoreline	Mount Walker	Yes	5.8	0	No
Long Creek	Mount Queets	No	1.1	1.1	Yes

Stream or River * indicates shoreline of statewide significance. B = Branch; E = East; F = Fork; M = Middle; N = North; P = Prong; S = South; T = Tributary; U = Unnamed; W = West	USGS 7.5 Minute Series Map where Point is Located	Currently Designated in WAC 173-18?	Total River Miles of Stream or River	River Miles on Federal Lands	20 cfs Upstream Limit on Federal Land?
Long Creek, U T	Hurricane Hill	No	No information	No information	Yes
Lost River	Mc Cartney Peak	No	5.5	5.5	Yes
Manor Creek, S F	Stequaleho Creek	No	2.4	0	No
Maple Creek	Spruce Mountain	Yes	3.4	0	No
Matheny Creek	Finley Creek	Yes	17.1	12.5	Yes
Matheny Creek, U T	Finley Creek	No	4.4	4.4	Yes
Matheny Creek, U T	Matheny Ridge	No	No information	No information	Yes
Matheny Creek, U T	Matheny Ridge	No	No information	No information	Yes
Mckinnon Creek	Salmon River West	No	0.8	0.5	Yes
Miller Creek	Kalaloch Ridge	Yes	4.8	0	No
Miller Creek, E F	Christmas Creek	Yes	No information	No information	Yes
Minter Creek	Hoh Head	Yes	3.0	0	No
Mosquito Creek	Hoh Head	Yes	4.8	0	No
Mosquito Creek, N F	Hoh Head	No	1.2	0	No
Mount Tom Creek - From its' confluence with U T	Mount Tom	No	8.3	8.3	Yes
Mount Tom Creek, U T	Mount Tom	No	0.7	0.7	Yes
Mount Tom Creek, U T	Mount Tom	No	0.9	0.9	Yes
Mount Tom Creek, U T	Mount Tom	No	No information	No information	Yes
Mud Creek	Salmon River East	No	2.2	0.5	Yes
Murphy Creek	Quillayute Prairie	No	No information	No information	Unclear
Nolan Creek	Christmas Creek	Yes	4.4	0.0	Yes
Noname Creek	Chimney Peak	No	0.7	0.7	Yes
O'Neil Creek	Mount Olson	No	No information	No information	Yes
Owl Creek	Spruce Mountain	Yes	5.7	0	No
Paradise Creek	Bob Creek	No	0.6	0.6	Yes
Paull Creek	Mount Olympus	No	1.3	1.3	Yes
Promise Creek	Kimta Peak	No	2.4	2.4	Yes
Pyrites Creek	Chimney Peak	No	1.3	1.3	Yes
Queets River	Mount Queets	No	53.7	53.7	Yes
Queets River *	Kloochman Rock	No	No information	No information	Yes
Queets River, U T	Bob Creek	No	0.4	0.4	Yes
Queets River, U T	Kimta Peak	No	0.0	0	No
Queets River, U T	Kimta Peak	No	0.6	0.6	Yes
Queets River, U T	Mount Queets	No	0.1	0.1	Yes
Queets River, U T	Mount Queets	No	0.9	0.9	Yes
Queets River, U T	Mount Queets	No	0.9	0.9	Yes
Queets River, U T	Salmon River East	No	0.8	0.8	Yes
Quinault River	Mount Steel	No	16.5	14.3	Yes
Quinault River *	Bunch Lake	Yes	No information	No information	Yes
Quinault River, N F	Mount Christie	Yes	18.5	18.5	Yes
Quinault River, N F, U T	Mount Christie	No	1.0	1.0	Yes

Stream or River *** indicates shoreline of statewide significance.** B = Branch; E = East; F = Fork; M = Middle; N = North; P = Prong; S = South; T = Tributary; U = Unnamed; W = West	**USGS 7.5 Minute Series Map where Point is Located**	**Currently Designated in WAC 173-18?**	**Total River Miles of Stream or River**	**River Miles on Federal Lands**	**20 cfs Upstream Limit on Federal Land?**
Quinault River, N F, U T	Mount Christie	No	No information	No information	Yes
Quinault River, U T	Mount Hoquiam	No	0.6	0.6	Yes
Quinault River, U T - Entire length in Jefferson County is a Shoreline	Mount Olson	No	No information	No information	Yes
Rocky Brook	Brinnon	No	2.2	1.8	Yes
Royal Creek	Mount Deception	No	0.8	0.8	Yes
Rustler Creek	Chimney Peak	No	9.2	9.2	Yes
Rustler Creek, U T	Mount Christie	No	0.7	0.7	Yes
Rustler Creek, U T	Mount Christie	No	1.5	1.5	Yes
Rustler Creek, U T	Mount Christie	No	0.3	0.3	Yes
Saghalie Creek	Mount Christie	No	3.2	3.2	Yes
Salmon Creek	Uncas	Yes	1.6	0.0	No
Salmon River, M F	Matheny Ridge	No	4.8	3.3	Yes
Salmon River, N F	Matheny Ridge	No	2.6	2.6	Yes
Sams River	Finley Creek	No	14.9	14.3	Yes
Sams River, U T	Matheny Ridge	No	1.4	1.4	Yes
Seattle Creek	Mount Christie	No	1.5	1.5	Yes
Shale Creek	Christmas Creek	Yes	3.4	0	No
Silt River	Wellesley Peak	No	5.1	5.1	Yes
Silt River, U T	Wellesley Peak	No	0.7	0.7	Yes
Snahapish River	Winfield Creek	Yes	11.9	0	No
Snahapish River, U T	Christmas Creek	No	0.8	0	No
Snow Creek	Uncas	Yes	3.5	0	No
Solleks River, U T	Stequaleho Creek	Yes	0.9	0.0	Yes
Solleks River	Kloochman Rock	No	9.0	0.0	Yes
Stalding Creek	Kimta Peak	No	1.1	1.1	Yes
Stequaleho Creek	Stequaleho Creek	Yes	5.9	0.0	Yes
Tacoma Creek	Salmon River West	No	1.5	0.6	Yes
Three Prune Creek	Kimta Peak	No	2.4	2.4	Yes
Townsend Creek	Mount Walker	No	6.2	6.2	Yes
Tsheltshy Creek	Bunch Lake	No	12.6	12.6	Yes
Tshletshy Creek, U T	Bob Creek	No	0.7	0.7	Yes
Tshletshy Creek, U T	Bob Creek	No	1.0	1.0	Yes
Tshletshy Creek, U T	Bob Creek	No	1.7	1.7	Yes
Tshletshy Creek, U T	Bob Creek	No	1.0	1.0	Yes
Tshletshy Creek, U T	Bob Creek	No	1.5	1.5	Yes
Tshletshy Creek, U T	Kloochman Rock	No	0.4	0.4	Yes
Tumwata Creek	Spruce Mountain	No	2.7	2.7	Yes
Tunnel Creek	Mount Townsend	No	No information	No information	Yes
Tunnel Creek, U T	Mount Townsend	No	0.7	0.7	Yes
Twin Creek	Spruce Mountain	No	1.0	1.0	Yes
Upper O'Neil Creek	Chimney Peak	No	0.8	0.8	Yes

Stream or River *** indicates shoreline of statewide significance.** B = Branch; E = East; F = Fork; M = Middle; N = North; P = Prong; S = South; T = Tributary; U = Unnamed; W = West	**USGS 7.5 Minute Series Map where Point is Located**	**Currently Designated in WAC 173-18?**	**Total River Miles of Stream or River**	**River Miles on Federal Lands**	**20 cfs Upstream Limit on Federal Land?**
White Glacier	Mount Olympus	No	6.0	6.0	Yes
Wild Rose Creek	Bunch Lake	No	1.3	1.3	Yes
Willoughby Creek	Winfield Creek	No	0.4	0	No
Winfield Creek	Winfield Creek	Yes	4.3	0	No
Winfield Creek, U T	Winfield Creek	No	1.2	0	No
Wynoochee River	Mount Hoquiam	No	0.6	0.6	Yes

Table 1-2. Comparison of 1998 SMP Listed Lakes, WAC 173-20 Listed Lakes, and Bahls et al. (2006) Results; and Recommended Shoreline of the State Status (Includes Only Lakes within County Jurisdiction)

Recommended Shorelines of the State are indicated in Red Text

Lake Name	1998 SMP Listing	WAC Listing	Results of Bahls et al. 2006	Recommended Status
Anderson	Listed	Listed	Not Assessed	**Shoreline of the State**
Crocker	Listed	Listed	Not Assessed	**Shoreline of the State**
Gibbs	Listed	Listed	Not Assessed	**Shoreline of the State**
Leland	Listed	Listed	Not Assessed	**Shoreline of the State**
Lords	Listed	Listed	Not Assessed	**Shoreline of the State**
Peterson	Listed	Listed	Not Assessed	**Shoreline of the State**
Sandy Shore	Listed	Listed	Not Assessed	**Shoreline of the State**
Tarboo	Listed	Listed	Not Assessed	**Shoreline of the State**
Unnamed Lake (commonly called Mill Pond)	Listed	Listed	Not Assessed	**Shoreline of the State**
Wahl	Listed	Listed	Not Assessed	**Shoreline of the State**
Beausite	Not Listed	Not Listed	Open Water 10-19 Acres, Possible Shoreline	**Shoreline of the State**
Rice	Not Listed	Not Listed	Open Water 20+ Acres, Possible Shoreline	**Shoreline of the State**
Teal	Not Listed	Not Listed	Open Water 10-19 Acres, Possible Shoreline	**Shoreline of the State**
Ludlow	Not Listed	Not Listed	Open Water 10-19 Acres, Possible Shoreline	**Shoreline of the State**
Browns	Not Listed	Not Listed	Open Water 1-9 Acres, Not Shoreline	Not a Shoreline of the State
Delaney	Not Listed	Not Listed	Open Water 1-9 Acres, Possible Shoreline	Not a Shoreline of the State

Recommended Shorelines of the State are indicated in Red Text

Lake Name	1998 SMP Listing	WAC Listing	Results of Bahls et al. 2006	Recommended Status
East Wahl (Twin Lakes)	Not Listed	Not Listed	Open Water 1-9 Acres, Possible Shoreline	Not a Shoreline of the State
Embody	Not Listed	Not Listed	Open Water 1-9 Acres, Possible Shoreline	Not a Shoreline of the State
Horseshoe	Not Listed	Not Listed	Open Water 10-19 Acres, Possible Shoreline	Not a Shoreline of the State
Thorndyke	Not Listed	Not Listed	Not Found – <1 Acre Open Water	Not a Shoreline of the State
Larson	Not Listed	Not Listed	Not Assessed	Not a Shoreline of the State

2.0 METHODS

2.1 DATA AND INFORMATION SOURCES

The information contained in this report was derived from readily available published and unpublished studies and literature as well as GIS maps and data. A full bibliography is contained at the end of the report. Metadata are available through the Jefferson County Department of Community Development.

This report presents an inventory and analysis of Jefferson County's shorelines at distinct spatial scales: the ecosystem (or watershed) scale, the basin scale, and the shoreline reach scale. The relationship between the various scales of analysis is represented in Figure 2-1. As noted in Section 1.2.1, much of the key inventory information is displayed on maps provided in the map folio (Appendix C). Table 2-1 describes the key GIS data sources used for various inventory elements (themes) described in the text and identifies the map or maps where the information is displayed[1]. Table 3 is not an exhaustive list. Some GIS data used in preparation of this report are not displayed on a map and thus do not appear in Table 2-1. In some cases, mapping data not available in GIS format are integrated in the report text as graphic figures.

2.2 ANALYSIS OF ECOSYSTEM-WIDE PROCESSES

For purposes of this report, ecosystem-wide processes (or landscape processes) are assessed at the watershed scale according to Water Resource Inventory Area (WRIA) boundaries. In this document, *ecosystem-wide processes* refers to the dynamic physical and chemical interactions that form and maintain the landscape at the geographic scales of watersheds to basins (hundreds to thousands of square miles). These processes include the movement of water, sediment, nutrients, pathogens, toxins, and wood as they enter into, pass through, and eventually leave the watershed. The assessment approach for nearshore and freshwater processes varies slightly as outlined below.

[1] Data described in the text are from the applicable data source shown in this table unless otherwise noted.

FIGURE 2-1. Schematic diagram showing the scales of analysis (watershed, basin, and reach/drift cell) and report structure.

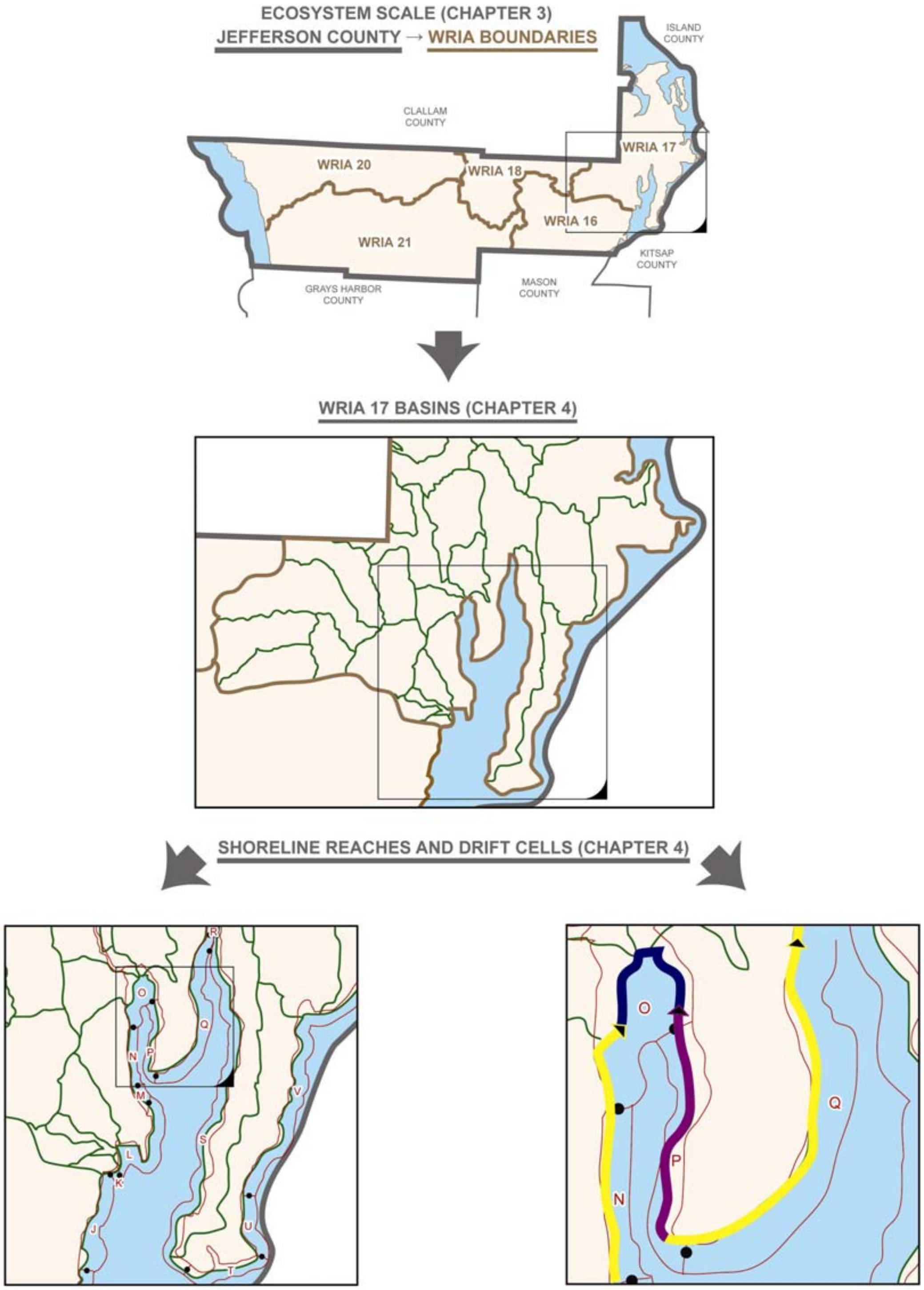


Table 2-1. Jefferson County Shoreline Inventory and Characterization
Primary GIS / Mapping Data Sources

Theme	Map Name/ No.	Source	Issues / Notes
Shorelines of the State	Maps 1A,1B and IC. Jefferson County Shorelines of the State	County mapping for regulated shorelines (existing Shoreline Environment Designations); lakes; wetlands; floodplains. USGS/Ecology (1998) for potential upstream limits of 20 cfs and 1,000 cfs rivers and streams. NW Watershed Institute/ Washington Trout (Bahls et al. 2006) for potential lakes of 20 acres.	
WRIA Boundaries		Ecology.	
Federal / Tribal Land		Protected Lands database (CommenSpace for Jefferson County, 2004).	
Ecosystem-scale Analysis			
Hydrology / Streams and Lakes	Maps 2 and 3. Hydrology	County / WDNR (2004).	Multiple sources with variety of spatial accuracy and detail; County pursuing conversion to National Hydrology Framework.
WRIA Boundaries		Ecology.	
Watershed Boundary		County / WDNR (wshed_oly).	
Permeability		Low, Medium, High permeability ratings for geologic units, based on WDNR 100K scale geologic mapping with input from Ecology.	Geology mapping not available countywide; includes east and west portions of County.
Wetlands / Potential Wetlands		NWI; 1999-2000 landsat (30 m resolution) for wetland classes; hydric soils based on SSURGO (digital NRCS/SCS soil survey).	Soil data of limited extent; NWI spatial accuracy is limited and dated.
Topography		USGS 10 m DEM; LIDAR for eastern Jefferson County.	
Floodplains (100-year floodplain)		County; derived from digital FEMA mapping (1998).	Mapping not available countywide; includes east and west portions of County.
Rain-on-Snow (ROS) and snow-dominated (SD) Zones		WDNR Forest Practices, 1991; 1:250K scale mapping; selected for areas classified as “peak rain on snow” and snow dominated zones.	

Theme	Map Name/ No.	Source	Issues / Notes
Channel Migration Zones (CMZ)		Designated Channel Migration Study for Eastern Jefferson County (Klawon, 2004). Undesignated CMZs: Additional information on specific reaches of the Hoh River (US BOR, 2004; Herrera Consultants and Northwest Hydraulics 2002; Perkins Geosciences and Terra Logic, 2004) is noted.	Eastern County limited to Duckabush, Dosewallips, Big Quilcene and Little Quilcene Rivers. Additional information on Hoh River was reviewed but not available in GIS format for inclusion in map folio. Scanned graphics are included in report text.
Land Cover (early and late seral stage vegetation; human imprint)		1999-2000 landsat data; 30 m resolution. Late Seral Stage: all forest classes. Early Seral Stage: all non-forest vegetative classes. Human Imprint: all developed or altered classes (agricultural; residential; commercial; transportation; etc.).	Countywide coverage; resolution appropriate for landscape analysis only; slightly dated; good classification for alterations and mature forest cover.
Hydrology / Streams and Lakes; WRIA Boundaries; Watershed Boundary; Permeability; Wetlands	Maps 4 and 5. Water Quality	As described above (Hydrology Map set).	
Dairy farms		Ecology point data.	Limited spatial extent – eastern County only.
Water Quality (not shown on map)		2004 Ecology Water Quality Assessment / 303(d) data.	Data limited to tested waterbodies.
Septic Permits		County; parcel query from County Dept. of Health records for properties with septic tanks (2006).	Limited spatial extent – eastern County only.
Tilled Fields		1999-2000 landsat data; 30 m resolution. Classification = “Row Crops”.	
Lost Wetlands		Lost depressional wetlands depicted by hydric soil units on 2% slopes or less that intersect “Human Imprint” areas (as described below).	
Human Imprint		1999-2000 landsat data; 30 m resolution: Areas classified as developed or altered (agricultural; residential; commercial; transportation; etc.).	

Theme	Map Name/ No.	Source	Issues / Notes
Hydrology / Streams and Lakes; WRIA Boundaries; Watershed Boundary	Maps 6 and 7. Sediment	As described above (Hydrology Map set).	
Road Density		County data; WDNR.	County data limited to major roads; WDNR Trans layer much more thorough – includes network of logging roads throughout County.
LSI Landslides		Landslide Inventory, WDNR Forest Practices (Vaugeois and Boyd, 2004) (aka Mass Wasting Events).	Compiled from a variety of 1:24000 scale products dating 1999-2003.
Landslide Hazard Zonation		WDNR Forest Practices (hazone-landform areas of landslide hazard, 2007).	Statewide mapping effort, compiled from previously existing public and private assessments and the landslide hazard zonation project (LHZ).
Erodible Soils		SSURGO (digital NRCS/SCS soil survey) where slope >= 30% and erodibility factor = 0.24 – 0.32.	Limited spatial extent – eastern County only.
Human Imprint		As described above.	
Reach-Scale Inventory Maps			
Shoreline Planning Area (i.e., Shoreline Inventory Reaches)	Maps 8, 9, and 10. Aquatic Resources	County mapping for regulated shorelines (existing SEDs); wetlands; Public Lands database for boundaries of federal and tribal land.	
Reach Breaks		SSHIAP for breaks in stream gradient and natural barriers to fish migration; drift cells for marine reach breaks.	Differ in places from reach breaks defined in previous County inventory (Harrington, 2005).
Potential Wetlands		As described above.	
Federal Land		As described above.	
100-year Floodplain		As described above.	
Channel Migration Zone		As described above.	
Riparian Corridor Conditions	Not mapped.	East Jefferson County Salmonid Refugia Report (May and Peterson, 2003).	Data on riparian conditions in eastern County was reviewed but not included in map folio. Ranked nodal corridors from study are shown as graphics in report text.

Theme	Map Name/ No.	Source	Issues / Notes
Shoreline Modifications (nearshore)	Maps 11, 12, and 13. Coastal Processes and Modifications	PNPTC survey/mapping data from 1999-2000 depicting bulkheads, marinas (line files) and docks, piers, jetties, groins, launch ramps, and stairs (point files).	Limited spatial extent – eastern County only. As documented by Hirschi et al., 2003.
Freshwater Shoreline Modifications	Not mapped.	Limited data sources; 2000 aerial photos for piers and docks on lakes.	No comprehensive mapping of levees, revetments, or other bank alterations to rivers and streams.
Shore Form Type	Maps 11, 12, and 13	WDNR (2001) ShoreZone Inventory depiction of marine shorelines, classified as: Accretional, Erosional, Stable.	General accuracy limitations with statewide dataset (filmed shoreline by helicopter). Additional nearshore geomorphic landform data included in Maps 26 and 27 (described below).
Feeder Bluffs	Not mapped.	No comprehensive mapping layer.	Data derived from variety of sources (drift cell descriptions; geo-hazards; coastal atlas slope stability mapping; and WDNR ShoreZone for "erosional" shorelines). Report incorporates Coastal Geologic Study for Kala Pt. To Tala Pt. (Johanessen 1999) – not in GIS format.
Drift Cells	Maps 11, 12, and 13	Ecology compiled statewide GIS file.	Compilation of drift cell studies of varying detail and dates of study; accuracy is limited.
Critical Aquifer Recharge Areas	Maps 14, 15, and 16. Critical Areas	County GIS, 2003. Produced from Geology source coverage based on susceptible aquifer areas specified in the Unified Development Code and from CAD drawings of Special Aquifer Recharge Protection Areas from the Jefferson County Natural Resources Department and the Jefferson County Public Utility District.	Limited spatial extent – eastern County only.
Landslide Hazard (County) / Landslide Hazard Zonation (WDNR)	Maps 26 and 27	County GIS. Metadata lacking. WDNR data (as described above).	Limited spatial extent – eastern County only.
Erosion Hazard	Maps 26 and 27	County GIS. Metadata lacking.	Limited spatial extent – eastern County only.

Theme	Map Name/ No.	Source	Issues / Notes
Potential Wetlands		As described above.	
Frequently Flooded Areas (100-year Floodplain)	Maps 8, 9 and 10	As described above.	
Priority Fish Presence	Maps 17, 18, and 19. Critical Shoreline Habitat	WDFW (2006) data for priority fish distribution (fishdist).	Maps currently show WDFW PHS fish presence/use as rearing vs. spawning vs. migration.
Priority Habitat Areas	Maps 11, 12, and 13	WDFW (2006) (phspoly) shown for areas associated with species use.	
Marine Resource Species (geoduck, urchin, oyster, crab, clam, razor clam, surfsmelt, sandlance, herring)	Maps 17, 18, and 19	WDFW (2006) shows documented presence of shellfish and forage fish species.	WDFW PHS/MRS data incorporates 2005 NOSC forage fish survey data.
Eelgrass	Map 20. Aquatic Vegetation	WDNR (2001) ShoreZone Inventory depiction of eelgrass, classified as: Continuous or Patchy. WDNR Aquatic Lands Eelgrass Sampling Sites, 2000-2005 for areas in eastern Jefferson County.	
Kelp	Map 20	WDNR (2001) ShoreZone Inventory depiction of kelp, classified as: Continuous or Patchy.	
Land Use / Land Ownership (not shown on map)	Maps 21, 22, and 23. Land and Shoreline Use Patterns	Parcel data with Assessor current use codes; Washington Public Lands Database (CommenSpace)	Assessor data has limited accuracy and currency difficult to verify.
Shoreline Features	Maps 11, 12 and 13	PNPTC survey/mapping data from 1999-2000 depicting marinas (line files) and boat launch ramps to illustrate water dependent shoreline access/use.	As documented by Hirschi et al., 2003.
Current and propsosed Shoreline Environment Designations	Maps 29, 30 and 31	County GIS (based on 1989 SMP designations currently in effect).	
Zoning		Jefferson County.	

Theme	Map Name/ No.	Source	Issues / Notes
Publicly Owned Tidelands	Maps 21, 22 and 23	WDNR Aquatic Lands (Feb 2007). Tidelands recorded in public ownership by federal, state, or county government or other public agency/entity.	Aquatic land ownership parcels.
Commercial Shellfish Growing Areas; Biotoxin Closure Zones; Recreational Harvest Beaches	Map 24. Shellfish Harvesting	WDOH (2006). Draft data by Jamestown Tribe showing tribal shellfish harvest beaches in east Jefferson County.	Data shows management zones by WDOH; does not necessarily show where actual commercial shellfish operations are currently active. Data developed by Jamestown Tribe were not available in GIS format but shown as graphic in report text (Figure 3-3).
Forest Cover	Map 25. Forest Cover and Impervious Surface	1999-2000 landsat data; 30 m resolution. Early and Late Seral Stage classes as described above.	Countywide coverage; resolution appropriate for landscape analysis only; slightly dated; good classification for alterations and mature forest cover.
Impervious Surface	Map 25. Forest Cover and Impervious Surface	Impervious Cover Mapping – Hood Canal Chum Salmon ESU (Hood Canal Coordinating Council, 2004).	Spatial extent limited to eastern Jefferson County (Chum Salmon Study Area).
Marine Shoreline Geomorphic Landforms	Maps 26 and 27. Geomorphic Classes	Battelle's Nearshore Restoration Prioritization for Jefferson County (Diefenderfer et al., 2006).	Limited spatial extent – eastern County only. Marine shoreline classified at ShoreZone unit scale into 7 landform types.
Lagoons, Salt Marshes, and Intertidal Wetlands	Maps 26 and 27	PNPTC (Todd et al., 2006) survey/mapping data of nearshore features.	Limited spatial extent – eastern County only.
Shoreline Slope Stability	Maps 26 and 27	Ecology (mid-1970s; digitized 2001). Areas shown include those mapped as unstable slopes.	Data originally published as hard copy maps in the Coastal Zone Atlas of Washington between 1978 and 1980; limited to 2,000 feet from marine shoreline.
Landslide Hazard	Maps 26 and 27	As noted above.	
Erosion Hazard	Maps 26 and 27	As noted above.	
Zoning; Wetlands; Priority Habitats	Map 28. Quinault River	Mapping themes as noted above.	~4.8 miles of Quinault River in unincorporated Jefferson County; limited GIS data available for this area of the County.

2.2.1 Marine (Nearshore) Shorelines

The marine nearshore environment encompasses the interface between subtidal marine habitats and the adjacent uplands, or more specifically the area that extends waterward from the upland edge of the marine riparian zone (200 feet landward of OHWM) to depths of about 65 feet mean low water (Hood Canal Coordinating Council, 2005). These environments are formed and maintained by landscape-scale processes such as net shore-drift and fish and wildlife movement patterns (Williams et al., 2004). Nearshore habitats and the species that occupy and depend on them (including juvenile salmonid species and many species of commercially/recreationally harvestable shellfish) require that these landscape processes function properly across various spatial scales (Williams and Thom 2001; Ruckleshaus and McClure, 2007).

Several investigators have shown that the health and sustainability of nearshore environments are linked to physical processes at the watershed scale (Williams et al. 2004, Difenderfer et al., 2006). Physical processes create habitat structure, which affects habitat-related processes, which in turn influence ecological functions and values (Table 2-2). Chemical and biological processes also influence nearshore environments. As an example, decomposition of beach wrack is important for food chain support functions.

This characterization examines physical, chemical, and biological factors influencing marine environments at the landscape scale including local/regional geology, fluvial systems, waves, wind and energy/exposure, and land use/human development. These factors operate via different mechanisms and exert varying degrees of influence depending upon landscape position. In Jefferson County, the western shores of the Pacific Ocean are subject to different influences than the marine shores of Puget Sound (eastern Jefferson County) due to differences in oceanographic processes/circulation, geomorphology, bathymetry, net shore-drift patterns, fluvial influences, nutrient dynamics, effects of coastal bluff landslides, and land use.

Table 2-2. Relationship of Nearshore Physical Processes to Habitats and Ecological Functions (adapted from Williams et al., 2004)

Processes	Habitat Structure	Habitat Processes	Ecological Function
Wave Energy Light (Increase) Light (Shading) Sediment Supply Substrate Pollution/Nutrients Hydrology Physical Disturbance	Density Biomass Length/Size Diversity Landscape Position Patch Shape/Size	Production Sediment Flux Nutrient Flux Carbon Flux Connectivity/Fragmentation	Prey Production Reproduction Refuge Biodiversity Maintenance Disturbance Migration Corridors

This analysis includes a qualitative assessment of processes affecting nearshore environments, based in part on the analysis of nearshore conditions in eastern Jefferson County presented in *Multi-Scale Restoration Prioritization for Local and Regional Shoreline Master Programs: A Case Study from Jefferson County, Washington* (Diefenderfer et al., 2006), which is hereby incorporated by reference.

2.2.2 Freshwater Shorelines

The ecosystem characterization approach used for non-marine shorelines (including estuaries and freshwater rivers, streams, and lakes) is based in part on the approach reported in *Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes* (Stanley et al., 2005) and on the *Draft Watershed Characterization for Jefferson County, Version 2* (Ecology, 2007), which covers eastern Jefferson County and is hereby incorporated by reference. This approach examines specific watershed processes, including the movement of water, sediment, nutrients, pathogens, toxicants, organic matter, and energy or heat, that form and maintain aquatic resources, including shorelines, over a large geographic scale. These processes interact with landscape features to create the structure and function of aquatic resources.

The analysis uses a coarse-grained approach for integrating watershed processes into shoreline management, restoration planning, and related land use planning efforts. Results of the characterization will help to identify areas that are important for maintaining watershed processes and whether or how much these “process-intensive” areas have been altered. This approach considers the relative degree of importance and extent of alteration for each basin, so that priorities for protection and restoration can be identified. A central assumption of this approach is that the health of aquatic resources is dependent upon intact upgradient watershed processes (Ecology, 2007).

The purposes of the freshwater watershed-scale analysis are to highlight the relationship between key processes and aquatic resource functions, and to describe the effects of land use on those key processes. This approach is not intended to quantify landscape processes and functions. Rather, the goals are to:

- Identify and map areas on the landscape important to processes that sustain shoreline resources;
- Determine their degree of alteration; and
- Identify the potential for protecting or restoring these areas.

The approach to characterizing watershed-scale processes acting on freshwater systems consisted of several steps, which are described below (see also Stanley et al., 2005 for a complete description of the background and methods for this approach).

2.2.2.1 Step 1 – Identify Aquatic Resources and their Contributing Areas

Project analysts identified and mapped aquatic resources including rivers, lakes, estuaries, and wetlands (existing and historic wetlands) using available GIS hydrography data from various sources. Mapped areas include aquatic resources that are subject to shoreline jurisdiction (e.g., large rivers and lakes) and resources outside of shoreline jurisdiction (e.g., small streams, depressional wetlands outside floodplains, etc.). Contributing areas are defined as the surface water drainage boundaries in each WRIA. Each WRIA is also divided into smaller units or basins that are referenced when discussing conditions at a more refined scale.

2.2.2.2 Step 2 – Identify Key Processes

Processes occurring at the watershed scale maintain aquatic resources to varying degrees. This analysis focuses on key processes that are fundamental to the integrity of the ecosystem and can be managed within the context of the available land use plans and regulations. In accordance with Stanley et al. (2005), analysts identified the following key processes as critical to sustaining the aquatic resources and likely to be altered by human activity:

- Hydrology
- Sediment
- Water Quality
- Organic Inputs

2.2.2.3 Step 3 – Identify and Map Process-intensive Areas

For this step, analysts used available GIS data to identify and map areas within the County that support ecosystem processes (Table 2-3). These so-called "process-intensive areas" are those areas which, when maintained in an unaltered condition, have the greatest *relative* influence on the dynamics of a specific process and consequently on aquatic resources[2]. In some cases, the process-intensive areas are areas where inputs to the processes occur (e.g., the feeder bluffs that generate sediment supply as a result of erosion). For other processes, inputs occur so broadly across the landscape that specific important input areas are difficult to identify. In those cases, the process-intensive areas are areas that facilitate movement or storage of materials such as water, sediment, or pathogens. Identifying an area such as a feeder bluff as a "process-intensive" area is not meant to suggest that the associated transport zones or depositional areas are not important; it simply focuses this coarse-scale analysis on the main trigger or generator of the net shore-drift processes (i.e., without the feeder bluff generating the sediment there is no sediment transport or deposition).

Commonly, multiple processes are present in a single area, sometimes due to feedback relationships among processes. Storage areas such as depressional wetlands are a good example because they store surface water, which traps sediment and facilitates phosphorus removal and contaminant adsorption, uptake and storage. Mapping of these areas allows us to identify where each process occurs as well as areas that support multiple processes and therefore may provide valuable protection and/or restoration opportunities.

[2] The use of the term "process-intensive areas" is used as a means of distinguishing, on a relative scale, areas that play a key role in how ecosystem processes operate within a watershed. This does not imply that other areas are not important for ecological functioning, land use management or other purposes.

2.2.2.4 Step 4 – Identify and Map Process Alterations

This step determines where land uses and/or actions associated with land use have altered naturally occurring processes. Knowing where and how processes have been altered provides information necessary to develop appropriate environment designations and standards for the type and intensity of development that shoreline segments can support while accommodating appropriate uses and achieving no net loss of shoreline functions and values. Altered areas may provide opportunities for restoration, while unaltered areas may have potential for conservation or similar protection (Ecology, 2007).

Table 2-3. Examples of Process-intensive Areas, Mechanisms by which they Operate, and Alterations for Key Ecosystem Processes

Key Process	Mechanism	Process-intensive areas	Alterations
Hydrology	Infiltration/recharge	Permeable deposits	Impervious area, loss of hydrologically mature forest cover, roads, ditches, storm sewers
	Surface water storage	Depressional wetlands Lakes Floodplains	Lost wetlands, streams disconnected from floodplains
	Surface runoff and peak flows	Rain-on-snow zones and snow-dominated zones	Loss of hydrologically mature forest cover, road density
	Groundwater flow (baseflow)	Surficial aquifers Surface expression areas (lakes, wetlands, streams)	Ditched/drained areas with shallow groundwater, groundwater consumption
Sediment	Surface erosion	Erodible soils on steep slopes	Native vegetation loss, roads near streams, till agriculture, developing lands
	Mass wasting	Landslide hazard areas	Roads in landslide hazard areas, vegetation removal
	Sediment storage	Depressional wetlands Floodplains	Loss of wetlands, floodplain disconnection, stream channelization
Water Quality (including heat/light inputs)	Contaminant storage Nutrient storage/ denitrification Riparian canopy cover	Wetlands that denitrify groundwater Wetlands that filter surface water Riparian/Hyporheic zones particularly in headwater streams Low-order streams	Onsite septic systems, agricultural and residential fertilizer, riparian disturbance, loss of wetlands, loss of vegetation
Organic Inputs	LWD recruitment	Riparian zones Historic channel migration zones Landslide hazard areas	Loss of mature forest, bank armoring, stream channelization, loss of mature forest

2.3 SHORELINE REACH-SCALE INVENTORY

Within Jefferson County there are approximately 250 linear miles of marine shoreline (including the inner shores of bays and marinas) and approximately 22 miles of lakeshore on 14 lakes that are designated as shorelines of the state in Jefferson County. In addition, this report provides a general inventory of more than 742 river miles of stream and river shoreline, of which approximately 238 river miles are within and County-regulated (non-federal and non-tribal) lands (per WAC 173-18, with revisions from 20 cubic feet per second [cfs] mapping from USGS, 1998).

Most of the shoreline areas under Jefferson County's jurisdiction are located in the eastern part of the County. All of the marine shorelines that fall within County jurisdiction are in the eastern part of the County on greater Puget Sound. The Pacific Coast shoreline and the lower reaches of freshwater rivers in the western part of the County are located on federal or tribal lands—including Olympic National Park (ONP), Olympic National Forest (ONF), and the Hoh and Quinault Indian Reservations—and are therefore not subject to the state SMA. All of the Queets River, the upper reaches and tributaries of the Hoh and Bogachiel Rivers, and potentially numerous other tributaries are also on federal or tribal lands (see Table 1-1). The marine shores of Indian Island and most of Protection Island – with the exception of the Zella M. Schultz State Seabird Sanctuary, a 48-acre parcel on the Island's southwestern edge managed by Washington Department of Fish and Wildlife – are also under federal jurisdiction. Although these areas are outside County jurisdiction, management and use of these areas influence the functions and values of SMA-regulated shorelines through various mechanisms.

The reach-scale inventory focuses on WAC-designated shorelines considered to be within County jurisdiction. In general, the inventory area includes, at a minimum, lands within 200 feet of the shoreline OHWM, plus floodplain and associated wetland and delta areas. This zone is referred to as the shoreline planning area. Areas outside the planning area were analyzed at the ecosystem scale as described above to develop a better understanding of shoreline processes and functions. Streams and lakes that are not currently designated as shorelines per WAC 173-18 or 173-20 but which may meet the criteria for shoreline designation are described and charecterized within Appendix D, and mapped along with WAC-designated shorelines within Appendix C, but not inventoried at the same level of detail as WAC-designated shorelines.

2.3.1 Marine (Nearshore) Reaches

The marine shoreline is divided into 64 individual reaches for inventory and analysis purposes[3]. Each reach is identified by a unique alpha designation beginning with "A" in the southwest corner of the County. The reach breaks were defined based primarily on net shore-drift patterns (drift cells) and other geomorphic factors. Major characteristics of the built and natural environments are described for each reach, including: zoning; existing land use; historical resources; shoreform; aquatic vegetation; marine resource species (including forage fish and

[3] Diefenderfer et al. (2006) also analyzed nearshore reaches both at finer ShoreZone Unit scale and Drift Cell Reach scale for purposes of identifying and ranking restoration sites in *Multi-Scale Restoration Prioritization for Local and Regional Shoreline Master Programs: A Case Study from Jefferson County, Washington*.

other species); commercial shellfish growing areas; shoreline modifications (bulkheads, marinas, docks, piers, jetties, groins, launch ramps, and stairs); threatened, endangered and priority habitats/species; salt marshes and intertidal wetlands and lagoons; geomorphic class; public access; and other attributes (see Table 2-1 for a list of primary datasets).

2.3.2 Freshwater Reaches

For freshwater shorelines, reaches were delineated based primarily on habitat. There are 59 river/stream reaches and 14 lake reaches. The reach identifier includes the water body name and a numeric qualifier. The attributes of the freshwater reach inventory are similar to the marine reach inventory and include ecological characteristics, human use, and other features as required by the state guidelines (see Table 2-1 for a list of primary datasets).

3.0 ECOSYSTEM CHARACTERIZATION AND ECOSYSTEM-WIDE PROCESSES

This chapter describes the ecosystem-wide processes that influence and shape shoreline functions, in accordance with WAC 173-26-210(3)(d). Information is presented at a coarse scale and provides a basis for understanding shoreline management in the context of the broader landscape. Details on individual shoreline reaches are provided in Chapter 4. Maps depicting key shoreline attributes described in this chapter are provided in the map folio in Appendix C and listed in Table 3-1[1].

Table 3-1. Appendix C Map Folio Names and Numbers

Map #	Map Title/Theme
1a	Jefferson County Shorelines of the State
1b	Jefferson County Shorelines of the State
1C	Difference between current and proposed upstream jurisdiction limits
2	Hydrology – East Jefferson County
3	Hydrology – West Jefferson County
4	Water Quality – East Jefferson County
5	Water Quality – West Jefferson County
6	Sediment - East Jefferson County
7	Sediment - West Jefferson County
8	Aquatic Resources – Southeast Jefferson County
9	Aquatic Resources – Northeast Jefferson County
10	Aquatic Resources – West Jefferson County
11	Coastal Processes and Modifications – Southeast Jefferson County
12	Coastal Processes and Modifications – Northeast Jefferson County
13	Coastal Processes and Modifications – West Jefferson County
14	Critical Areas – Southeast Jefferson County
15	Critical Areas – Northeast Jefferson County
16	Critical Areas – West Jefferson County
17	Critical Shoreline Habitat – Southeast Jefferson County
18	Critical Shoreline Habitat – Northeast Jefferson County
19	Critical Shoreline Habitat – West Jefferson County
20	Aquatic Vegetation – East Jefferson County
21	Land and Shoreline Use Patterns – Southeast Jefferson County
22	Land and Shoreline Use Patterns – Northeast Jefferson County
23	Land and Shoreline Use Patterns – West Jefferson County
24	Shellfish Harvest Areas – Eastern Jefferson County
25	Forest Cover and Impervious Surface – Eastern Jefferson County
26	Geomorphic Classes – Southeast Jefferson County
27	Geomorphic Classes – Northeast Jefferson County

[1] Graphic displays that are incorporated into the report text are referred to as Figures (Figure 1, 2,…). References to Maps refer to the map folio in Appendix C. Readers are also encouraged to review the maps from the County 2005 shoreline inventory in Appendix B.

Map #	Map Title/Theme
28	Quinault River
29	Proposed SEDs – Southeast Jefferson County
30	Proposed SEDs – Northeast Jefferson County
31	Proposed SEDs – West Jefferson County

3.1 REGIONAL OVERVIEW

Jefferson County is located on the Olympic Peninsula in northwest Washington State. It stretches east from the Pacific Ocean through the high country of the Olympic Mountains to Puget Sound. To the north, it is bounded by Clallam County and the Strait of Juan de Fuca, to the southeast by Mason County, and to the southwest by Grays Harbor County. In 2005, the County population was estimated to be 28,666 people, with the majority living in the eastern part of the County. The County seat and only incorporated city is Port Townsend, with a population of about 8,500. Other population centers include Port Hadlock, Chimacum, and Irondale (the "Tri-Area"), Port Ludlow, Brinnon, and Quilcene. The federal lands within ONP and ONF encompass most of the Olympic Mountains in the center of the County. West of the Olympic Mountains, Jefferson County is sparsely populated along the Hoh River and in the Kalaloch, Clearwater and Queets village centers. The area is composed of mostly commercial and Washington Department of Natural Resources (WDNR)-owned timberlands.

Parts of five WRIAs occur within Jefferson County (Figure 3-1): WRIA 16 (Skokomish-Dosewallips), WRIA 17 (Quilcene-Snow), WRIA 18 (Elwha-Dungeness), WRIA 20 (Sol Duc-Hoh), and WRIA 21 (Queets-Quinault).

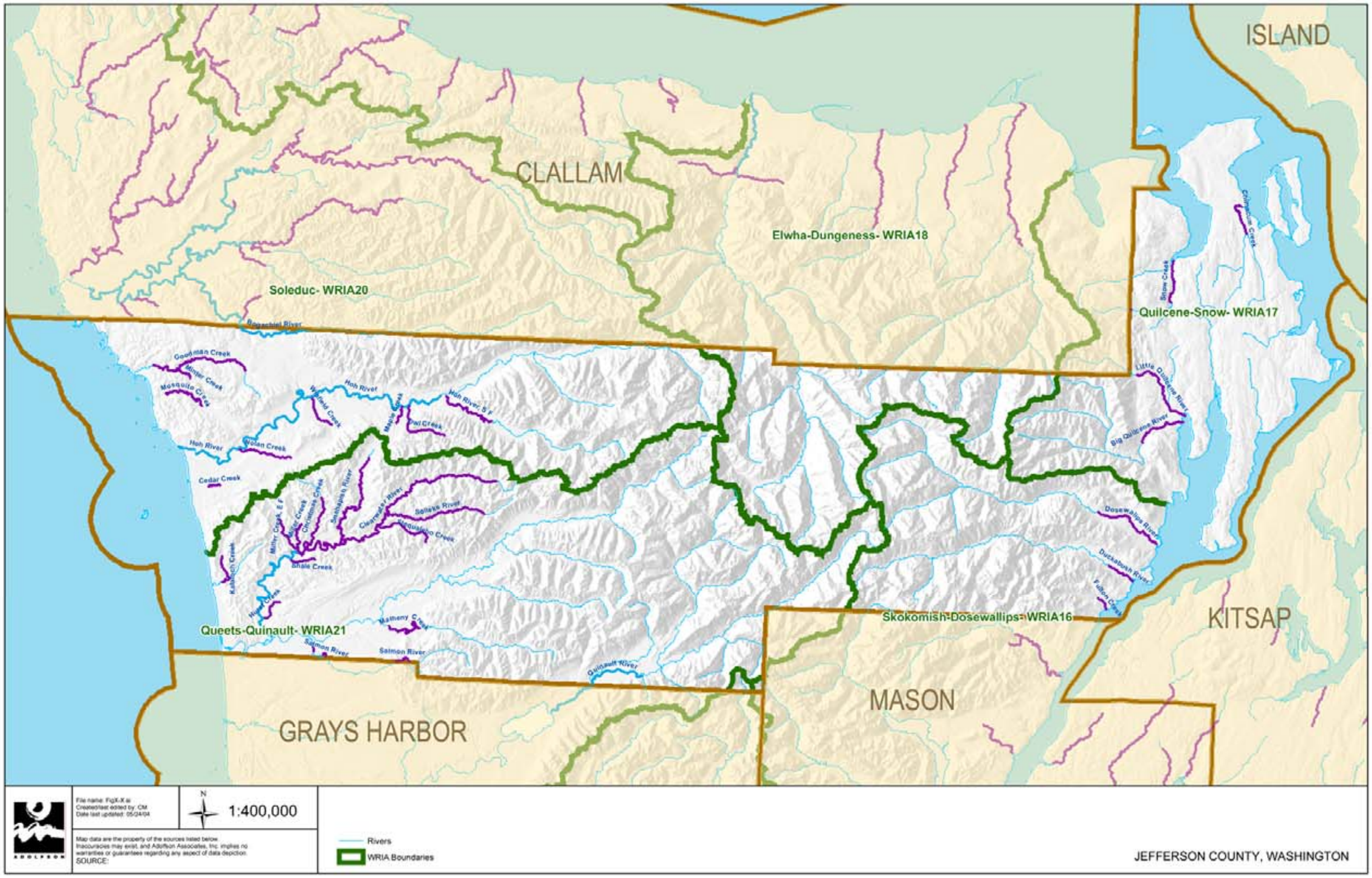
WRIA 16 extends from the Turner Creek watershed in southeast Jefferson County southward to, and including, the Skokomish watershed in northwest Mason County. The four principal watersheds within this WRIA—the Dosewallips, Duckabush, Hamma Hamma, and Skokomish—originate in the rugged terrain of the Olympic Mountains and terminate along the western shore of Hood Canal. The Dosewallips and Duckabush basins lie entirely within Jefferson County, while major portions the Hamma Hamma and Skokomish basins fall in Mason County. The upper portions of the major rivers are either not shorelines of the state (because mean annual flow is less than 20 cfs) or they lie within federal lands and therefore are not under Jefferson County shoreline jurisdiction. The ONP and ONF encompass more than 60 percent of WRIA 16.

WRIA 17 includes portions of Jefferson and Clallam Counties, extending from the Marple/Jackson watershed in southeast Jefferson County northward and westward to, and including, the Johnson Creek watershed along the west side of Sequim Bay. WRIA 17 is bordered to the north by the Strait of Juan de Fuca, to the east by Admiralty Inlet, northern Puget Sound and Hood Canal, and to the south and west by the Olympic Mountains and associated foothills and floodplains. Major basins within this watershed include the Big Quilcene River, Little Quilcene River, Hood Canal West, Admiralty Inlet, and Discovery Bay. Over 70 percent of the WRIA is privately owned (non-federal/tribal land).

WRIA 18 includes two large river systems (Dungeness and Elwha Rivers); one medium-sized river system (Morse Creek); and 14 smaller independent drainages, all of which drain to the

Strait of Juan de Fuca. The headwaters of the Upper Dungeness, Grey Wolf, and Elwha River Upper and Middle basins fall within Jefferson County. Thirty percent of the Dungeness River watershed and 83 percent of the Elwha River watershed are within the ONP. There are no designated shorelines of the state in WRIA 18 within Jefferson County.

Figure 3-1. Jefferson County, Washington, and WRIA Boundaries



WRIA 20 includes all streams that drain into the Pacific Ocean from Cape Flattery in Clallam County south to and excluding Kalaloch Creek in Jefferson County. The largest basin in WRIA 20 is the Quillayute. Other basins include the Waatch, Sooes, Ozette, and Hoh systems, as well as several small independent drainages. Basins within Jefferson County include the Upper, Middle, and Lower Hoh, Hoh River South Fork, Upper and Lower Bogachiel, Goodman Creek, and Sol Duc Lower.

WRIA 21 extends from Kalaloch Creek in Jefferson County in the north to Conner Creek in Grays Harbor County in the south. The largest basins within the WRIA are the Queets and Quinault. The Queets Upper, Middle, Lower, Matheny, and Salmon River basins, along with the Upper Quinault, Quinault North Fork, and Quinault Lake Frontal basins, lie within Jefferson County. Other basins in the WRIA include the Clearwater, Kalaloch, Raft, Moclips, and Copalis basins, of which the Clearwater Upper and Lower and Kalaloch basins fall within Jefferson County.

3.2 OVERVIEW OF KEY SPECIES AND HABITATS IN JEFFERSON COUNTY

This section describes some of the key shoreline-related resources of Jefferson County. This section is divided into the following main topics:

- Threatened and endangered species and critical habitats – Species listed under the federal Endangered Species Act (ESA) as threatened or endangered and their federally designated critical habitats,
- Nearshore habitats and species – Species and habitats primarily associated with saltwater environments,
- Freshwater habitats and species – Species and habitats primarily associated with freshwater environments, and
- Terrestrial habitats and species – Other species and habitats associated with upland areas.

In nature, species and habitats do not always have such clear distinctions: Some habitats are transitional between nearshore, freshwater, and terrestrial environments and many species use multiple habitat types or occupy different habitats at different times depending on the season, species life stage, and other factors.

This is not an exhaustive review of all habitats and species in the County, but a general overview of the resources that are most closely related to or affected by shoreline planning. The purpose of the overview is to assist the reader in understanding the elements of the biological environment that are created, maintained, altered, and/or potentially destroyed as a result of ecosystem processes and/or alterations of ecosystem processes described later in the chapter. Additional information on the locations of these specific resources in Jefferson County is provided in the reach inventory and analysis (Chapter 4) and in the map folio (Appendix C).

3.2.1 Threatened and Endangered Species and Critical Habitats

Jefferson County is home to several state and/or federally listed and proposed threatened and endangered species and critical habitats (Table 3-2). There are 91 bald eagle nesting territories in the County, along with three communal winter night roosts, and two wintering concentrations located along the Quinault River and Washington's Pacific Coast. Northern spotted owls and marbled murrelets also occur and nest in the County (USFWS, 2005). Large areas of critical habitat for marbled murrelets have been identified in western Jefferson County, while critical habitats for both marbled murrelets and spotted owls have been identified in eastern Jefferson County, particularly in old-growth areas of the ONP and along the Dosewallips River (Maps 17-19).

Table 3-2. Listed, Proposed, and Candidate Threatened and Endangered Species Occurring in Jefferson County

Common Name	Scientific Name	Federal Status [a]	State Status [b]
Birds			
Bald eagle	*Haliaeetus leucocephalus*	Threatened	Threatened
Brown pelican	*Pelecanus occidentalis*	Endangered	Endangered
Marbled murrelet	*Brachyramphus marmoratus*	Threatened	Threatened
Northern spotted owl	*Strix occidentalis caurina*	Threatened	Endangered
Short-tailed albatross	*Phoebastria albatrus*	Endangered	Candidate
Mammals			
West Coast DPS fisher	*Martes pennanti pacifica*	Candidate	Endangered
Southern resident killer whale	*Orcinus orca*	Endangered	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered	Endangered
Steller sea lion	*Eumetopias jubatus*	Threatened	Threatened
Blue whale	*Balaenoptera musculus*	Endangered	Endangered
Fin whale	*Balaenoptera physalus*	Endangered	Endangered
Sei whale	*Balaenoptera borealis*	Endangered	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered	Endangered
Sea otter	*Enhydra lutris*	None	Endangered

Common Name	Scientific Name	Federal Status [a]	State Status [b]
Fish			
Puget Sound ESU Chinook salmon	*Oncorhynchus tshawytscha*	Threatened	Candidate
Eastern Strait of Juan de Fuca/Hood Canal ESU summer chum salmon	*Oncorhynchus keta*	Threatened	Candidate
Puget Sound DPS steelhead	*Oncorhynchus mykiss*	Proposed threatened	None
Coastal Puget Sound bull trout	*Salvelinus confluentus*	Threatened	Candidate
Olympic mudminnow	*Novumbra hubbsi*	None	Threatened
Reptiles			
Leatherback sea turtle	*Dermochelys coriacea*	Endangered	Endangered
Green sea turtle	*Chelonia mydas*	Endangered	Threatened
Loggerhead sea turtle	*Caretta caretta*	Threatened	Threatened
Olive ridley sea turtle	*Lepidochelys olivacea*	Endangered	None

DPS = distinct population segment
ESU = evolutionarily significant unit
[a] Federal status under the Endangered Species Act (ESA) of 1973 as amended.
[b] State Species of Concern List, February 2007.

While there have been occasional, unconfirmed sightings of fishers, there are no known populations in Washington. There is currently a proposal to reintroduce them to the ONP (ONP, 2006).

Listed marine mammals and sea turtles occur primarily off the Pacific coast, although Southern Resident killer whales, humpback whales, and Steller sea lions are known to occur in Puget Sound. NOAA Fisheries has proposed critical habitat for Southern Resident killer whales in marine waters of eastern Jefferson County, including areas deeper than 20 feet along Puget Sound (Area 2) and the Strait of Juan de Fuca (Area 3). Hood Canal was not proposed as part of killer whale critical habitat due to lack of confirmed sightings there, and a large area of Admiralty Inlet north of the Quimper Peninsula (Area 3) was excluded for national security reasons (Federal Register, 2006).

Species of special concern under the Washington Department of Fish and Wildlife (WDFW) endangered, threatened, sensitive, candidate, and monitor species programs potentially found in Jefferson County include great blue heron (*Ardea herodias*), pileated woodpecker (*Dryocopus pileatus*), purple martin (*Progne subis*), Vaux's swift (*Chaetura vauxi*), and western bluebird (*Sialia mexicana*). Candidate and threatened mammals may include western gray squirrel (*Sciurus griseus*) along with western pond turtle (*Clemmys marmorata*). Many of these remaining species can be found in close proximity to developed areas, although most need undisturbed vegetated areas large enough to maintain viable habitat (Jefferson County, 2002).

3.2.1.1 Salmonids

Salmonids (including both federally listed and non-listed species) use streams, rivers, and nearshore habitats throughout Jefferson County. In eastern Jefferson County, Chinook, coho, pink, and summer and fall chum salmon, resident and searun cutthroat trout, as well as summer and winter steelhead are documented in the larger rivers and streams (Correa, 2002, 2003). Western Jefferson County rivers and streams provide spawning and rearing habitat for summer and fall Chinook, coho, and chum salmon as well as for winter and summer steelhead trout.

In 1999, the summer chum salmon populations that naturally spawn in tributaries to Hood Canal and in Discovery Bay, Sequim Bay, and the Dungeness River on the Strait of Juan de Fuca were determined to be at risk of extinction and were listed as threatened (Brewer et al., 2005). Hood Canal streams that have been documented as supporting indigenous summer chum populations include the Big Quilcene River, Little Quilcene River, Dosewallips River, Duckabush River, Hamma Hamma River, Lilliwaup River, Union River, Tahuya River, Dewatto River, Anderson Creek, and Big Beef Creek. Summer chum are occasionally observed in other Hood Canal drainages, including the Skokomish River which once supported a large summer chum population (WDFW and PNPTC, 2000). Summer chum salmon populations in the eastern Strait of Juan de Fuca occur in Snow and Salmon Creeks in Discovery Bay, and in Chimacum Creek.

Chinook salmon spawning in streams of Hood Canal are part of the Puget Sound Chinook Evolutionarily Significant Unit (ESU), which is also listed as threatened under the ESA. This includes two independent populations: those that naturally reproduce in the Skokomish River watershed, and stocks that spawn in the Hamma Hamma, Duckabush, and Dosewallips watersheds. The Dosewallips River is the likely primary population or source for this grouped population (Brewer et al., 2005).

Critical habitat for Chinook and summer chum salmon in eastern Jefferson County includes the marine shorelines of Hood Canal and the Strait of Juan de Fuca, as well as Fulton Creek, Duckabush, Dosewallips, Big Quilcene, and Little Quilcene Rivers, and Chimacum, Snow, and Salmon Creeks (Federal Register, 2005a). Critical habitat for bull trout in Jefferson County includes the shorelines of the Pacific Ocean, Strait of Juan de Fuca, and Hood Canal, as well as all or a portion of the Hoh River, Clearwater River, Goodman Creek, Elwha River, Mosquito Creek, and Salmon River (Federal Register, 2005b).

The Hoh watershed, mainstem Salmon River, and upper Elwha and Dungeness River watersheds also provide habitat for bull trout, a threatened species (Haring, 1999; Smith, 2000; Smith and Culverwell, 2001). The Hoh River is one of six “core” areas for bull trout on the Olympic Peninsula, which include the Quinault, Queets, Hoh, Elwha, Dungeness, and Skokomish River basins. Core areas are defined by the U.S. Fish and Wildlife Service (USFWS) as areas supporting sustainable and reproducing populations of genetically distinct bull trout. The bull trout population in the Hoh watershed may be the largest population in Washington State (10,000 Years Institute, 2004). In general, Hoh River bull trout appear to be largely limited to the mainstem of the river, but anecdotal evidence suggests they have historically also used tributaries. Spawning has been documented only in the upper mainstem and South Fork Hoh River, and at floodplain interfaces at the mouths of two tributaries in ONP. Adults and juveniles use the entire river as a migration corridor to and from spawning, rearing, and foraging grounds (Brenkman 2004, pers. comm., as cited in 10,000 Years Institute, 2004).

3.2.2 Nearshore Habitats and Species

Key nearshore marine habitats in Jefferson County include eelgrass and kelp beds; shellfish beds; forage fish spawning areas; marine mammal habitats (seal and sea lion haulouts); seabird/waterfowl concentration areas; estuaries and other intertidal wetlands/marshes, and nearshore riparian habitats (Maps 14-20, 24, 26, and 27). These species and habitats occur so widely throughout the County on both the east and west shores that virtually all of the County's nearshore marine environment supports or has potential to support highly valuable and ecologically sensitive resources.

3.2.2.1 Eelgrass and Kelp

Eelgrass (*Zostera marina*) is a native marine seagrass that forms extensive meadows on gravel, fine sand, and mud substrates in the lower intertidal and shallow subtidal zones of protected or semi-protected shorelines (Bulthuis, 1994; Thom et al., 1998). Typical locations for eelgrass have medium to fine sands and contain relatively high levels of organic matter and nutrients (Simenstad, 2000). This generally includes shallow tideflats, along channels in tideflats or estuaries, and in the shallow subtidal fringe. The eelgrass zone is typically confined to areas between tidal elevations of +1 meter to -2 meters relative to mean lower low water (MLLW) (Thom et al., 2001; Simenstad, 2000).

Eelgrass can grow to a height of 2 meters, forming a relatively tall, dense canopy. In undisturbed environments, eelgrass corridors can be nearly contiguous within a drift cell but they also occur as patches between drift cells. Generally, the steeper the beach gradient and more turbid the waters, the narrower the eelgrass corridor (Simenstad, 2000). Eelgrass beds provide a source of organic matter to intertidal/shallow subtidal food webs. The plants produce organic carbon which enters the food web through the microbial decomposition and processing of both particulate and dissolved eelgrass materials (Williams and Thom, 2001). Numerous species of fish, including juvenile salmon, and other marine animals incorporate the decomposed organic matter into their diets. Salmon and other species also depend on eelgrass for habitat structure and refuge from predators. The leaves provide attachment sites for epiphytic algae and other organisms, and ameliorate wave and current energy. Herring use eelgrass for spawning and for protection while they mature (PSAT, 2001).

In eastern Jefferson County, fringing eelgrass beds are found along the shorelines of Discovery Bay, Port Townsend Bay, Marrowstone Island, Hood Canal, and between Tala and Kala Points (Map 20). Historically, eelgrass is believed to have occurred widely along the County's western shore including at the mouth of the Hoh River (Shaffer and Wray, 2004).

Kelp, or macrophytic brown algae, can form dense, highly productive undersea forests that support numerous species of fish and marine mammals. Dense kelp beds also dissipate wave energy and provide sheltered habitat for resting/rafting seabirds and other animals within the kelp bed or adjacent surface waters. Kelp forests are composed primarily of bull kelp (*Nereocystis luetkeana*) and other large brown algae. Kelp attach to the bottom with holdfasts and require rocky or coarse substrates. Distribution is limited to areas with appropriate substrates, light penetration to the bottom, and moderate wave/current energy.

In eastern Jefferson County, kelp beds are generally found along the Straits, with patchy distribution along the shores of western Discovery Bay, western Marrowstone Island, and Hood Head (Map 20). According to survey data from the WDNR Nearshore Habitat Program Research Project, the Protection Island kelp bed has seen significant decline over the past decade (http://www2.wadnr.gov/nearshore/research/projectpages.asp?pagename=kelp_page1&id=17). Understory kelp is still present in significant quantities on Dallas Bank, off the northwest shore of the island, but canopy-forming kelp is largely or entirely absent (Norris, personal communication, 2007). On the west coast of the County, kelp beds have been mapped near Tealwhit Head, Strawberry Point, Toleak Point, Hoh Head, and Diamond Rock, and near Destruction Island (Figure 3-2) (Shaffer and Wray, 2004; Silver, personal communication, 2006).

3.2.2.2 Shellfish Resources

Cobble to fine sand beaches and tidal sand and mudflats are important habitats for many shellfish species. Intertidal areas in Jefferson County support hardshell clams including butter clams (*Saxidomus gigantea*), native littleneck (*Protothaca staminea*), manila clams (*Venerupis philippinarum*), cockles (*Clinocardium nuttalli*), and horse clams (*Tresus* spp.). Geoducks (*Panopea abrupta*) typically burrow offshore in subtidal areas up to 2 to 3 feet into the mud or soft sand. Shrimp, crab, Olympia oysters (*Ostreola conchaphila*) and non-native Pacific oysters (*Crassostrea gigas*) also inhabit the shoreline areas. Dungeness crab (*Cancer magister*) frequent eelgrass beds, and red rock crab (*Cancer productus*) inhabit rocky terrain with less silt content (Jefferson County, 2002).

Figure 3-2. Coastal Watershed Institute, Tribal Marine Cultural Resource Survey for Portions of Western Jefferson County (Shaffer and Wray, 2004)

Shellfish beds perform a number of important ecological functions including cycling nutrients, stabilizing substrates, creating habitat structure (e.g., oyster reefs), enhancing water quality (filtering and retention), and providing food for a wide variety of marine invertebrates, birds, fish, and mammals. Extensive shellfish beds and commercial and recreational shellfish harvest beaches are found along the shorelines of Hood Canal, Discovery Bay, Oak Bay, Quilcene Bay, Port Townsend Bay, and Dabob Bay (Map 24). Tribal shellfish beaches and growing areas are also widely distributed throughout the east County (Figure 3-3). On the west shore, shellfish beds are found from the mouth of the Hoh River south past Kalaloch and near the northern edge of the County near Strawberry Bay, Strawberry Point, and Tealwhit Head (see Figure 3-2). There is an active razor clam (*Siliqua patula*) fishery on the County's west coast.

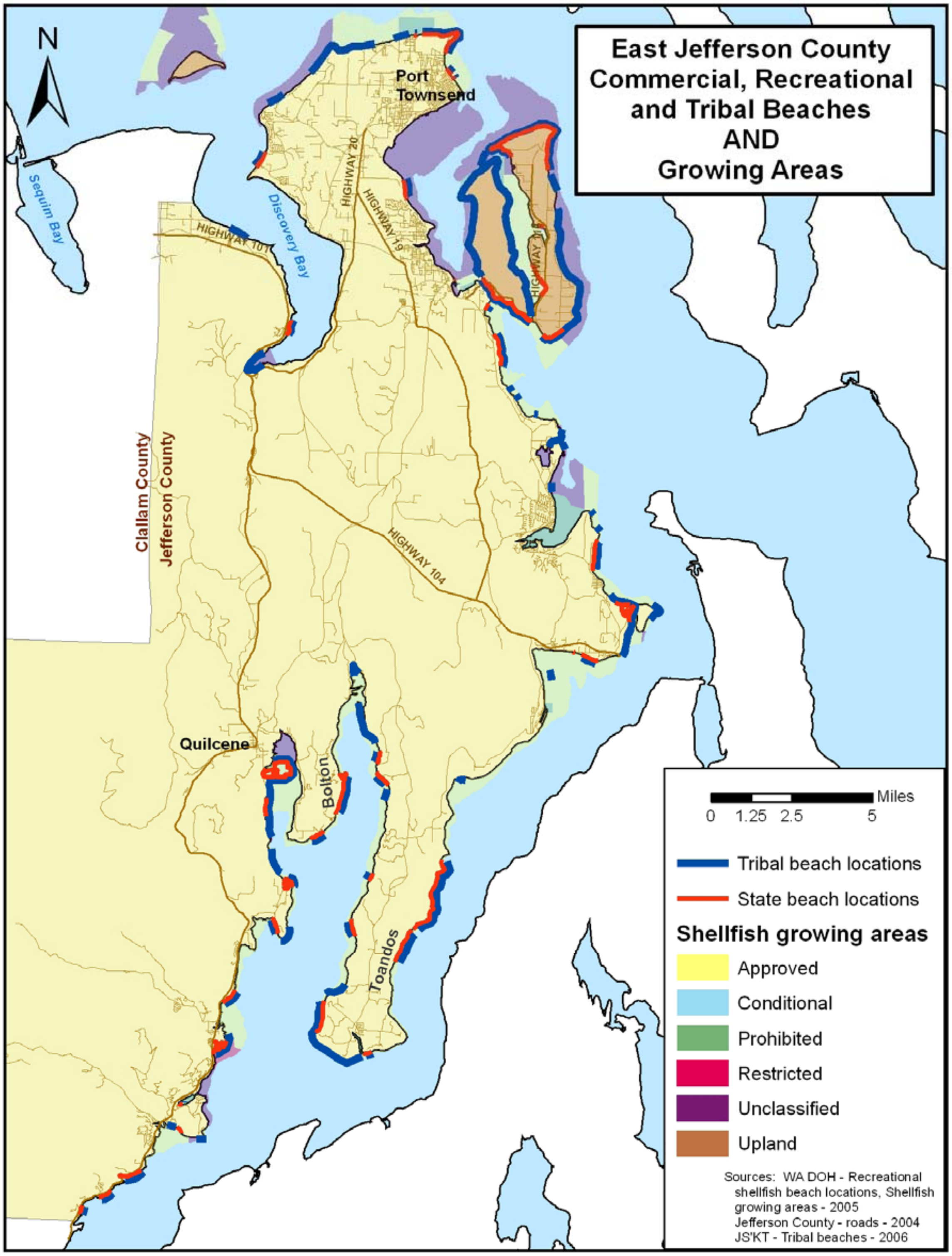
3.2.2.3 Forage Fish

Forage fish—a crucial prey base for salmonids including federally listed stocks—use a variety of shallow nearshore and estuarine habitats for spawning, feeding, and rearing (Long et al., 2005). Surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) both spawn within a limited range of tidal elevations in the upper intertidal zones of beaches, and have specific habitat requirements including substrate size and type (Penttila, 1978; 1995). Pacific herring (*Clupea harengus*) spawn in intertidal and shallow subtidal areas, depositing eggs on marine vegetation at elevations between 0 and -10 feet MLLW (WDFW, 2000a). Suitable spawning habitat for these species is therefore limited within the region, and these species are particularly vulnerable to changes in beach sediment characteristics (sources, transport or deposition), nearshore riparian cover, or beach morphology (WDFW, 2000a).

The WDFW, North Olympic Salmon Commission (NOSC) and the Jefferson County Marine Resources Committee have mapped sand lance spawning beaches within Discovery Bay, Port Townsend Bay, Kilisut Harbor, Scow Bay, Oak Bay, Port Ludlow, Tala Point, Tarboo Bay, and other scattered sites along Hood Canal and Dabob Bay (Maps 17 and 18). Surf smelt spawning beaches are more limited in extent, with known spawning occurring in Discovery Bay, Port Townsend Bay, Kilisut Harbor and Scow Bay, Port Ludlow, Tala Point, and Dabob Bay, particularly along the western Toandos Peninsula, and Quilcene Bay. Herring pre-spawn holding areas include Discovery Bay and the entrance to Hood Canal; spawning sites have been documented within Discovery Bay, Port Townsend, Kilisut Harbor, and Dabob Bay (Long et al., 2005) (Maps 17 and 18).

The WDFW/NOSC surveys did not cover western Jefferson County, but Shaffer and Wray (2004) have identified several areas of the western coastal shore as supporting forage fish species as shown in Figure 3-2. These areas are mainly at the mouths of major rivers such as Mosquito Creek, the Hoh River, Cedar Creek, Kalaloch Creek, and Goodman Creek. In the Hoh River, surf smelt occur within the first river mile (10,000 Years Institute, 2004).

Figure 3-3. Commercial, Recreational, and Tribal Shellfish Growing Beaches and Harvest Areas in Eastern Jefferson County



3.2.2.4 Marine Mammals

Seals and sea lions known to occur in Jefferson County include harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), Steller sea lions (*Eumetopias jubatus*), sea otters (*Enhydra lutris*), and northern elephant seals (*Mirounga angustirostris*). The harbor seal is the most common, widely distributed pinniped found in Washington waters. Harbor seals use hundreds of sites to rest or haul out along the coast and inland waters including intertidal sand bars and mudflats in estuaries, intertidal rocks and reefs, sandy, cobble, and rocky beaches, islands, logbooms, docks, and floats. California sea lions use haulout sites located on jetties, offshore rocks and islands, logbooms, marina docks, and navigation buoys. Steller sea lions use haulout sites primarily along the outer coast from the Columbia River to Cape Flattery. Solitary northern elephant seals are occasionally seen using beaches at Destruction, Protection, and Smith/Minor Islands as well as Dungeness Spit as haulout sites. In recent years, pups have been occasionally recorded at these sites as well. Seal and sea lion haulout sites have been identified near the mouths of Duckabush and Dosewallips Rivers, as well as Dabob Bay, Port Ludlow, Indian and Marrowstone Islands, Protection Island, and Discovery Bay (Jeffries et al., 2000) (Maps 17-19). Washington Department of Fish and Wildlife maintains a seal exclusion fence at the mouth of the Dosewallips River, to maintain water quality in recreational shellfish harvest areas (Christensen, 2004). Alexander Island, Toleak Point, and Hoh Head on the west coast have been identified as harbor seal/sea lion haulouts (see Figure 3-2) (Shaffer and Wray, 2004).

According to WDFW PHS data, sea otters (*Enhydra lutris*) also occur on the west coast at Destruction Island and several other offshore islands (Map 19). Sea otters are endangered in Washington State. Distribution is limited to the northwest coast from Destruction Island to Neah Bay (Lance et al., 2004).

Orcas or killer whales (*Orcinus orca*) and other whales may also use nearshore marine habitats, although they primarily occur in deeper waters and along the outer coast. These species are discussed in Section 3.2.1.

3.2.2.5 Seabirds and Waterfowl

Common seabirds and waterfowl along Jefferson County shorelines include rhinoceros auklets (*Cerorhinca monocerata*), mergansers (*Mergus* spp.), scoters (*Melanitta* spp.), guillemots (*Uria* and *Cepphus* spp.), loons (*Gavia* spp.), grebes (*Aechmophorus occidentalis*), cormorants (*Phalacrocorax* spp.), herons and egrets (Ardeidae), swans (*Cygnus* spp.), geese (*Branta canadensis*), brants (*Branta bernicla*), and a variety of ducks, sandpipers (Scolopacidae), gulls (Larinae), murrelets (*Brachyramphus marmoratus*), and puffins (*Fratercula* spp.). Migratory species including a number of shorebirds and seabirds may use shorelines of Jefferson County for periods of time during migration (Ecology, no date). Protection Island hosts a small, declining population of tufted puffins (*Fratercula* cirrhata), listed as a Candidate species in Washington State and a Species of Concern under the federal Endangered Species Act (McConnell, personal communication, 2007). State priority wildlife species that are associated with estuarine habitat include the bald eagle (*Haliaeetus leucocephalus*), great blue heron (*Ardea herodias*), and osprey (*Pandion haliaetus*). These species occur widely in nearshore habitats throughout Jefferson County (Maps 17 and 18).

Audubon Washington (2001) has identified Important Bird Areas (IBA) in Washington State, defined as places that are essential to maintaining healthy bird populations. In Jefferson County, IBAs include Protection Island – which hosts 70 percent of nesting seabirds in all of Puget Sound – and Indian-Marrowstone Island/Oak Bay, which provides important wintering habitat for thousands of waterfowl and several hundred brants.

3.2.2.6 Estuaries and Intertidal Wetlands/Marshes

Estuaries are embayments (bays) or semi-protected inland waters with freshwater inputs that serve as transition zones between freshwater and marine environments. They encompass the area at the mouth of a river or stream dominated by processes related to the discharge of fresh water (generally from the head of tidal influence seaward to the point where fluvial influences no longer dominate) .Within the large Puget Sound estuary, there are many larger river estuaries (e.g., Skagit, Nisqually) and numerous smaller estuaries. Estuarine habitat in Jefferson County is diverse, ranging from riverine estuaries to small alongshore salt marshes influenced mainly by marine processes. Estuaries provide critical ecological functions and biological resources including flood attenuation, nutrient retention and cycling, erosion/shoreline protection, food web support, and habitat structure/connectivity. Estuaries and deltas associated with watersheds where salmon spawn and rear provide salinity gradients that allow juveniles to gradually adjust to salt water. These areas also serve as nurseries for a wide variety of aquatic species that provide a forage base for salmon.

Juvenile salmonids and other species use estuaries and other shallow water habitats, including the shallow waters along gently sloping beaches, as a refuge from predation when migrating, especially in the absence of complex habitat features such as woody debris or submerged vegetation (Kahler et al., 2000). Juvenile Chinook salmon and summer chum are both highly dependent on estuarine environments (WDFW and PNPTC, 2000). For these and other reasons, preservation and/or restoration of estuaries is considered crucial to the success of ongoing efforts to recover threatened stocks in the Puget Sound and Hood Canal-Strait of Juan de Fuca (Brewer et al. 2005; Hood Canal Coordinating Council, 2005; Todd et al., 2006).

Salt marshes and brackish marshes are habitats that occur in areas with tidal inundation. Salt marshes typically occur at elevations at and above mean higher high water (MHHW) in areas where sediment supply and accumulation are relatively high. Therefore, salt marshes can occur in bays, along sand spits sheltered from waves and currents, and most commonly on river and stream deltas. Salt marsh vegetation, especially the root mats and dense stems, trap and stabilize sediments. Marshes tend to grow outward over time as sediments entering the delta from rivers are captured and retained by salt marsh vegetation. Marshes are fairly stable and respond to natural or human disturbances of watersheds and shorelines. Salt marshes provide complex, branching networks of tidal channels where juvenile salmonids feed and take refuge from predators. They also form migratory linkages to riverine and marine environments (Brewer et al., 2005).

Major estuaries in eastern Jefferson County include the Chimacum Creek, Shine, Mats Mats, Thorndyke Bay, Duckabush and Dosewallips River deltas, Quilcene Bay, Tarboo Creek delta, Port Ludlow, and Discovery Bay (Maps 26 and 27) (Todd et al., 2006). Salt marsh distribution in eastern Jefferson County is generally coincident with the major estuaries[2]. On the west coast of the County, there is a narrow but very productive estuary at the mouth of Goodman Creek (Silver, personal communications, 2006). The mouth of the Hoh River is confined by bedrock, so there is no classic estuary and the area lacks eelgrass beds or other aquatic vegetation (10,000 Years Institute, 2004).

In addition to the major "natal" estuaries listed above, there are tidal marsh systems that are not directly associated with natal watersheds but are believed to support the early marine life histories of juvenile salmon species (Hood Canal Coordinating Council, 2005). These so-called "pocket estuaries" occur where small streams or embayments with freshwater seeps occur. Linkages between major estuarine deltas (like the Dosewallips River and Dabob Bay) and other shallow nearshore habitats/corridors are critical for rearing and migrating salmonids (WDFW and PNPTC, 2000).

3.2.2.7 Nearshore Riparian Areas

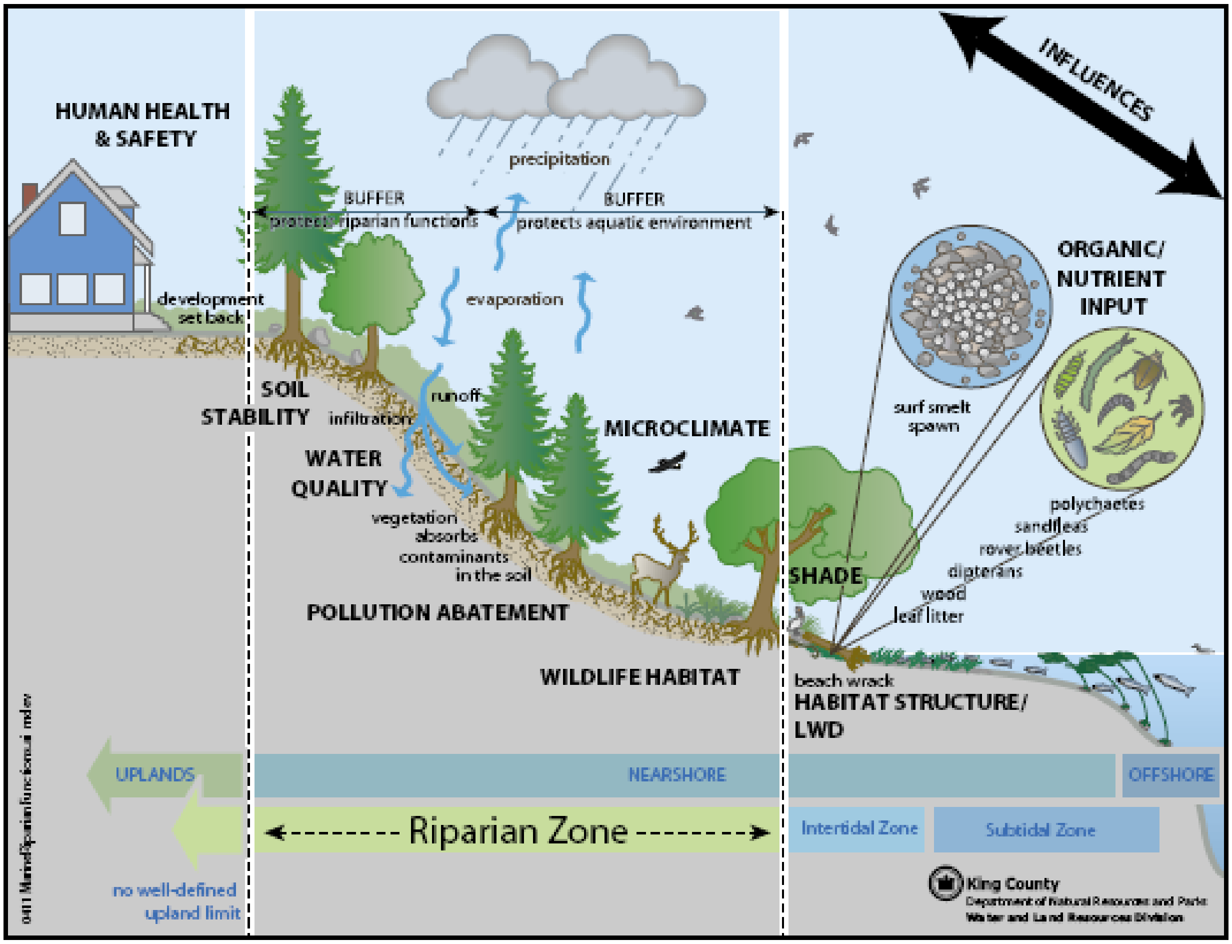
Riparian areas occur at the interface between upland and aquatic areas, both in the marine nearshore and freshwater environments. Brennan and Culverwell (2004) note that healthy nearshore riparian systems are defined by the following characteristics:

- Long linear shapes,
- High edge-to-area ratios,
- Microclimates distinct from those of adjacent uplands,
- Standing or flowing water present all or much of the year, or a capacity to convey or retain water,
- Periodic flooding, which results in greater natural diversity,
- Composition of native vegetation differing somewhat from upland (inland) systems (e.g., different species abundance, diversity, and structure), and
- Support systems for terrestrial and aquatic biota.

Intact riparian habitats provide a variety of essential ecological functions, including water quality protection, sediment control, wildlife habitat, nutrient microclimate control, insect food sources for juvenile fish, shaded cover, and woody debris to help build complex habitat and stabilize beach substrate (Brennan and Culverwell, 2004) (Figure 3-4). A healthy nearshore riparian vegetation zone is also essential for stabilizing slopes and protecting against landslides and other erosion hazards. Plant root masses provide mechanical stability and the vegetation promotes evapotranspiration. This can mitigate the effects of excessive soil moisture, which can lead to erosion and/or mass instability (Brennan and Culverwell, 2004).

[2] This report uses estimates of salt marsh and tidal wetland habitat as reported by Todd et al. (2006), which may vary from results reported by Collins and Sheik (2005) due to differences in habitat classification and analysis methods. Readers are encouraged to review the source materials for more information.

Figure 3-4. Conceptual Model of Marine Riparian Functions (as described in Brennan and Culverwell, 2004)



Because they perform critical functions for stream and freshwater wetland ecosystems, freshwater riparian habitats have been extensively studied. Marine riparian systems by comparison have received less scientific investigation. Nevertheless, recent work published in the Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2680 (Lemieux et al., 2004) shows that nearshore riparian vegetation provides similar functions as freshwater riparian habitats.

3.2.3 Freshwater Habitats and Species

3.2.3.1 Wetlands

The state of Washington (WAC 173-22-030) defines wetlands as “those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.” Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands are known to play a vital role in the landscape by performing:

- Biogeochemical functions related to trapping and transforming chemicals and improving water quality in the watershed;
- Hydrologic functions related to maintaining the water regime in a watershed and reducing flooding; and
- Food web and habitat functions (Granger et al., 2005).

The four principal wetland types identified within Jefferson County include:

- Wet meadows, which are characterized by having standing water from late fall to early spring and are often dominated by reed canarygrass (*Phalaris arundinacea*), spike rushes (*Eleocharis* spp.), bulrushes (*Scirpus* spp.), and sedges (*Carex* spp.);
- Scrub/shrub wetlands, with seasonal flooding and vegetation dominated by shrubs and small trees such as hardhack (*Spiraea douglasii*), willow (*Salix* spp.), red alder (*Alnus rubra*), or red osier dogwood (*Cornus stolonifera*);
- Forested wetlands, areas that are not usually flooded but have saturated soils, and where vegetation is dominated by large trees such as black cottonwood (*Populus trichocarpa*), red alder (*Alnus rubra*), Oregon ash (*Fraxinus latifolia*), and western red cedar (*Thuja plicata*) with an understory of vine maple (*Acer circinatum*), cascara (*Rhamnus purshiana*), salmonberry (*Rubus spectabilis*), and devil's club (*Oplopanax horridum*); and
- Shallow marsh, which includes freshwater marshes and open water wetlands (Jefferson County, 2002).

These areas are scattered throughout the County, particularly in areas dominated by certain "hydric" soil types (including organic soil deposits of peat and muck), areas of low slope/depressional areas, along streams, and on slopes/transitional areas where groundwater is expressed to the surface (Maps 2-7 and 14-16).

Wetlands associated with shorelands, shoreland areas, or shorelines of the state are managed under the SMA. In context of SMA, *associated wetlands* means wetlands that are in proximity to shorelines or that influence or are influenced by waters subject to the Act (WAC 173-22-030 (1)). These typically include wetlands that physically extend into the shoreline jurisdiction, and wetlands that are functionally related to the shoreline through a hydrologic connection or other factors.

3.2.3.2 Riparian Areas

Freshwater riparian areas function in many of the same ways as nearshore riparian areas. Riparian zones contribute to healthy streams by dissipating energy and inhibiting sediment input, suppressing the erosional processes that move sediment, and by mechanically filtering and/or storing upland sediments before they can enter stream channels (Knutson and Naef, 1997). Riparian areas also perform water quality functions related to pollutant removal. This occurs primarily through denitrification and trapping/storing phosphates and heavy metals that are adsorbed to fine sediments.

One of the most critical roles that riparian areas play in the ecosystem is creating habitat. Riparian zones are a major source of large woody debris (LWD) input to streams.

Approximately 70 percent of the structural complexity within streams is derived from root wads, trees, and limbs that fall into the stream as a result of bank undercutting, mass slope movement, normal tree mortality, or windthrow. LWD creates complex hydraulic patterns that allow pools and side channels to form. It also creates waterfalls, enhances channel sinuosity, and instigates other physical and biochemical channel changes. The in-channel structural diversity created by LWD is essential to aquatic species in deep, low velocity areas for hiding, overwintering habitat, and juvenile rearing, in all sizes of streams and rivers (Knutson and Naef, 1997). Forest practices including clearcutting have damaged and degraded many of the riparian zones on state-owned and private forest lands in Jefferson County. In contrast, riparian habitat conditions in the federally owned lands in the upper watersheds of WRIAs 16, 17, 18, and 20 managed by the National Park Service (NPS) and the U.S. Forest Service (USFS) are among the best in the County. The lower Dosewallips River, lower Little Quilcene River, upper Chimacum Creek, and western Jefferson County rivers and streams outside of the National Park boundary typically have degraded riparian habitats and consequently poor LWD recruitment potential (Correa, 2002, 2003; Smith, 2000). Where data are available for WRIA 21, riparian conditions are mostly “fair” to “good” (Smith and Caldwell, 2001). Western Rivers Conservancy and Wild Salmon Center created the Hoh River Refugia Corridor, which is managed through the Hoh River Trust. Restoration of riparian function along the 30-mile-long, one-mile-wide corridor is underway (Hoh River Trust, 2006).

Wetlands and riparian zones in Jefferson County probably support muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), river otter (*Lutra canadensis*), beaver (*Castor canadensis*), raccoon (*Procyon lotor*), weasel (*Mustela* spp.), and other species. Water bodies, wetlands, and adjacent agricultural fields also provide suitable nesting and feeding habitat for mallard duck (*Anas platyrhynchos*), American widgeon (*Anas americana*), green-wing teal (*Anas crecca*), common coot (*Fulica atra*), common merganser (*Mergus merganser*), blue-wing teal (*Anas discors*), great blue heron (*Ardea herodias*), and lesser and greater Canada goose (*Branta* spp.) (Jefferson County, 2002).

3.2.4 Terrestrial Wildlife Habitats

Other habitat resources within Jefferson County include terrestrial forests (including old growth), river-cut canyons, glacially eroded canyons, active glaciers, riparian areas, coastal dunes, wetlands, sphagnum bogs, grasslands, lakes, and rivers. A majority of the County falls within the Northwest Coast ecoregion, dominated by coniferous forests. Lowland forests are dominated by western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), and western red cedar (*Thuja plicata*). Forests in the mountains are dominated by Pacific silver fir (*Abies amabilis*), and mountain (*Tsuga mertensiana*) or western hemlock. Within the coastal fog belt, Sitka spruce (*Picea sitchensis*) becomes abundant (WDNR, 2005). Bigleaf maple (*Acer macrophyllum*) is also a component of the rainforests. The old-growth conifers can reach up to 200 feet in height, and are characterized by somewhat open canopies and low densities (Smith, 2000). Low-elevation areas of eastern Jefferson County lie within the Puget Trough ecoregion; Douglas-fir forests with western hemlock and red cedar historically dominated vegetation in these areas.

Changes in forest cover and composition of forest stands outside the ONP have been extensive in Jefferson County. A study by Labbe et al. (2006) in Hood Canal showed dramatic changes in riparian forest composition and structure across different shoreline types, landforms, and landscape positions. Comparisons of historical and contemporary forest composition at 80 stream-riparian locations across Hood Canal showed significant vegetation change for particular vegetation types at lower elevation sites in/near bottomlands. Over the historical period, nearly 58 percent of cedar-spruce forest type sites transitioned to hardwood/mixed forest, as compared to other forest types, which showed change of 35 percent or less. Over two-thirds of sites that underwent vegetation change transitioned from conifer-dominance to hardwood/mixed forest (Labbe et al., 2006). Changes of this nature can adversely impact LWD recruitment to stream channels and cause loss of instream habitat complexity. Potential increases in nitrogen loading as a result of increased coverage of red alder are another concern, as alder has the capacity to fix nitrogen in soil.

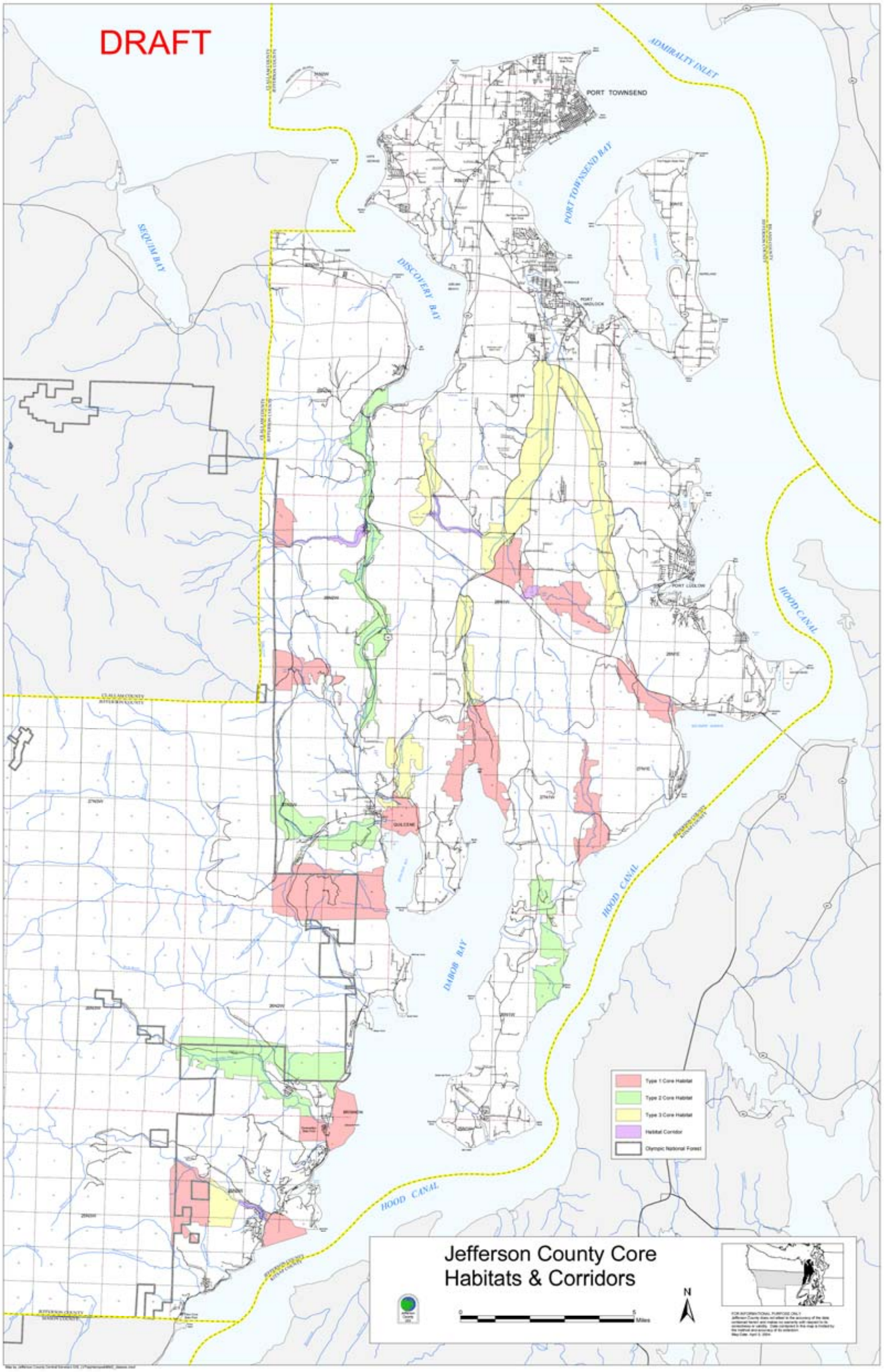
Grassland and oak habitats occur in the Puget Trough ecoregion as well. Many rare grassland species are declining with increased urbanization and the suppression of frequent fires that once sustained the grasslands, leading to more densely forested areas (WDNR, 2005). In Jefferson County, grassland and associated oak habitats are rare. Grassland habitat has been identified along the Big and Little Quilcene Rivers, while remaining oak habitats have only been documented along Discovery Bay.

The ONP, established in 1897 as a forest reserve, then nine years later as Mount Olympus National Monument, was intended to preserve elk, which were being hunted to the point of possible extermination for their teeth (popular as watch fobs). Congress designated the site as a national park in 1938. The park was expanded in 1956 to provide protection to an ocean corridor protecting the beaches and adjacent land along the northern coast of the Olympic Peninsula. ONP and ONF have been designated a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site (one of only 112 worldwide) and an International Biosphere Reserve (Jefferson County, 2002). The ONP, which covers a large portion of Jefferson County land area, protects and encompasses three distinct ecosystems, including some of the largest remaining tracts of Pacific Northwest old-growth forest and, on the west side of the park, temperate moist coniferous forest, as well as subalpine and alpine plant communities of the Olympic Mountains. The ONP also protects the largest population of Roosevelt elk in its natural environment in the world, and at least 16 animal and 8 plant species endemic to the Olympic Peninsula (Parametrix et al., 2005).

3.2.4.1 Priority Wildlife Habitats and Core Areas

WDFW-designated priority habitats for the County include elk herd habitat in the southeast portion of the County, and nest sites for several species of birds, including great blue herons, harlequin ducks, and purple martin. Nonbreeding concentrations of trumpeter swans, waterfowl, and seabirds have also been identified within the County (Tomassi, 2004).

Figure 3-5. Eastern Jefferson County Core Habitats and Corridors (Tomassi, 2004)



Jefferson County identified important wildlife habitat areas and corridors linking wildlife habitat in eastern Jefferson County (Tomassi, 2004) (Figure 3-5). Blocks of primary habitat used by wildlife species for breeding, rearing, foraging, wintering, roosting, and resting, and that are essential to the species' survival, as well as being key to the protection of biological diversity, were identified as "Core Areas". Core Areas contain features or habitat types of particular importance to wildlife, such as snag-rich stands, mature forest, or forested wetlands. Core Areas were identified along Snow Creek, Chimacum Creek, Thorndyke Creek, Tarboo Creek, Donovan Creek, Big Quilcene River, Dosewallips River, and Duckabush River, as well as the vicinity of Mt. Walker. As recommended by Tomassi (2004), Core Areas require special protection and management to ensure that land use practices related to clearing and grading, clearcutting, agriculture, snag removal, road construction, buffer reduction, residential development, and other activities do not fragment or destroy these areas.

3.3 ECOSYSTEM-WIDE PROCESSES

3.3.1 Hydrogeologic Setting

The movement of water, sediment, nutrients, pathogens, organic material, and heat/light through a watershed is governed to a large extent by the surrounding climate, topography, geology, and soils (Stanley et al., 2005). Collectively these governing factors are referred to as the hydrogeologic setting. The hydrogeologic setting plays a key role in determining most geochemical and biological processes within a watershed.

3.3.1.1 Climate

Jefferson County has a maritime climate dominated by moderate temperatures and abundant moisture. Maximum Fahrenheit (F°) temperatures average in the mid 40s in January in the lowlands; in the summer, average maximum temperatures range from 77°F in Quilcene in the east, to 69°F in Clearwater in the west. Temperatures in the lowlands rarely reach the 90s or fall into the teens in this region.

Some of the most extreme variations of annual precipitation in the United States occur on the Olympic Peninsula. In Jefferson County, annual precipitation varies from 126 inches at Spruce in the western foothills of the Olympic Mountains, to approximately 240 inches on Mt. Olympus at the crest of the mountains, to 50 inches in Quilcene along Hood Canal, to 18 inches in Port Townsend on the northeast tip of the Olympic Peninsula. Measurable precipitation falls on 176 days in Clearwater and 116 days in Port Townsend. This pattern of annual precipitation is caused by a dominant winter storm tract from the southwest creating a rain shadow over the northeastern Olympic Peninsula. Storms dump moisture as they rise over the mountains, and air dries and warms as it falls into the Puget Sound-Strait of Juan de Fuca trough. A storm that dumps heavy rain on the western slopes of the Olympic Mountains might only create a light mist along the Strait of Juan de Fuca. Most precipitation falls between October and April, as rain below 1,000 feet and snow above 2,500 feet elevation. Rain in the mid-summer is relatively rare, with high pressure aloft and moderate temperatures predominating.

Severe flooding and coastal bluff landslides often occur when there is a heavy snowfall followed by rain (called a rain-on-snow event). This creates a situation where the accumulated precipitation of several storms runs off the landscape over a very short time. Examples of this phenomenon are the storms of the winter of 1996-97, which triggered numerous, massive, coastal bluff landslides in the Puget Sound region, as well as numerous mass wasting events in west Jefferson County, causing significant tributary and river channel changes, sedimentation, and scour (Smith, 2000).

3.3.1.2 Topography and Bathymetry

Coniferous forest, high precipitation, and large rivers characterize Jefferson County west of the Olympic Mountains. Some of the largest trees in the world grow here in a temperate rainforest ecosystem. Larger rivers such as the Hoh, Queets, and Quinault are glacially fed at their headwaters. In their lower reaches these rivers meander over large floodplains. The landscape is generally hilly in the west but rises dramatically to the east in the Olympic Mountains. Although the Olympic Mountains are not particularly high (Mt. Olympus is the tallest peak at 7,969 feet above sea level), these mountains are rugged and composed of relatively recent metamorphic rock. The broad, hilly country between the Olympic Mountains and the Pacific Ocean has not been glaciated for at least the past 17,000 years (Abbe, 2000 as cited in Correa, 2002).

The landscape in eastern Jefferson County was shaped by repeated glaciations, the last retreating about 12,000 years ago. This left a landscape of layered glacial and outwash sediments (glacial till) with little exposed bedrock. The coastal shoreline of east Jefferson County is now characterized by bluffs carved out of these glacial sediments, often topped by Douglas-fir and hemlock forest. Several sizable rivers flow east out of the Olympic Mountains and into Hood Canal, providing salmon habitat and forming relatively large delta estuaries. Prairies occurred along Discovery Bay, on Protection Island, and in Port Townsend in the drier northeast section of the study area, but few remnants of this ecosystem exist today.

Similar to the glacially carved features that characterize the topography of eastern Jefferson County, the area's bathymetry was formed by glacial scouring and subglacial erosion. Glaciers and subglacial meltwater scoured channels and troughs (Booth, 1994). These interconnected, north-south trending basins dominate much of the marine environment of Puget Sound today. There are four major divisions in Puget Sound between these interconnected channels, which are marked by the presence of sills or submarine ridges that constrict water flow from one basin to the next.

The northern part of Jefferson County falls within the northernmost subbasin of the Main Basin in Puget Sound (Figure 3-6). The Main Basin originates at a shallow sill at the north end of Admiralty Inlet. The Main Basin is delimited to the north by a line between Point Wilson (near Port Townsend) and Partridge Point on Whidbey Island, to the south by Tacoma Narrows, and to the east by a line between Possession Point on Whidbey Island and Meadow Point (near Everett) (shown as Area 3 on Figure 3-6).

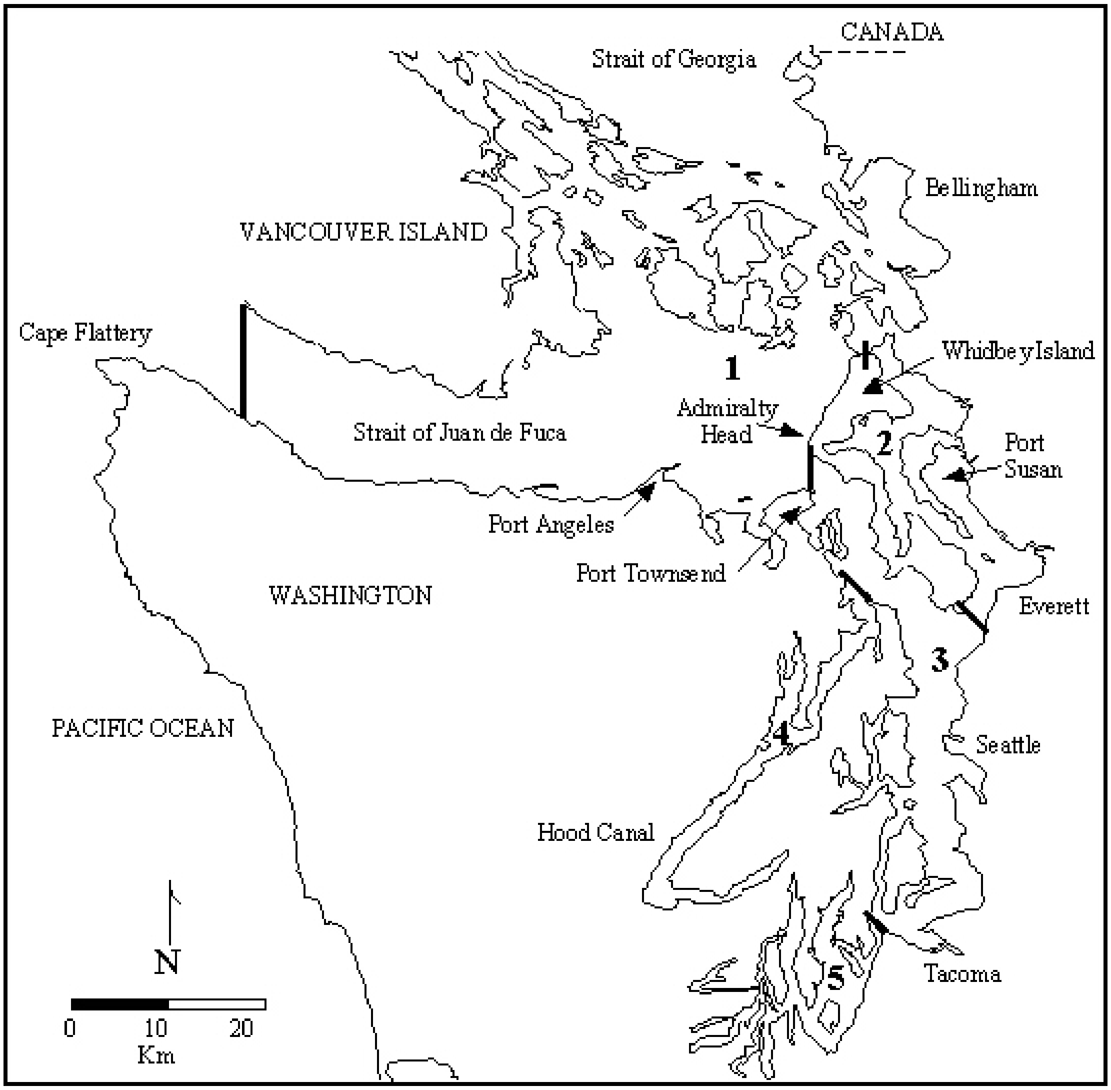
Deep, north-south trending basins (Admiralty Inlet, Hood Canal) and large bays (Port Townsend, Dabob, Quilcene and Discovery Bays) characterize the bathymetry of eastern Jefferson County. These basins and bays typically have deep water centrally and at the bay entrance, and shallower low-tide terraces close to shore, with river deltas near bay heads. Additionally, there are numerous smaller bays throughout the County that have more limited areas of deep water including Kilisut and Squamish Harbors, Oak and Thorndyke Bays, and Port Ludlow.

The predominant waterway of northern Jefferson County is the Strait of Juan de Fuca (shown as Area 1 on Figure 3-6). The deepest water in this portion of the study area is found between the entrance to Discovery Bay and Protection Island. Shallow Dallas Bank is located on the north side of Protection Island (12 to 54 feet deep). The shores on the Strait near Port Townsend possess broad sand flats and shallow water adjacent to shore, with considerably deeper water found farther offshore.

Admiralty Inlet marks the northern end of the Main Basin in Puget Sound, which extends approximately 62 miles from Point Wilson (near Port Townsend) to the Tacoma Narrows. The sill at the north end of Admiralty Inlet is 18.6 miles wide and is 213 feet deep at its shallowest point. Deep water is found immediately south of the sill (330 to 450 feet deep).

Hood Canal branches off Admiralty Inlet between Tala Point and Foulweather Bluff, and is the smallest of the Puget Sound area basins, being 56 miles long and 0.5 to 2.0 miles wide (shown as Area 4 on Figure 3-6). Like many of the other basins, it is partially isolated by a sill (164 feet deep), which is located between South Point and Lofall. The deepest water in the basin (over 617 feet deep) is found in central Dabob Bay. Generally, water depths in Hood Canal range from 138 to 348 feet.

Figure 3-6. Regional Water Masses and Subareas of Puget Sound: (1) Northern Puget Sound, (2) Whidbey Basin, (3) Main Basin, (4) Hood Canal, and (5) Southern Basin (Gustafson et al., 2000)



3.3.1.3 Geology

Bedrock Geology

Bedrock at the coast of eastern Jefferson County was mapped as several different units that were originally deposited during the Cretaceous Period (66 to 146 million years ago). Exposed bedrock in the southern portion of the study area is part of the Crescent Formation, consisting primarily of Eocene basalt, deposited within the last 66 million years (Whetten et al., 1988; Ecology, 1978). Crescent Formation rocks are exposed along the northern, eastern, and southeastern flanks of the Olympic Mountains (Tabor and Cady, 1978). Basalt outcrops exist at the coast in southern Port Ludlow Bay and east of Mats Mats Bay, extending up to Olele Point. Basalt appears black or near black with reddish portions near the top of flows where oxidation has occurred. Basalt flows are characterized by closely spaced, random joints, and contain rare pillow lavas (Tabor and Cady, 1978). Basalt was deposited as massive flows and breccia (Whetten et al., 1988), and is also found in conglomerate along the east shore of Discovery Bay (Tabor and Cady, 1978). Basalt is a crystalline rock and is very resistant to erosion; erosion of the intertidal basalt has advanced generally less than 20 to 40 feet in approximately 4,500 to 5,000 years.

The Oak Bay and southernmost Port Townsend Bay shores contain outcrops of Quimper sandstone. This unit is gray to olive gray, fine to coarse grained, feldspathic sandstone that weathers yellowish brown (Whetten et al., 1988). Quimper sandstone contains minor siltstone beds and spherical to elliptical calcareous concretions as large as 1 foot in diameter. Quimper sandstone is quite resistant to marine erosion, but sea cliffs have eroded at a considerably higher rate than the more resistant basalt cliffs.

Unconsolidated Geologic Deposits

The Cordillera Ice Sheet advanced into and retreated from western Washington at least six times during the Pleistocene Epoch, within the last 24 million years (Easterbrook, 1986). Characteristics of the advance and retreat of the six known glaciations in the Puget Lowland show a very similar pattern (Easterbrook, 1992), especially during the three most recent glaciations that deposited stratigraphic sequences in eastern Jefferson County: the Double Bluff, Possession, and Fraser glaciations. Glacial advances typically began by the spreading of an apron of outwash in front of the advancing ice. Advance outwash deposits were deeply scoured by overriding ice, incorporating pebbles and cobbles that were already rounded into till that was deposited upon the truncated outwash sediment (Easterbrook, 1992).

The Double Bluff glaciation is the oldest known glacial deposit in the northern Puget Lowland. Evidence of glacial advance is present in exposures of Double Bluff Drift at its type locality at southwestern Whidbey Island and in bluffs in Hood Canal. Double Bluff Drift consists of glaciofluvial gravel, sand and silt, till, and glaciomarine drift (Easterbrook, 1969). The Double Bluff glaciomarine drift is dated at 150,000 to 200,000 years ago (Blunt et al., 1987; Easterbrook, 1992).

Non-glacial fluvial, peat, and lacustrine sediments of the Whidbey Formation are also exposed in bluffs between Port Townsend and Hood Canal. This formation was deposited during the Whidbey Interglaciation and overlies Double Bluff Drift. The Possession Drift of the Possession glaciation was deposited upon a surface of moderate relief, either on outwash sand and gravel or on the Whidbey Formation (Easterbrook, 1992). At its type locality on southeastern Whidbey Island, the Possession Drift consists of compact, sandy till, sand and gravel, and stony clay glaciomarine drift (Easterbrook, 1969). Possession Drift is exposed near Mats Mats Bay.

The most recent glacial advance into the Puget Lowland was the Vashon Stade of the Fraser glaciation. This followed the Olympia nonglacial interval during which floodplain and lacustrine silt, clay, and peat were deposited between 22,000 and 28,000 years ago in the central Puget Lowland (Hanson and Easterbrook, 1974). In the early stages of the Vashon Stade (16,000 to 18,000 years ago), meltwater streams delivered large quantities of outwash sand and gravel from the glacier terminus, creating a thick sequence of advance outwash sand and gravel deposits (Easterbrook, 1969). Advance outwash deposits are composed mostly of pebbly sand with cross bedding and scour-and-fill features. Advance outwash deposits are common in high bluffs underlying Vashon till, and provide abundant beach-forming sediment to the nearshore system.

The advance of the most recent continental ice sheet, in the Vashon Stade, deposited abundant till over advance outwash deposits. Glacial ice reached a maximum thickness of approximately 4,000 feet in the study area (Easterbrook, 1969). Vashon till, which is very common in the County, is a relatively high-strength deposit, having been compacted by the full thickness of the glacial ice sheet. Till can stand in very steep bluffs for extended periods of time, such as in the bluff at the Port Townsend ferry landing. Till appears as tan to light gray with pebbles among a fine grain matrix (diamicton). Late stage Vashon deposits in the study area include recessional-continental deposits that contain ice-contact deposits and outwash deposits (Pessl et al., 1989). Recessional-continental deposits contain sand, gravel, and silt in meltwater deposits that are generally very low strength and relatively thin beds. Deposits from the Vashon Stade are preserved in extensive unconsolidated deposits exposed in the upper parts of coastal bluffs throughout most of the study area. Bedrock outcrops are commonly overlain by a mantle of glacial deposits of varying thickness.

From the Strait of Juan de Fuca south to Quilcene Bay, the beaches generally have two similar sets of characteristics: either exposed high bluffs (composed primarily of glacial deposits) with mixed sediment beaches, or protected bays with moderate amounts of riparian and marsh vegetation. Both of these settings include expanses of undeveloped shores with clusters of residential and/or commercial development. The shores of southeastern Jefferson County are of differing geology, and are composed of a mix of glacial and non-glacially derived deposits. The relatively erosion-resistant basalt and marine sedimentary strata (notably along Hood Canal in the vicinity of Brinnon and the Olele Point area north of Port Ludlow) control the nearshore character and coastal processes, which will be discussed in more detail in the reach descriptions (Chapter 4).

3.3.2 Shoreline Processes, Process-intensive Areas, and Alterations

3.3.2.1 Nearshore Processes

Key processes at work in the marine nearshore environment are described below. These processes form the physical shape of the shoreline, influence nutrient dynamics, and create the other biogeochemical conditions that sustain the marine ecosystem. Emphasis is on processes affecting the shores of Puget Sound in eastern Jefferson County since the western coastal areas are outside of County shoreline jurisdiction. Much of the information described in text is depicted on maps 2 though 7 in Appendix C (Table 3-3). The reach-scale maps referenced in Chapter 4 and shown in Table 3-1 also depict some of the features discussed below.

Table 3-3. Map Locations for Ecosystem-scale Attributes, including Nearshore and Freshwater Process-intensive Areas and Alterations

Theme	Map Name/ No.
Permeability Channel Migration Zones (CMZ) Land Cover (early and late seral stage vegetation; human imprint)	Maps 2 and 3. Hydrology (Key areas and Alterations)
Septic Permits Tilled Fields Lost Wetlands Human Imprint	Maps 4 and 5. Water Quality (Key areas and Alterations)
Hydrology / Streams and Lakes WRIA Boundaries Watershed Boundary Road Density LSI Landslides Landslide Hazard Zonation Erodible Soils	Maps 6 and 7. Sediment (Key areas and Alterations)

This section discusses:

- Circulation processes, including tides and currents,
- Water quality processes for nitrogen, phosphorus, and pathogens,
- Beach processes including coastal erosion, net shore-drift, coastal bluff landslides, and fluvial influences, and
- Climate change including temperature, precipitation and runoff, and sea level rise.

Circulation

Eastern Jefferson County oceanographic processes are characteristic of the normal mean circulation pattern in a fjordal estuary, with seaward flow at the surface and landward flow at depth. Fresh water derived from local rivers typically flows seaward at the surface, since these water masses are of lower salinity and warmer (hence, less dense) than incoming ocean water. Colder, more saline water originating from the Pacific Ocean flows landward along the bottom (Nightingale, 2000). The combined forces of lunar influence, winds, and bathymetry determine the extent to which these layers are mixed. During neap tides (when the moon is in the first and last quarters) when the tidal range is smallest, seawater intrusions and the influx of saltier water to Puget Sound are greatest. However, during spring tides (that occur with the new and full moon), higher velocity tidal currents result in increased mixing of fresh and salt water (Nightingale, 2000).

A temperature, salinity, and density difference between freshwater runoff and nutrient upwelling from ocean water determines the extent of mixing. This is influenced strongly by the force exerted on the water surface by wind (Nightingale, 2000). Because the variables that drive circulation exhibit considerable spatial variability across the marine landscape, the degree of mixing can vary significantly across small distances. For example, strong winds, deep water, ocean intrusions, and currents coupled with riverine inputs result in the Strait of Juan de Fuca being well-mixed with cold and nutrient rich water year-round. The presence of a shallow sill at the entrance to Admiralty Inlet magnifies the extent of the mixing. This strong mixing zone produces well-mixed water in Port Townsend Bay, with higher levels of dissolved oxygen than inlets and bays outside of the influence of the Admiralty Inlet sill (Nightingale, 2000; Strickland, 1983).

In contrast, neighboring Discovery Bay is persistently stratified with colder, saltier, and denser water near the bottom and lower salinity and warmer water at the surface. The combined effect of bathymetry, low wind mixing, and low current exchange produces the seasonally stratified and poor flushing characteristics of Discovery Bay. This weak mixing and flushing produces low nutrient levels near the surface and low oxygen levels near the bottom (Newton et al., 1998; Strickland, 1983). A similar condition exists in Hood Canal where seawater density stratification, poor flushing and circulation, and high levels of organic production contribute to low-oxygen conditions (Fagergren et al., 2004; HCDOP, 2006).

Tides and Currents

A portion of the marine water originating from the Pacific Ocean enters through the Strait of Juan de Fuca then diverges south into the inlets and bays of eastern Jefferson County. Similar to the rest of Puget Sound, tides in eastern Jefferson County are semi-diurnal, exhibiting two unequal high and two unequal low tides per day.

Tidal currents are moderate throughout the larger straits, but become increasingly strong when water funnels through constrictions such as at Admiralty Inlet. The strongest tidal currents observed in the study area are found at Point Wilson (4.8 to 5.5 knots) and Admiralty Inlet (approximately 4 knots). Lesser tidal currents have been measured near Olele Point (1.6 knots) and Foulweather Bluff (1.3 knots).

The Strait of Juan de Fuca is a wind-dominated system, with currents changing dramatically within hours in response to both regional and larger scale oceanic winds. Strong seasonal storms contribute pulses of both fresh water and sediment to the Strait of Juan de Fuca. These pulses form large lenses of very low salinity and very high turbidity within the nearshore zone along the majority of the shoreline of the Strait of Juan de Fuca. These lenses appear to occur primarily during winter and spring months (Shaffer and Crain, 2004 as cited in PSAT, 2005).

Water Quality

Nutrients (Nitrogen and Phosphorus)

The nearshore and marine waters of Jefferson County receive inputs of nutrients and organic matter from adjacent uplands, streams, rivers, and groundwater seeps, as well as from nearshore bottom sediments and mixing with deeper ocean waters via upwelling and estuarine circulation. In general, inputs from natural sources of nitrogen and phosphorus are several orders of magnitude greater than anthropogenic sources in Puget Sound (Harrison et al., 1994). However, in some areas, including Hood Canal, anthropogenic inputs have been shown to far exceed what can be contributed naturally (Fagergren et al., 2004).

Nutrient loads from streams and rivers entering the nearshore are affected by the magnitude of river discharge, as well as watershed land uses. Major human sources of nutrients from upland areas include agricultural operations (animal manure, fertilizers), wastewater treatment plants, and stormwater runoff from residential landscapes (Embrey and Inkpen, 1998 as cited in Fagergren et al., 2004). Major anthropogenic sources of nutrients in Hood Canal include human sewage, stormwater runoff, chum salmon carcasses from hatchery returns, agricultural waste, and forestry (Fagergren et al., 2004).

In enclosed bays or inlets, or during periods of greater stratification and reduced circulation and mixing with oceanic waters, specific locations within Puget Sound can receive excess nutrients from anthropogenic sources. Nutrient levels in these protected waters (e.g., Hood Canal) can result in eutrophication and low levels of dissolved oxygen (hypoxia), which can be detrimental to marine organisms. Eutrophication can also lead to contamination of shellfish beds (including associated bacterial contamination) as well as negative impacts on riparian buffers and forage fish spawning; critical salmonid, shorebird and seabird nesting and foraging; and marine mammal foraging, migration, and haulout habitats. Nearshore areas of Jefferson County that are susceptible to eutrophication from increased nutrient inputs, or from stratification that can locally concentrate nutrients, include Hood Canal and enclosed bays such as Mats Mats Bay, Kilisut Harbor, and Discovery Bay.

The same processes that control nutrient inputs, dispersion, and areas of concentration also influence inputs and concentrations of pathogens, pollutants, and toxins in nearshore waters of Jefferson County. Water quality impairments are described in the reach analyses (Chapter 4).

Riparian buffers offer discernible water quality protection from nearshore nutrient sources. The effectiveness of riparian buffers for protecting water quality depends on a number of factors, including soil type, vegetation type, slope, annual rainfall, type and level of pollution, surrounding land uses, and sufficient buffer width and integrity. Soil stability and sediment control are directly related to the amount of impervious surface and vegetated cover. Soil quality is typically degraded in developed areas where riparian vegetation has been removed and soils have been compacted (May, 2003). Water that is not absorbed or intercepted by vegetation will increase the potential for landslides. Runoff over the surface can lead to erosion, siltation, burial of aquatic environs, and introduction of contaminants into water. Pollutants such as excess nutrients, metals, and organic chemicals are commonly found in stormwater and agricultural runoff, usually in particulate form. Sediment control therefore often removes a large percentage of the pollutant load as well (May, 2000).

Pathogens

This report focuses on fecal coliform as an indicator of pathogens because it is the most commonly occurring pathogen and because it is monitored in Ecology water quality studies. Fecal coliform bacteria signal the possible presence of feces and pathogenic organisms, yet there is growing concern that they do not reliably predict the occurrence and survival of enteric viruses and other pathogens in the marine environment (Glasoe and Christy, 2004). Human sources of fecal matter and associated pathogens include but are not limited to septic systems built on or near marine and estuarine shorelines, marina and boating activities, and pet waste.

Beach Processes and Coastal Erosion

Eastern Jefferson County beaches represent a commonly occurring beach character found in northern Puget Sound, with two distinct foreshore components: a high-tide beach and a low-tide terrace (Downing ,1983; Johannessen, 1993). The high-tide beach consists of a relatively steep beach face with coarse sediment and an abrupt break in slope at its waterward extent. Sand in a mixed sand and gravel beach is typically winnowed from the high-tide beach by waves (Chu, 1985) and deposited on the low-tide terrace. Extending seaward from the break in slope, the low-tide terrace typically consists of a gently sloping accumulation of poorly sorted, fine-grained sediment (Komar, 1976; Keuler, 1979). Lag deposits derived from bluff recession are also found in the low-tide terrace. These deposits are typically composed of larger clasts, ranging from cobbles to boulders.

Puget Sound area beach composition is dependent upon three main influences: wave energy, sediment sources, and relative position of the beach within a littoral cell. Wave energy is controlled by fetch, or the open water over which winds blow without any interference from land. Within the Jefferson County study area, the maximum fetch at some Strait of Juan de Fuca sites such as Fort Worden is essentially unlimited to the west (including the Strait of Juan de Fuca, west across the Pacific Ocean). Fetch from the north is greatest at Admiralty Inlet (to the Gulf Islands), and measures approximately 49 miles. Southerly fetch measures 28.5 miles from Hood Canal to Dabob Bay. Though southerly fetch measures the least at some of the County shores, winds and waves originating from the south are the strongest (predominant) and most frequent (prevailing) wind direction in Puget Sound. WDNR's ShoreZone Inventory classified most of the beaches in eastern Jefferson County as "semi-protected" (40.3 percent), "protected" (26.7 percent), and "very exposed" (19.2 percent). Fewer beaches were rated as "semi-exposed" (5.7 percent) and/or "very protected" (8.1 percent) (WDNR, 2001).

Wind-generated waves intermittently erode beaches and the toe of coastal bluffs, contributing to the initiation of bluff landslides. These coastal bluffs (referred to as feeder bluffs or contributing bluffs) are the primary source of sediment for most Puget Sound beaches, including the Jefferson County study area (Keuler, 1988; Downing, 1983). Bluff composition and wave energy influence the composition of beach sediment. Waves sort coarse and fine sediment, and large waves can transport cobbles that small waves cannot. Additionally, beaches supplied by the erosion of coarse gravel bluffs differ in composition from those fed by the erosion of sandy material. The exposed strata of the eroding bluffs in the study area are largely composed of sand, gravel, and silt (WDNR, 2001; Ecology, 1978). These same materials dominate sediment found on the beaches, with the exception of fine sand through clay, which are winnowed from the beach face and deposited in low-tide terraces and in deeper water.

In addition to the previously mentioned influences (wave energy and sediment sources), tidal range also affects beaches over time. Rosen (1977) demonstrated that, with other parameters equal, coastal erosion rates tend to increase with decreasing tidal range. This is due to the focusing of wave energy at a narrow vertical band with small tidal range, in comparison to the dissipation of wave energy over a large vertical band with a greater tidal range. The northeastern portion of the County, from the Strait of Juan de Fuca to Point Hannon (Hood Head), has a tidal range (MLLW to MHHW) on the order of 7.9 to 9.4 feet, which is considered to be *mesotidal* (2 to 4 meter range). The Hood Canal area of Jefferson County has a greater tidal range of 9.9 to 11.4 feet, which is in the upper range of *mesotidal*. This means that wave erosion, under the same wave conditions, would be greater in the Strait of Juan de Fuca, and progressively less into Hood Canal. This is because the wave energy is focused on the upper beach and bluff toe less of the time. When the greater wave energy at the Strait of Juan de Fuca is factored in, coastal erosion rates would be expected to be substantially greater in the Strait.

The majority of coastal erosion in the region occurs when high-wind events coincide with high tides and act directly on the backshore and bluffs (Downing, 1983). Most coastal landsliding occurs during and following prolonged high-precipitation periods in the winter (Tubbs, 1974; Gerstel et al., 1997; Shipman, 2004).

Net Shore-drift

Wind-generated waves typically approach the shore at an angle, creating beach drift and longshore currents and transporting sediment by a process called littoral drift. *Net shore-drift* refers to the long-term, net result of littoral drift. Net shore-drift cells represent a sediment transport sector from source area to deposition area along a reach of coast.

Each drift cell acts as a system consisting of three components: a sediment source (erosional feature) and origin of a drift cell; a transport zone where sediment is moved alongshore by wave action with minimal sediment input; and a deposition zone often creating spits or barrier beaches. The deposition area is the drift cell terminus. Deposition of sediment occurs where wave energy is no longer sufficient to transport the sediment in the drift cell.

This process of net shore-drift transporting sediment over time from a feeder bluff to a depositional shoreform creates unique drift cells—stretches of shoreline where sediment flow is essentially isolated from adjacent stretches of shoreline. Properly functioning drift cells are essential for creating and maintaining nearshore habitats for salmon, shellfish, and other species. Thus, drift cells are useful for planners to divide the shore into manageable, coherent reaches for characterization and management. Drift cells in the Puget Sound-Strait of Juan de Fuca region range in length from hundreds of feet to 5 miles or more.

Net shore-drift cells were mapped in eastern Jefferson County several times by different scientists. Mapping was performed by Ralph Keuler (1988) for the USGS in the early 1980s (Figure 3-7, see also Maps 11 and 12 in Appendix C). However, Keuler's mapping effort did not encompass the entire County; it extended only to northern Oak Bay. Johannessen (1992) completed a net shore-drift study of San Juan County and parts of Jefferson, Island, and Snohomish Counties for Ecology's Shorelands Division. This included southeast Jefferson County up to Oak Bay. This information was published as a compendium to the larger net shore-drift compilation by Schwartz et al. (1991).

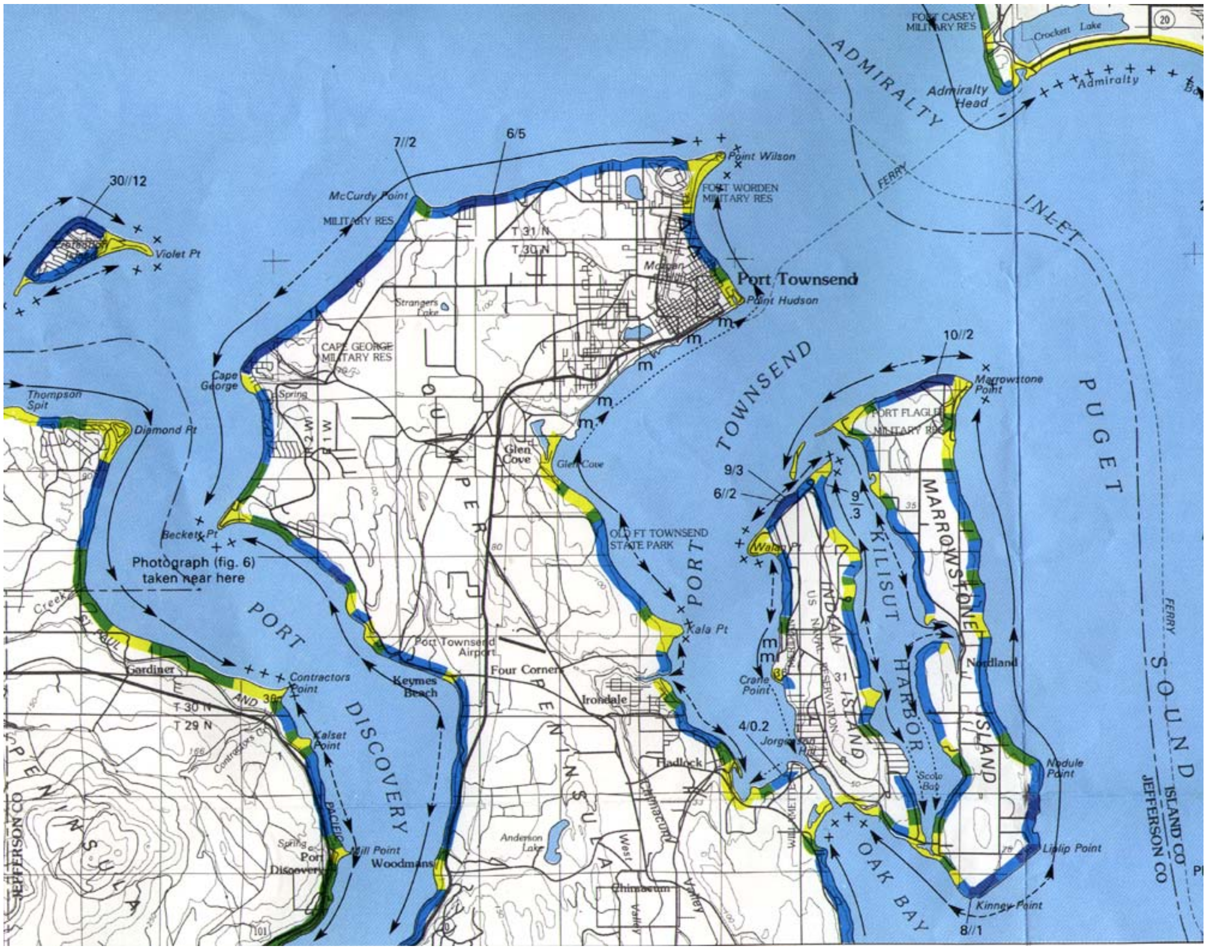
The Johannessen net shore-drift study was conducted through systematic field investigations of the entire coast to identify geomorphologic and sediment indicators that revealed net shore-drift cells and drift direction (Jacobsen and Schwartz, 1981). The net shore-drift mapping methods employed by Keuler and Johannessen used well-documented, isolated indicators of net shore-drift in a systematic fashion.

The first drift cell mapping effort was completed in the late 1970s as part of the Coastal Zone Atlas of Washington series (Ecology, 1978). The methods used in that study differed greatly from those applied by Johannessen and Keuler in that the Atlas relied exclusively on limited historic wind records. Recently, Ecology digitized the Johannessen and Keuler net shore-drift mapping, but the mapping was not technically reviewed and numerous errors and misinterpretations exist in the digital dataset. As a result, Coastal Geologic Services (CGS) reviewed and edited the eastern Jefferson County mapping, which is now as accurate as the original mapping allows without conducting new field or photographic investigations.

Eastern Jefferson County contains 52 net shore-drift cells and 7 regions of negligible net shore-drift (Maps 11 and 12). The general patterns of sediment transport through net shore-drift and sediment sources and depositional areas will be described in the individual reach descriptions (Chapter 4). In general, shores that are exposed to southerly wind and waves typically have northward net shore-drift. Shores that have substantial greater exposure to the northwest or north typically have eastward or southward drift. At the north-facing shores along the Strait of Juan de Fuca, easterly net shore-drift generally occurs due to substantial fetch from the west. Due to local variations in the north-south trending topography of the eastern Jefferson County marine landscape, there are some localized exceptions to these patterns such as at Olele Point and Whitney Point.

In eastern Jefferson County, there are areas where resistant basalt and sandstone (described above) are found at the coast, notably along Hood Canal south of Quilcene Bay and near the Olele Point area north of Port Ludlow, where there is little or no net shore-drift of sediment.

Figure 3-7. Net Shore-drift Mapping for Northeastern Jefferson County (from Keuler, 1988)



Coastal Bluff Landslides

The erosion of glacial and non-glacial sedimentary deposits has created high-elevation, often unstable bluffs along the shores of much of eastern Jefferson County. According to Ecology's recently digitized slope stability mapping (based on the 1970s Coastal Zone Atlas), 83 historic landslides were identified in the Jefferson County study area. Recent landslides were mapped at 327 locations. The greatest density of slides was found along the east and west shores of the Toandos Peninsula, east and west Marrowstone Island, north Indian Island, north of Point Ludlow, Point Wilson to Cape George, northeast Discovery Bay, and from Port Townsend to Kala Point. Landslides were also observed in higher density around the following headlands: Quatsap Point, Fisherman's Point, Termination Point, Point Hannon to Tala Point, Kinney Point, and South Point (Maps 26 and 27).

Coastal landslides contribute the majority of sediment input to the beach and net shore-drift system. Coastal landslides typically occur during periods of high precipitation, on bluffs where a combination of characteristics makes the bluff vulnerable to slope failure (Tubbs, 1974). These characteristics include the underlying geology of a bluff or bank, its level of exposure (fetch), the local hydrology (groundwater and surface water), and the extent of development impacts

(Hampton et al., 2004). Many Jefferson County bluffs are quite susceptible to coastal landslides as a result of wave exposure.

Undercutting of the toe of the bluff is usually the long-term “driver” of bluff recession (Keuler, 1988). Windstorms that create significant wave attack of the bluff toe can directly trigger bluff failures. Bluffs that are exposed to greater fetch are subject to higher wave energy during storms, resulting in greater toe erosion and bluff undercutting, and thus more frequent landslides (Shipman, 2004). More commonly, toe erosion precedes bluff landslides by a period of years, as bluff instability gradually progresses up the slopes. Bulkheads reduce wave attack to bluff toes and reduce or eliminate undercutting, but can accelerate erosion of the beach.

Storms that coincide with elevated water levels, such as a storm surge or extraordinary high-high tide, can produce dramatic toe erosion. An example of this was the February 4, 2006 windstorm, which brought near record high water levels coincident with 45 to 50 knot winds. Waves reached bluff toes during this storm where this had not occurred for many years and undermined reaches of bluff that may not fail (slide) until subsequent high-precipitation periods (Thorsen, 1987). Exposed bluffs composed of glacial drift south of Port Townsend typically experience long-term, mean erosion rates of 1.5 to 4 inches per year (Keuler, 1988), and bluffs farther west have little data for erosion rates. Coastal erosion rates are contingent on the position of a particular site within a net shore-drift cell, as described above.

Landslides are more likely to occur in areas where there is a history of landslides, or where the bluff strata are composed of an unconsolidated, permeable layer (sand), underlain by a relatively impermeable layer (such as dense silt or clay) (Gerstel et al., 1997). As water seeps through the permeable layer and collects above the impermeable layer, a zone of weakness or “slip-plane” is created. This stratigraphic pattern is a typical initiator of mass wasting (including landslides, but also including larger deep-seated failures). This bluff configuration is fairly common in eastern Jefferson County.

Abundant glacially derived sediment, delivered via landslides or eroded from bluffs, creates beaches primarily composed of sand and pea gravel overlying cobble. Sand lance and surf smelt (referred to as forage fish) prefer to spawn on beaches of mixed sand and pea gravel (Penttila, 2000). Eelgrass beds offshore depend on sediment high in sand and pea gravel and are not able to thrive in small sediment-deprived systems dominated by cobble (Hirschi, 1999). Salmon rely on forage fish for food, gently sloping beaches as safe havens from predators during migration, and eelgrass beds for cover and foraging habitat (Groot and Margolis, 1991).

Bluff-top trees are favorite spots for nesting and perching by bald eagles. Overhanging vegetation provides shade for surf smelt and sand lance eggs, serves as a source of terrestrial insects for consumption by marine fishes, and provides cover at high tide (Brennan and Culverwell, 2004).

A substantial quantity of seepage has been observed in some eastern Jefferson County bluffs including along Discovery Bay and Oak Bay. The highest volumes of groundwater observed seeping from the bluff face typically occur following prolonged heavy precipitation. Periods of high rainfall intensity and duration (especially during saturated soil conditions) are the most common trigger of coastal landslides (Tubbs, 1974), such as those observed during the New Year of 1996-97 (Gerstel et al., 1997; Shipman, 2001).

Fluvial Influences on the Nearshore

Fluvial sources (rivers and streams) contribute to nearshore character and can act as an agent of change on the marine landscape. Though most river sediment reaching the coast is initially deposited in deltas, much of the sediment is transported beyond beaches and deposited on delta fronts and in deeper water. This is the case because fluvial sediment is often too fine to remain in the nearshore due to prevailing wave regimes. Downing (1983) stated that 90 percent of river-borne sediment input to the Puget Lowland is too fine to remain in nearshore systems. The coarse grain portion of the sediment yield from rivers and streams is typically transported alongshore in net shore-drift cells, such as at the mouth of the Dosewallips and the Duckabush Rivers. However, some areas have net shore-drift cells converging on stream mouths, such as at the head of Dabob, Quilcene and Discovery Bays, and at Chimacum Creek (Maps 11-14). As stated previously, the majority of beach sediment is derived from recession of unconsolidated bluffs.

The quantity and quality of fluvial sediment delivered to the nearshore depends on the nature of the upland: its elevation, the types of rocks and soil found there, the density of vegetation, and the climate (Komar, 1976). The greater the volume of sediment, the greater the influence on nearshore processes. Some of the larger fluvial systems influencing nearshore processes include McDonald Creek, the Little and Big Quilcene Rivers, the Dosewallips River, the Duckabush River, and Snow and Salmon Creeks. When lower portions of river systems are diked or cut off from depositional floodplains, excessive fluvial sediment is often deposited at the river mouth, forming a prograded river delta and damaging valuable estuarine habitat.

Fluvial systems influence the nearshore by locally decreasing the salinity of the water, and by providing sediment to local beaches, which can aid in the formation of ecologically valuable habitats including marshes, distributary channels, shallow water deltaic habitats, and sand and mudflats. Fluvial influences also affect the abundance and density of aquatic flora (e.g., eelgrass) and fauna. Altered littoral drift patterns can be caused by the river or stream discharge into the nearshore. These altered conditions commonly lead to the deposition of alongshore bars or shoals and heightened shoreline complexity. Features such as these can be permanent or ephemeral, displaying seasonal dynamics concurrent with changes in discharge and wave conditions.

Global Climate Change

Over time, global climate change will undoubtedly impact Jefferson County’s shorelines. Effects are likely to be most pronounced on, but not limited to, nearshore areas. The United Nations Intergovernmental Panel on Climate Change (2007) concluded that, “Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level.”

Researchers at the University of Washington’s Climate Impacts Group and others have devoted significant effort to modeling potential effects of climate change on the Pacific Northwest in particular. They note that even if all carbon dioxide emissions were halted today, ambient atmospheric concentrations would continue to change climate conditions in the Puget Sound region for many decades, without taking projected emission increases into account (Snover et al., 2005 as cited in King County, 2006). A great deal of uncertainty exists as to the magnitude, precise timing, and extent of climate change impacts in the Puget Sound region. What is certain, however, is that impacts will occur. Developing plans and taking action now will serve to minimize harm to human communities and natural resources in the future.

The Intergovernmental Panel on Climate Change predicts that between 1990 and 2100, average global surface temperature could increase from 2.5 to 10.4^{o}F, and global sea level could rise between 4 and 35 inches, depending on both the rate of natural changes and the response of the climate system to greenhouse gas emissions now and in the future (IPCC, 2006 as cited in King County, 2006). Increasing temperatures and sea levels are likely to impact shorelines of Jefferson County in multiple ways, as described below.

Temperature

Casola et al. (2005a) note that Washington has already experienced climate change over the past century. Average surface air temperature has increased by approximately 1.5^{o}F. Snowpack has declined over the past 80 years, particularly at low elevations. The onset of snowmelt and peak stream flows in snow-fed rivers occurs earlier in the year, and many plants bloom earlier. Hydrologic models also indicate that spring soil moisture has been increasing, though no direct observations are available (Casola et al., 2005a).

Over time, Washington is likely to face an increase in temperature across all seasons (Casola et al., 2005a). Pacific Northwest average temperatures are likely to rise between 2.5 and 3.7^{o}F by the 2020s, and additional increases between 3.1 and 5.3^{o}F for the 2040s. Along with air temperatures, water temperatures are also expected to increase. These projected environmental changes may create inhospitable conditions for coldwater fish species (salmon, trout) in lakes, rivers, and salt water, potentially beyond those species' ability to adapt. Lake and ocean stratification may also increase along with temperatures, reducing available nutrients and increasing competition among fish species in those environments. Additionally, areas of Puget Sound that are already suffering from low dissolved oxygen levels (e.g., Hood Canal) may be further impaired with rising air and water temperatures (Casola et al., 2005a).

Snover et al. (2005, as cited in King County, 2006) note that some marine plant species, such as eelgrass and bull kelp, appear to have a narrow range of tolerance for water temperature and may suffer as a result of projected temperature increases. In turn, changes in those communities could alter habitat for other species that are not substantially affected by moderate water temperature increases, but that depend on bull kelp and eelgrass for food, shelter, or nesting sites.

Casola et al. (2005a) emphasize that the unusual life cycle of Pacific salmon species might make them particularly sensitive to air and water temperature changes. High summer stream temperatures could create thermal barriers to upstream migration of adult salmon, in addition to stressing juvenile salmon rearing in those streams. Reduced winter snowpack and runoff occurring earlier in the season may increase the frequency of redd-scouring events and prevent juvenile salmon from being flushed to salt water in runoff. In salt water, higher water temperatures or altered currents may affect the availability of food and change the distribution of predators, though impacts of climate change on these factors are not well understood (Casola et al., 2005a).

Marine and freshwater systems may also see changes in planktonic communities as water temperatures increase (King County, 2006). Prolonged periods of warm temperatures in shallow water favor several groups of organisms, including bluegreen cyanobacteria, some of which make substances that are toxic to people and animals; dinoflagellates, some of which make toxins that cause red tides; and chlorophyte algae, some of which form large filamentous masses that cover rocks and structures (King County, 2006).

Precipitation and Runoff

Models predicting precipitation levels in response to a changing climate are somewhat uncertain, as precipitation is influenced by many factors that are not well understood (Casola et al., 2005a). However, most models predict that climate change during the 21st century is likely to result in more precipitation throughout Washington, with most increases occurring from October through March. Warmer temperatures will cause more of this precipitation to fall as rain rather than snow, resulting in reduced snowpack and changes in the timing of spring runoff (Casola et al., 2005a).

Streamflow, stormwater runoff, and water temperature will all likely be affected by changes in air temperature and precipitation (Casola et al., 2005a). With regard to streamflow, Casola et al. (2005a) predict varying impacts depending on whether a stream is fed primarily by snowmelt or rainfall. Coastal rivers at low elevations (e.g., the Hoh River) exhibit flow volumes closely tied to seasonal precipitation patterns; winter flows in these systems are thus likely to increase along with precipitation during winter months. Rivers draining intermediate “transient snow zone” elevations (e.g., the Quinault River) are more sensitive to the percentage of winter precipitation falling as snow, and typically run at peak flows during November and December and again during spring runoff. These rivers are likely to see an increase in “wet season” flows as rainfall increases, reduced spring and summer flows, and an earlier occurrence of runoff. Projected average flows in the Quinault River after 2040, for example, are 4,000 to 5,000 cubic feet per second (cfs) higher in December than current average flows, while average flows in June after 2040 may be 3,000 to 4,000 cfs lower than current average flows. Moderate floods are also expected to increase in basins dominated by transient snow zones, though large floods are expected to occur at approximately the same frequency as they do today (Casola et al., 2005a).

Summer base flows in river systems that depend on snowmelt may become lower as temperatures warm and snowpack decreases toward mid-century (King County, 2006). Peak runoff will also likely occur earlier in the spring. This has the potential to greatly impact fish and other biota adapted to coldwater habitat during the warm, dry months of summer (King County, 2006).

In its Draft Shoreline Inventory Report, King County (2006) notes that, “while many predictions of the future have a degree of uncertainty, the temperature and precipitation predictions are based on much more rigorous and well understood scientific data and relationships for their conclusions than many predictions of the biological impacts.”

Sea Level Rise

The Intergovernmental Panel on Climate Change (IPCC) estimates that sea levels will rise between 4 and 35 inches by 2100 (IPCC, 2006 as cited in King County, 2006). In Olympia, land subsidence is already responsible for a sea level rise of approximately 1 foot per century. Coupled with climate change, this may cause port district inundation and central business district flooding in the future (Casola et al. 2005b).

Casola et al. (2005b) note a number of ways in which climate change might affect sea levels and coastlines of Washington State. Rising sea levels could increase coastal flooding and erosion, particularly at flat beaches and in areas of tectonic subsidence. Shoreline armoring in many areas may have to be enhanced to protect infrastructure, while development and housing in other areas may simply have to be abandoned or moved in response to flooding. The occurrence of landslides and freshwater flooding may also increase along with winter precipitation. Further development in coastal hazard areas could be discouraged in order to minimize additional risks to infrastructure in the future (Casola et al., 2005b).

Sea level rise also has the potential to considerably change shoreline jurisdiction geographic locations over time, as a sea level rise of up to 3 feet will cause a substantial movement of water inland (King County, 2006). This would have the potential to cause flooding of beachfront homes and associated property damage, in addition to significantly increasing erosion of feeder bluffs. Other ecological processes along coastlines are likely to be disrupted as well. Casola et al. (2005b) present a number of possible alternatives to address rising sea levels, including:

- Preserving ecological buffers to allow for inland beach migration;
- Enhancing shoreline protection while recognizing the negative consequences for shoreline habitat;
- Restoring wetlands for runoff and flood control;
- Monitoring for invasive species; and
- Creating a disaster relief plan for flooding and erosion events.

3.3.2.2 Nearshore Process-intensive Areas

Nearshore process-intensive areas are identified in this section. The process-intensive areas are discussed generally and then identified specifically for each WRIA. Process-intensive areas for water quality, coastal erosion, and beach processes in the Jefferson County study area often coincide (Table 3-4). In general, process-intensive areas include marine riparian areas, feeder bluffs, stream/river deltas, estuaries, accretionary landforms, and tidal inlets. These areas play a primary role in shaping and maintaining critical nearshore habitat including eelgrass meadows, kelp forests, mudflats, tidal marshes, sand spits, beaches and backshore, banks and bluffs, and marine riparian areas. These habitats in turn provide critical functions. For example, eelgrass meadows, kelp forests, flats, tidal marshes, sand spits, and riparian zones provide primary production. All habitat types support invertebrates and juvenile and adult fishes (including juvenile salmonids), and provide foraging and refuge opportunities for birds and other wildlife. The presence and maintenance of all of these habitats is completely dependent on continued bluff sediment input and the lack of disturbance to the net shore-drift system (Johannessen, 1999).

Several known factors cause these habitats stress, for example physical disturbances from shoreline armoring, marina construction, shading from overwater structures, contamination by chemicals, and competition from non-native species (King County DNR, 2001). Impacts of climate change were not analyzed as potential habitat stressors. (Alterations to nearshore processes are further discussed in the next section.)

Table 3-4. Processes and Process-intensive Areas in the Nearshore Zone

Process	Process-intensive Area	Description
Water quality, Coastal erosion	Marine riparian	Marine riparian areas play a role in nutrient cycling, sediment control, and heat/light inputs. Riparian scale processes affect wildlife habitat, microclimate, nutrient levels, fish prey production, shade, and habitat structure (Brennan and Culverwell, 2004). The effectiveness of riparian buffers for protecting water quality depends on soil type, vegetation type, slope, annual rainfall, type and level of pollution, surrounding land uses, and sufficient buffer width and integrity. Soil stability and sediment control are directly related to the amount of impervious surface and vegetated cover. Water that is not absorbed or intercepted by vegetation will increase potential for landslides, or run off the surface, which can lead to surficial erosion, siltation, burial of aquatic environs, and contamination of water. Pollutants such as excess nutrients, metals, and organic chemicals are commonly found in stormwater and agricultural runoff, usually in particulate form. Sediment control therefore often removes a large percentage of the pollutant load as well (May, 2000). For wildlife, the principal functions of riparian buffers are to provide habitat and travel corridors, microclimate regulation, organic input, and to ameliorate the impacts of human disturbance such as light and noise (Parametrix et al., 2005). Large woody debris from riparian sources provides potential nesting, roosting, refuge and foraging opportunities for wildlife; foraging, refuge, and spawning substrate for fishes; and foraging, refuge, spawning, and attachment substrate for aquatic invertebrates and algae.
Beach processes - Coastal erosion	Feeder bluffs	Drift cells are composed of feeder bluffs, transport zones, and accretionary zones. Feeder bluffs provide the beach sediment necessary to maintain critical habitats throughout the drift cell such as forage fish spawning areas and eelgrass beds, as well as the accretionary landforms at the end of a drift cell such as spits and pocket estuaries. Landslides, or run off the surface, can also contribute beach sediment to the nearshore which can lead to surficial erosion, siltation, burial of aquatic environs, and contamination of water. Spits and pocket estuaries often protect salt marsh habitat, which provides primary productivity, shelter and forage to a variety of species including juvenile salmonids. Tidal inlets (further discussed below) maintain circulation processes important for flushing spit/marsh complexes, maintaining water quality and nutrient dynamics for these critical habitats.

Process	Process-intensive Area	Description
Beach processes - Fluvial processes	Deltas	Deltas form at the mouth of streams and rivers where they enter the nearshore. As water enters the larger water body, streamflow velocity decreases and the stream loses capacity to carry most of the sediments and debris that were being transported in the stream. Deltas not only provide an additional source of sediment, organics, and LWD to the nearshore, but they generally provide habitat functions for salmonids including foraging, predator avoidance, physiological transition from fresh to salt water, and migratory corridors to marine feeding grounds (Simenstad et al., 1982). Other nearshore-dependent species also benefit from the habitat functions of deltas.
Beach processes - Circulation	Estuaries, tidal inlets, tidal marshes, lagoons, etc.	Estuaries are highly productive habitats that provide flood attenuation, nutrient retention and cycling, erosion/shoreline protection, food web support, and habitat structure/connectivity functions. Water circulation in an estuary has a fundamental influence on the functions of estuary habitat. Water movement from river flows, tides, and waves erodes and deposits sediments, conveys nutrients and organic material, and transports fish and prey items. Water movement also affects the physical shape and complexity of the estuary (e.g., slope, depth, connections to other habitats, size of the system, channel network, and landform) which affects habitat for shellfish, salmonids and other species. These same processes also create habitat features, such as pockets and bars within the estuary (Redman et al., 2005). Estuaries are important nurseries for outmigrating salmonid fry as they adjust to changing salinity levels. These areas also serve as nurseries for other aquatic species that provide a forage base for salmon. Juvenile salmonids and other species use shallow water habitats as a refuge from predators when migrating. Estuaries are also key areas for shellfish production and as such depend on healthy circulation patterns and good water quality. Pocket estuaries are non-natal lagoons with freshwater input and coastal stream mouths. Salt marshes, brackish marshes, and lagoons are habitats that occur in areas with tidal inundation and flushing. Salt marsh vegetation traps and stabilizes sediments. Salt marshes provide complex, branching networks of tidal channels where juvenile salmonids feed and take refuge from predators. They also form migratory linkages to riverine and marine environments (Brewer et al., 2005).

WRIAs 16 and 17

Eastern Jefferson County contains 52 net shore-drift cells and 7 regions of negligible net shore-drift, encompassing numerous feeder bluffs and accretionary shoreforms. Important feeder bluffs have been identified at Tala Point, just north of Mats Mats Bay, at Olele Point, just south of Kala Point, and just north of Hadlock (Johannessen, 1999). In addition, numerous areas along the Toandos Peninsula, the Bolton Peninsula, Marrowstone Island, and near McCurdy Point have been identified as unstable areas with recent or old landslides, suggesting they may be important for sediment generation (Maps 26 and 27).

Major estuaries and deltas include the Duckabush, Dosewallips, Quilcene, Tarboo Creek and Dabob Bay, Port Ludlow Bay, and Discovery Bay (Maps 26 and 27). A sill at the entrance to Hood Canal is considerably shallower than areas just north or south of the sill, limiting water exchange into and out of the Canal. Marine riparian and critical saltwater habitat areas are described in detail in the individual reach sections. Compared to the Hood Canal and Admiralty Inlet shorelines, the Strait of Juan de Fuca supports few spit features and other locations of wave-transported sediment deposition (Todd et al., 2006). Notable exceptions occur within Discovery Bay and very large spits such as Dungeness Spit (in Clallam County).

Collectively, the watersheds of WRIAs 16 and 17 are regionally important to the Puget Sound basin, and to the recovery of Puget Sound Chinook salmon and Eastern Strait of Juan de Fuca summer chum salmon (Redman et al., 2005). Nearshore areas in particular are identified as high priorities for protection and improvement if regional salmon recovery goals are to be achieved. Redman et al. (2005) identified the following actions as essential to the recovery of these species (this list includes actions specific to eastern Jefferson County, WRIA 16 and 17; see Chapter 6 of the *Regional Nearshore and Marine Aspects of Salmon Recovery in Puget Sound* for further information):

- Protect all feeder bluffs;
- Protect delivery of upland sediment sources to the nearshore from shoreline protection targets;
- Protect functioning drift cells that support eelgrass bands and depositional features along the shoreline of Discovery Bay to Fort Worden;
- Protect against catastrophic events (oil spills); and
- Protect pocket estuaries and shallow water/low velocity habitats from further degradation near the deltas (within 5 miles), but skew this protection area to the east to reflect oceanographic currents.

May and Peterson (2003) identified “Nearshore and Estuarine” (NSE) refugia as part of their comprehensive salmon refugia study for eastern Jefferson County. NSE refugia are based upon drift cells and include those estuaries, nearshore migration corridors, and shoreline areas that provide refuge habitat for migrating and rearing salmon. Refugia are classified as follows (from May and Peterson, 2003):

- Category A: Priority refugia with natural ecological integrity. While not necessarily pristine, these areas are nearly intact, relatively undisturbed, and generally exhibit properly functioning conditions. These areas are generally in excellent condition.
- Category B: Primary refugia with altered ecological conditions. These are refugia with somewhat disturbed conditions, but which still support natural assemblages of native salmon. These areas are generally in good condition.
- Category C: Secondary refugia with altered ecological integrity. These areas may belong in Category A or B if not for hatchery influences, migration barriers, and/or degraded habitat. These areas are generally in fair condition. The author also placed in this

category refugia that did not support a higher rating due to a lack of quantitative data. These areas could be called "possible refugia."

- Category D: Potential refugia with altered ecological integrity. These areas are best described as "potential future refugia" due to significantly degraded habitat conditions. These areas were likely historically important for salmon, but today do not support natural levels of salmon productivity.

Category A refugia are limited to a few areas including the west shore of Dabob Bay, parts of Squamish Harbor/Shine Creek estuary, the west shore of Thorndyke Harbor (Thorndyke Creek estuary), and scattered parts of Port Townsend Bay near Chimacum Creek (Figure 3-8).

WRIAs 16 and 17 also provide some of the most important and productive shellfish harvesting areas in the Puget Sound basin. The major bays/estuaries including Discovery Bay, Tarboo Bay, Oak Bay, Quilcene Bay, and the beaches and inlets of Dabob Bay and Hood Canal are process-intensive areas for shellfish resources (Map 24).

<u>WRIA 18</u>

The portion of WRIA 18 within Jefferson County falls entirely within the ONP. The Elwha River dams and shoreline armoring are largely responsible for sediment starvation along the shoreline within the Elwha drift cell (located in Clallam County). An estimated 17.7 million cubic yards of clay, silt, sand, gravel, and cobbles have accumulated behind these dams (PSAT, 2005). Within the Jefferson County portion of WRIA 18, fluvial processes that may affect marine shorelines along the Strait of Juan de Fuca are generally protected within ONP.

<u>WRIAs 20 and 21</u>

A majority of process-intensive areas in WRIAs 20 and 21 lie in along the Pacific Coast and lower river reaches on federal and tribal land (not in Jefferson County jurisdiction). Land use along the middle reaches of rivers within Jefferson County jurisdiction is mainly private/commercial forestry, contributing organics, sediments, and tannins from wood waste (cedar spalts) to the nearshore. Overall, these river segments are contributing a small percentage of nearshore habitat processes relative to oceanic processes (temperature, currents, storms, etc.).

3.3.2.3 Nearshore Process Alterations

Alteration of the physical and biochemical processes that create and maintain the nearshore environment will typically have deleterious effects on shoreline functions and values. This section describes the primary alterations of concern for Jefferson County's marine shores, including

- Shoreline armoring,
- Removal of nearshore riparian vegetation,
- Water quality degradation, and
- Hydrologic alterations and effects on slope stability

Figure 3-8. Nearshore Refugia in Eastern Jefferson County, WRIAs 16 and 17 (May and Peterson, 2003)

Executive Summary Salmonid Refugia Report

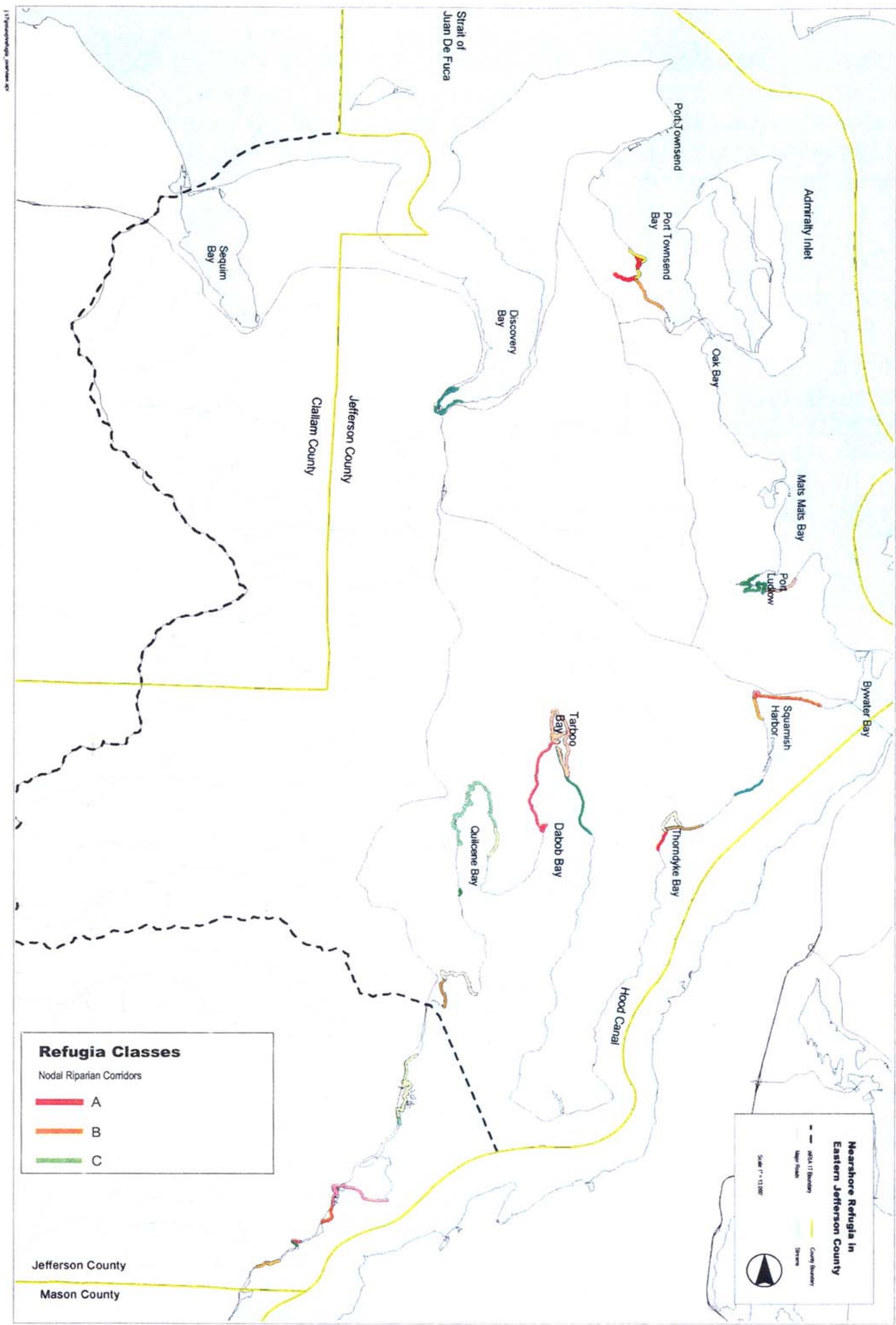


Figure ES-4. NSE Refugia in Jefferson County

Shoreline armoring can disrupt sediment generation and net shore-drift patterns, which can adversely affect shoreline morphology and habitat function (see Maps 12 –14). Bulkheads and other types of armoring along feeder bluffs inhibit or eliminate sources of beach sediment for drift cells. Beaches in front of armored shorelines can lose fine sediment through the increased wave reflection off of the armoring. Over time a heavily armored area (with bulkheads and/or groins) can lose its beach because the sediment that is necessary to sustain the beach is no longer reaching it or is not staying on the beach.

When "hard" structures intrude into the nearshore zone they can also increase the rate of beach erosion by intensifying the wave energy (Macdonald et al,. 1994). In a drift cell where bulkheads prevent bluff sediment from reaching the intertidal zone, the depositional beach at the terminus of the cell often experiences accelerated erosion even if it is miles "down drift" from the affected bluffs. These alterations can ultimately change the structure of the habitat from mixed-fine substrate communities (that often support eelgrass) to coarser substrate communities with less habitat value for migrating salmon fry. Other consequences are habitat fragmentation, loss of migratory corridors, and degradation of foraging habitat. Intertidal bulkheads, other types of fills, and docks can also force juvenile salmonids into deeper water, where the risk of predation may be significantly higher.

Bulkheads, groins, piers, ramps, docks, and other shoreline modifications affect forage fish spawning habitat directly and indirectly. Direct impacts include loss of shoreline/riparian vegetation, burying of habitat by structures, damage from equipment working in an area while eggs are incubating on the beach, and substrate coarsening and lowering of the beach profile in front of bulkheads (MacDonald et al., 1994). Indirect impacts occur primarily through disruption of sediment transport and/or sediment impoundment, and water quality degradation (Long et al., 2005). Because forage fish depend on suitable beach substrates, these species are particularly vulnerable to shoreline modifications and processes affecting sediment input, transport, or deposition (see Maps 17-19). Forage fish, particularly surf smelt and sand lance, require intact riparian vegetation, which provides shade and microclimate control for spawning areas (Rice, 2006). Pacific herring vary slightly in that their spawning is primarily in the lower intertidal and shallow subtidal zones, and therefore their habitat requirements are focused on vegetation such as eelgrass or algae.

Alteration of habitat forming processes (disruption of alongshore sediment generation and transport) can threaten important aquatic plant communities (Ruckelshaus and McClure, 2007;WDNR Nearshore Research Project, 2007 available at http://www2.wadnr.gov/nearshore/research/). Eelgrass and kelp beds are susceptible to altered sediment processes, reduced light penetration caused by overwater structures, and poor water quality (see Map 20). Since these aquatic communities provide essential feeding, rearing, and refuge areas for juvenile salmonids, alterations can be harmful to young fishes (Maps 17-19). Species of birds and fish that depend upon juvenile salmon as prey can also be impacted by habitat alterations affecting young fishes. Other threats to eelgrass and kelp include dredging, erosion/sedimentation from upland construction activities, construction of overwater structures (such as docks and piers) that impede light penetration, increased water temperature due to lack of shade and other causes, pollutant loading, excessive nutrient inputs, and competition from invasive exotic plants such as cordgrass and Sargassum (PSAT, 2001).

Removal of shoreline vegetation, which accompanies most types of shoreline modification or development, reduces shade and LWD recruitment potential, which impacts the supply of prey resources for juvenile and resident salmon. (WDFW and PNPTC, 2000). Failure to maintain or plant bluff vegetation along bluffs can result in low root strength (for example, with scattered ornamental plants and grass) and an increased likelihood of future landslides (Ziemer and Swanston, 1977; Bishop and Stevens, 1964). Bluffs with significant modifications to both the natural drainage regime and vegetation are particularly susceptible to landsliding. Reestablishment and maintenance of native vegetation cover or installation of a fibrous-rooted vegetation cover along with some type of drainage control can reduce the likelihood of bank failures (Gray and Sotir, 1996; Menashe, 1993; Menashe, 2001; Roering et al., 2003).

Alterations such as dredging, filling, and grading, and stormwater/wastewater disposal can negatively impact the quality of nearshore habitats. Improper application, excessive concentrations, and overuse of pesticides, herbicides, and fertilizers are common in urban shoreline areas where manicured landscapes are desired by landowners. Fertilizers and other urban and agricultural runoff degrade water quality by introducing high levels of organic nutrients, petroleum byproducts, and other contaminants into the aquatic system. The increase in nutrients (eutrophication) can cause plankton blooms, which may consume oxygen as the plankton die and are decomposed. Onsite septic systems are often implicated as one of the causes of excessive nutrients in runoff because these systems are generally ineffective at removing nitrates (WDOH, 2005) (Maps 4, 22, and 23). Flame retardants, pharmaceuticals, and estrogenic compounds are examples of other harmful substances that can impact water quality and accumulate within the tissues of marine species (EPA, 2006).

Bottom fish, various invertebrates, and other aquatic animals are susceptible to reduced dissolved oxygen levels that can occur as a result of nutrient and pathogen contamination. Water quality contamination, especially fecal coliform contamination, is potentially disastrous for shellfish communities and can shut down commercial and recreational harvesting (Map 24) (Glasoe and Christy, 2004). Fecal concentrations are influenced by such factors as rainfall and drainage area characteristics, including land uses, fecal pollution sources, and runoff patterns. In general, residential areas contribute the highest concentrations compared to commercial and industrial areas (Glasoe and Christy, 2004). Pollution sources that can potentially contribute to stormwater contamination include cross connections with sewage lines, failing onsite sewage systems, pet and other animal wastes, and bacterial growth within the drainage system itself. None of the potential sources is benign and the cumulative loadings can be immense.

Shellfish resources are highly susceptible to changes in water quality and habitat loss caused by urbanization and certain types of human development (Glasoe and Christy, 2004). Recreational harvest advisories or closures are in effect for much of the eastern Jefferson County marine shoreline. Closures due to marine biotoxins or pollution are in effect for portions of the Pacific Coast as well as areas around Discovery Bay, Port Ludlow, and Port Townsend Bay (WDH, 2006a, 2006b). Commercial shellfish harvesting is restricted or prohibited in some areas including Port Ludlow, South Point, and the north shore of Indian Island (Map 24).

Runoff volumes often increase and become more concentrated as a result of development due to loss of forest cover and increased impervious surfaces and roads (see Maps 6, 7, and 25). This is due to decreased infiltration and interception of water. Concentrated surface water can locally erode bluff crests while also saturating soils, which exacerbates natural slope stability problems along coastal bluffs and can trigger landslides (Shipman, 2004). Runoff flowing down a driveway and rapidly across a lawn (which can absorb little water when wet) as sheet flow to the bluff face is an example of this alteration. A broken tightline on a bluff face is another type of alteration that triggers slides. Failed tightlines (often constructed out of inexpensive and low-strength flexible, corrugated pipe) often contribute to initiating coastal landslides (Johannessen and Chase, 2003).

WRIA 16

Shoreline armoring, such as bulkheads, docks, stairs, and boat ramps, has contributed to beach erosion and disconnection of sediment sources throughout WRIA 16 (Correa, 2003). In addition, several intertidal areas have been filled for residential development. Stairways along the shoreline interrupt riparian corridors and may also lead to bluff instability. Highway 101 and various dikes truncate deltas of several streams and rivers, impairing the fluvial processes that sustain the nearshore. In general, the most altered areas in terms of shoreline structures (stairs, bulkheads, docks, etc) are just north of the Fulton Creek estuary and in the Brinnon area between Boston Point and Jackson Cove (Map 11).

Land use in WRIA 16 has altered the quality of nearshore waters. Paulson et al. (2006) found that 92 percent of total nitrogen in Hood Canal came from surface and groundwater from the surrounding subbasins. They found that point-source discharges and subsurface flow from shallow shoreline septic systems contributed less than 4 percent of the nitrogen load to the upper layer. Nitrogen leached from onsite sewage systems is potentially the largest anthropogenic source of nitrogen entering Hood Canal. Use of a well-maintained septic system can effectively reduce biochemical oxygen demand $(BOD)_4$, bacteria, and pathogens, but most are not designed to effectively reduce nitrogen. It has been estimated that nitrogen leached from onsite sewage systems contributes between 33 and 84 percent (39 and 241 tons) of all anthropogenic nitrogen entering Hood Canal. Past surveys along the shoreline of Lower Hood Canal found that as many as one-third of the onsite sewage treatment systems were failing, resulting in increased fecal coliform in this area, closure of shellfish harvesting areas, and declaration of a public health emergency (Fagergren et al., 2004). Other sources of nitrogen include stormwater runoff, agriculture/animal waste, wastes from boats/watercraft, and forestry.

Restoration projects could be targeted to actions that would trap nutrients now flowing directly to Hood Canal. Removing dikes, filling borrow pits, and restoring/preserving wetlands and side channels could improve conditions in altered areas (Fagergren et al., 2004).

WRIA 17

Shoreline armoring such as bulkheads, docks, jetties, and piers has contributed to beach erosion and disconnection of sediment sources throughout WRIA 17 (Map 12). Several intertidal areas have been filled for residential development, parking lots, and the footings for the Hood Canal Bridge. The most altered shores (in terms of structures and armoring) are at Port Ludlow, Port Hadlock, Mats Mats Bay, and Squamish Harbor. Scattered marinas and bulkheads, and an abandoned log storage yard near Ludlow Creek, may also contribute to disruption of net shore-drift processes in WRIA 17.

Diking and filling of deltas such as the Salmon/Snow Creek delta have reduced the complex web of distributary channels and sloughs that support post-emergent salmon fry. Further descriptions of drift process alterations can be found in the reach inventory and characterization sections in Chapter 4.

Potential pollutant sources in WRIA 17 include both point and non-point sources. According to 2006 Ecology National Pollutant Discharge Elimination System permit records, there are 28 regulated point-source discharges located in the County, most of which occur in WRIA 17. These point sources include wastewater and stormwater discharges to marine and freshwater receiving waters, as well as discharges to municipal wastewater systems by sand and gravel operators, hard rock quarries, boat yards, and other industrial facilities. The fish hatchery on the Big Quilcene River also contributes to the nutrient load within WRIA 17 (Fagergren et al., 2004).

WRIA 18

Headwaters of larger streams and rivers in WRIA 18 are found within Jefferson County, but these headwaters are protected within ONP. Process alterations in the WRIA downstream are located in Clallam County and include two dams on the Elwha River restricting fluvial sediments and LWD from entering the nearshore, as well as fish hatcheries and pulp mills contributing nutrients, metals, and toxics to the Strait of Juan de Fuca.

WRIA 20

Impacts to the estuarine environment in WRIA 20 include loss of habitat complexity due to filling, dikes, and channelization, and loss of tidal connectivity caused by tidegates (Smith, 2000). Nearshore impacts include bulkheads, overwater structures, filling, dredging, and alteration of sediment processes (Map 13). The nearshore area is influenced most by the Columbia River, which forms a low-salinity plume that extends along the Washington Coast, depositing sediments important for beach maintenance, particularly in those areas south of the Hoh River mouth. This sediment supply has decreased by 24 to 50 percent due to dams in the Snake and Columbia River basins.

The vast majority of land use in the WRIA is forestry (94 percent), and sedimentation has been identified as a major habitat problem in all of the subbasins. Sediment loads are transported downstream, and there is concern that increased sedimentation to the estuary and nearshore environment is reducing the eelgrass and kelp habitat by changing nearshore substrates and increasing turbidity. Water quality processes are generally thought to be good; however, some contaminants have been found offshore, the source of which is the aluminum smelters on the lower Columbia River (Smith, 2000).

WRIA 21

The sediment source for the beaches in WRIA 21 is mostly from nearby rivers and sea cliff erosion, with some sediment from the Columbia River. Forest practices in the middle and upper reaches of river basins within the WRIA that result in increased sedimentation and reduced LWD can have a negative effect on nearshore processes.

The overall condition of estuaries in the WRIA is "good" (Smith and Caldwell, 2001). However, the Queets and Quinault estuaries have reduced levels of LWD and the lowest reaches of the Quinault River have been impacted by a low level of bank hardening and shoreline development, mostly on the south bank. Various attempts to protect the village of Taholah from ocean wave action have resulted in the construction of a seawall. Large rock continues to be added to the north end of the seawall, affecting the mouth of the Quinault River and the lowest portion of the estuary (Smith and Caldwell, 2001).

3.3.2.4 Freshwater Processes

As with nearshore areas, the health and functioning of freshwater shoreline systems is influenced to a large degree by the movement or storage of materials such as water, sediment, nutrients, pathogens, and organic matter (e.g., LWD). This report focuses on the following key processes:

- Hydrology processes including surface water runoff, peak flows, surface water storage, groundwater flow/discharge,
- Water quality processes for nitrogen, phosphorus, pathogens, toxins/metals, and heat/light inputs,
- Sediment processes including mass wasting, surface erosion, and bank erosion, and
- Organic debris.

The process-intensive areas and alterations described in this section of the text are shown on the map folio in Appendix C and listed in Table 3-5.

Table 3-5. Map Locations for Key Freshwater Process-intensive Areas and Alteration Themes

Theme	Map Name/ No.
Hydrology / Streams and Lakes Permeability Wetlands / Potential Wetlands Topography Floodplains (100-year floodplain) Rain-on-Snow (ROS) and Snow-dominated Zones Channel Migration Zones (CMZ) Land Cover (early and late seral stage vegetation; human imprint)	Maps 2 and 3. Hydrology
Hydrology / Streams and Lakes WRIA Boundaries Watershed Boundary Permeability Wetlands Dairies Water Quality (not shown on map) Septic Permits Tilled Fields Lost Wetlands Human Imprint	Maps 4 and 5. Water Quality

Theme	Map Name/ No.
Land Use / Land Ownership (not shown on map) Zoning	Maps 21, 22, and 23. Land and Shoreline Use Patterns
Forest Cover Impervious Surface	Map 25. Forest Cover and Impervious Surface

Hydrology

Two important mechanisms by which hydrologic processes operate are infiltration and groundwater recharge. In the glaciated Puget Sound landscape, areas of high permeability include unconsolidated surficial geologic deposits of large grain size such as glacial outwash, especially recessional outwash (Dinicola, 1990 as cited in Vaccaro et al., 1998). These areas have a relatively high capacity for infiltrating precipitation and surface water, and they are identified as important infiltration/recharge areas (Winter, 1988). The main hydrogeologic units that produce groundwater for domestic residential or agricultural use in eastern Jefferson County are Vashon Advance Outwash (Qva), Older Glacial Deposits (Qgo), and to a much lesser extent, Vashon Recessional Outwash (Qvr). These hydrogeologic units make up most of the unconsolidated materials that overlie bedrock. The Vashon Lodgment Till (Qvt) is not an important water-bearing unit but it does control the rate of infiltration and therefore acts as a semi-confining layer (Simonds et al., 2003).

Impervious surfaces can impact infiltration in all areas of a watershed, but it is particularly detrimental in areas that naturally support high rates of infiltration and recharge (i.e., permeable deposits on low slopes). Land use is a predictor of effective impervious area. Vaccaro et al. (1998) showed that recharge in heavily developed areas (with 95 percent impervious surfaces) is reduced by 75 percent, while recharge in residential areas (with 50 percent impervious surfaces) is reduced by 50 percent (in Stanley et al., 2005). Numerous studies report that watersheds with greater than 10 percent impervious area experience increases in runoff resulting from decreased infiltration capacity (Glasoe and Christy, 2004; Paul and Meyer, 2001; Booth and Reinelt, 1993). Booth and Jackson (1997) describe numerous impacts to aquatic resources resulting from increased impervious area that are significant and measurable (see Map 25).

A related factor influencing hydrologic processes is the percent of forest cover in a watershed. Loss of hydrologically mature vegetation, especially in rain-on-snow and snow-dominated zones, can alter natural surface runoff patterns. Cleared portions of the rain-on-snow zone can produce 50 to 400 percent more outflow from snowpacks than forested areas during rain-on-snow events (Coffin and Harr, 1992 as cited in Stanley et al., 2005a). The primary causes of this increased outflow are the additional amount of snow on the ground, and the increased rate of snowmelt that occurs in the absence of sun-blocking vegetative cover (Brunengo et al., 1992; Coffin and Harr 1992). Rain-on-snow areas that are converted from forest cover to non-forest cover have a higher likelihood of generating peak runoff.

Surface Water Storage

Surface water storage is an important component of the hydrologic cycle. The loss of surface water storage potential can increase the volume and shift the timing of streamflow (Collins et al., 2003) or increase water level fluctuations in lentic systems (Euliss and Mushet, 1999). Land use can directly impact water storage through the filling of floodplains, wetlands, and/or hyporheic zones, or indirectly decrease storage by disconnecting a stream/river from its floodplain. Reduced connectivity occurs as a result of dikes or levees along stream channels; stream channelization and incision; and/or wetland ditching. Some of these alterations operate primarily at the watershed scale (e.g., increased sediment supply); others are more evident at the reach scale (i.e., channel modifications and incision).

Surface Runoff and Peak Flows

Much of the surface runoff in Jefferson County river systems is derived from rainfall and snowmelt for those rivers and streams with headwaters at high elevations in the Olympic Mountains. The spring snowmelt is driven by climate and does not change significantly based on land management. However, winter snowmelt is an important component of the rain-on-snow mechanism that causes most major peak flow events (WFPB, 1997). This analysis focuses on rain-on-snow zones as a key hydrologic mechanism influencing aquatic resource structure. In the Puget Sound region, rain-on-snow and snow-dominated zones are concentrated at elevations of 1,500 to 4,500 feet where weather patterns commonly cause temperature fluctuations from freezing to above freezing (WDNR, 1991). Mature forest, especially coniferous forest, in rain-on-snow forest zones influences winter snow accumulation and melt rates by changing the intensity of solar radiation and wind-assisted heat flux (WFPB, 1997).

Surface runoff and peak flows are closely linked to infiltration/recharge as described above. Runoff is inversely correlated to infiltration/recharge. Runoff is affected by development that increases drainage density, synchronizing runoff during peak events, and consequently increases the magnitude and frequency of peak flows. Road density is used in this analysis as an indicator of increased drainage density because roads are commonly associated with artificial conveyances such as ditches and storm sewers. Furthermore, roads in forested areas have been shown to cause physical disturbances that increase drainage density by extending the length of headwater channels, converting subsurface flow to overland flow. Forest practices and land clearing in rain-on-snow zones can also alter natural surface runoff patterns. Cleared portions of the rain-on-snow zone can produce 50 to 400 percent greater outflow from snowpacks than forested areas during rain-on-snow events (Coffin and Harr, 1992).

Groundwater Recharge/Discharge/Flow

Groundwater flow paths occur at regional, intermediate, and shallow scales corresponding to flow paths and residence time. Regional groundwater is maintained along deep flow paths in pre-Quaternary bedrock, which are defined by major topographic features such as the Strait of Juan de Fuca and the Olympic Mountains. Such groundwater is not readily influenced by the local land use patterns and is therefore not analyzed here.

Shallow groundwater occurs in upper Pleistocene and Holocene deposits and is governed largely by local topography and surficial deposits. Recharge of these shallow aquifers occurs mainly in glacial drift plains and is discharged as surface water via springs, seeps, lakes, and streambeds. Shallow groundwater boundaries typically follow surface watersheds.

Intermediate groundwater falls somewhere between regional and shallow groundwater in terms of flow path depth and the scale of movement. Intermediate groundwater often has the ability to move under major rivers and across drainage boundaries.

Precipitation is the primary source of groundwater recharge. However, alterations to flow paths and groundwater extraction/consumption influence the availability of groundwater for maintaining ecological functions during the summer low-flow period. Draining areas of shallow groundwater via ditching, pumping, or other practices shortens the groundwater flow paths and decreases retention time. Consequently, the availability of groundwater for discharge during low runoff periods decreases. Extraction also reduces the amount of groundwater available for discharge, and the placement of wells in the vicinity of surface water expressions can also limit discharge by altering groundwater flow paths (Freeze and Cherry, 1979; Morgan and Jones, 1999).

Shallow soils in the montane region limit shallow groundwater features. Infiltrated water either travels laterally as subsurface flow at the soil-bedrock contact, or percolates to deep groundwater through cracks and fissures in the bedrock. River valleys and outwash plains in the lowlands contain much deeper, porous soils on low relief that store large quantities of water in surficial aquifers. Data from Cox et al. (2005) also suggest that the presence of outwash and permeable alluvial fan deposits adjacent to river valleys/floodplains creates conditions for groundwater discharge. Therefore, the presence of these conditions increases the probability that groundwater discharge is occurring. Infiltration, recharge, and discharge processes are dependent on temporal and spatial factors. In general, recharge will take place during the later part of the season at lower flows in some portions of the river depending on the presence of adjacent permeable deposits.

Water Quality

Nutrients (Nitrogen and Phosphorus)

Changes to hydrology and sediment supply at the watershed scale can influence nutrient cycling in aquatic ecosystems. Alterations to these processes are discussed in other sections. This analysis focuses on alterations to nutrient inputs resulting from certain land uses. Fertilizer originating from commercial forest lands, agricultural, and residential areas can be a potential source of increased nitrogen inputs to both aquatic ecosystems and groundwater. In addition, fecal waste generated from septic tanks, commercial agriculture, and/or hobby farms can also contribute excess nitrogen and other nutrients.

Phosphorous is not strongly correlated to specific types of land use (Ebbert et al., 2000). However, areas in which fertilization and surface erosion are both prevalent (e.g., dairy farms, till agriculture, urban growth areas) can be potential sources of increased phosphorous input.

Other human impacts that alter aquatic resources can also influence nutrient retention and removal. Cox et al. (2005) found that denitrification occurs throughout riparian areas at high levels (4 to 16 milligrams per liter [mg/L]). Denitrification occurs when bacteria in the soil convert nitrogen to nitrates, making it easier for plants to absorb. When soil oxygen levels are low, another form of bacteria turns the nitrates into gases such as nitrogen, nitrous oxide, and nitrogen dioxide which return to the atmosphere. Consequently, floodplain disconnection and loss of riparian forest cover can limit hyporheic function and nitrogen fixation rates and preclude deposition of sediment and adsorbed phosphorous. Loss of wetlands decreases the amount and rate of denitrification in a watershed.

Pathogens

This report focuses on fecal coliform as an indicator of pathogens because it is the most commonly occurring pathogen and because it is monitored in Ecology water quality studies. For purposes of this report, process-intensive areas for water quality involving pathogens are areas where pathogens are stored or removed. Pathogen inputs are primarily associated with human disturbance, and natural concentrations in water are very low. Human sources of fecal matter and associated pathogens include onsite septic systems and animal operations such as dairies and hobby farms.

Because pathogens are derived primarily from anthropogenic sources, much of the research regarding their removal is based on water quality management facilities. However, some research results can be applied to natural systems. The U.S. Environmental Protection Agency (EPA) (2001) showed that standing water promotes pathogen removal through increased filtration and predation by other microbes. Additionally, recent USGS studies (Cox et al., 2005) found that fecal coliform was not discharged to surface water from groundwater. This indicates that surface transport is a major pathway for these pollutants. Therefore, areas that promote water and sediment retention and/or predation by microorganisms, such as floodplains, depressional wetlands, and permeable deposits draining into surface waters via subsurface flow or groundwater recharge, are process-intensive areas for pathogen removal (Tate, 1978; Hemond and Benoit, 1988). Destruction of these areas or land uses that lead to altered function can cause impairment of the landscape's ability to process pathogens.

Toxins/Metals

Toxins and metals associated with certain land use practices can be harmful when released to aquatic ecosystems (Table 3-6). Many urban land uses can introduce contaminants such as organic compounds, polychlorinated aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides. For example, gas stations and industrial processing facilities may release PAHs from the combustion of petroleum, oil and coal (Van Metre et al., 2000; Schueler and Holland, 2000a). Heavy metals (e.g., cadmium, copper, and zinc) can be released from motor vehicles, building materials, and rooftops (Schueler and Holland, 2000b). Some lawn care products used by residential property owners and businesses contain potentially harmful insecticides, herbicides, and/or chemical fertilizers (Schueler and Holland, 2000c, 2000d). Rural land uses (i.e., agriculture and forestry) are also potential sources of pesticides (Allan, 2004).

Toxins and metals generally do not occur in naturally high concentrations, so the mechanisms by which these contaminants impact water quality are related to increased inputs (land uses) and storage or uptake in the environment. Depressional wetlands with organic soils and wetlands with clay soils that have a high cation exchange capacity retain metals/toxins through adsorption. Riparian areas also are likely to remove toxins through adsorption since there are organic soil layers present. Sediment deposited in floodplains can also temporarily store/adsorb toxins.

The primary mechanism of contaminant transport from urban and rural lands to the surrounding watershed is runoff. Impervious surfaces (i.e., roads, sidewalks, pavement, rooftops) are key in the transport of stormwater runoff and associated contaminants (Brabec et al., 2002; Booth, 2000).

Table 3-6. Sources of Toxins and Metals by Land Use

Land Use	Examples of Contaminant Sources	Potential Contaminants
Rural Agricultural	Irrigated crop farming, confined animal feeding operations	Insecticides, Herbicides
Rural Forestry	Logging, campgrounds	Metals
Urban Commercial	Automotive repair shops, dry cleaners, gas stations, food processing	Metals (Cu, Pb, Zn), Polychlorinated Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs)
Urban Industrial	Chemical manufacturing, metal finishing fabricating, mining/milling, railroad yards	Metals (Cu, Pb, Zn), Polychlorinated Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs)
Urban Municipal	Airports, landfills/dumps, septic systems, wastewater treatment plants, transportation corridors (motor vehicles), utility stations	Metals (Cu, Pb, Zn), Polychlorinated Hydrocarbons (PAHs), Polychlorinated Biphenyls (PCBs)
Urban Residential	Parks, septic systems, transportation corridors (motor vehicles)	Metals (Cu, Pb, Zn), Insecticides, Herbicides

Cu = copper, Pb = lead, Z = zinc

Heat and Light

Heat and light affect water temperature, which is an important component of water quality. A number of factors control heat and light inputs to aquatic resources. Most factors such as climate, groundwater inputs, and air temperature are difficult to manage in the context of the SMP. This analysis focuses on riparian areas as important for heat and light because these areas provide the best opportunity for management.

The relationship between riparian condition and its influence on heat/light inputs is discussed extensively in scientific literature (Welch et al., 2003). Thirty meters is the recommended minimum riparian width required to maintain natural function of heat/light inputs in Puget Sound (Castelle et al., 1994; May, 2000), but a wider buffer is necessary to maintain microclimate (Brosofske et al., 1997; May, 2000). Riparian zones as narrow as 11 meters may still provide a positive shading influence on streams (FEMAT, 1993; Knutson and Naef, 1997; May, 2000). The width of the riparian zone becomes less important in controlling thermal properties as streams become larger, because shading controls insolation to a lesser extent, and other factors such as channel geometry begin to have a more significant relative influence on temperature.

Organic Debris

Organic material including large woody debris (LWD) enters streams primarily via streambank erosion, mass wasting, and treethrow/windthrow from areas within roughly 200 feet of stream channels. Consistent sources such as treethrow (mortality, suppression, windthrow) and bank erosion/channel migration occur across all types and sizes of streams, while mass wasting is the primary source in low-order streams (Reeves et al., 2003; Benda et al., 2002). Fluvial transport and debris-laden floods are important mechanisms of LWD redistribution in large and small streams, respectively.

Riparian forest disturbances reduce woody debris in streams, which in turn leads to adverse changes in channel/habitat-forming processes (Bilby, 1984; Heifetz et al., 1986; McDade et al., 1990; Van Sickle and Gregory, 1990; Bilby and Ward, 1989). In headwater areas, roads may increase the incidence of landslides; however, associated loss of forest cover in these areas decreases LWD recruitment via landslides. Land use encroachment into riparian zones and channelization of streams reduce forest cover and decrease LWD recruitment potential via bank erosion or channel migration.

Sediment Delivery and Transport

Slopes with erodible soils and areas prone to mass wasting provide sediment input. Mechanisms for sediment input are closely aligned with geologic controls. Erosive soils are most commonly associated with alluvium and outwash. Sediment is often stored in depressional areas such as wetlands and lakes (Hruby et al., 2000) and on floodplains (Stanley et al., 2005), which by definition are composed of deposited alluvium. These areas trap sediment by reducing water velocity (or dissipating energy), allowing increased deposition of fine sediment. Process-intensive areas for sediment storage are the same as the water storage areas identified earlier.

Changes in sediment supply have wide-ranging impacts on aquatic ecosystems and can limit ecologic function by impairing habitat quality and water quality. Surface erosion and mass wasting are naturally occurring mechanisms of sediment supply, but each can increase sediment inputs to aquatic ecosystems when the landscape is altered by human use. Loss of forest cover and roads can increase inputs to aquatic systems by increasing rates of mass wasting and surface erosion. Altered hydrology may also increase hillslope inputs to aquatic resources as well as influencing rates of instream transport and storage. Sediment generated from construction sites is another potential source of sediment to aquatic habitats.

Mass Wasting

Mass wasting potential is a product of topography, soil and bedrock properties, hydrologic conditions, and vegetation. Roads (paved and unpaved) are often the most significant source of sediment inputs to aquatic ecosystems in Puget Sound (Swanson et al., 1987). Increased mass wasting rates are directly attributable to roads, which can influence slope failure directly by altering slope properties (Knutson and Naef, 1997) or indirectly by redistributing excess water to landslide-prone areas (Swanson et al., 1987). The loss of forest cover may also be an important factor that increases rates of mass wasting, but the literature demonstrates that roads are the dominant influence.

Surface Erosion

Surface erosion usually occurs as a result of particle entrainment by rainfall and overland flow. Historically, surface erosion was limited by forest cover (Swanson et al., 1987). However, loss of forest cover can lead to increased particle entrainment by rainfall and transport via overland flow, consequently increasing sediment inputs to aquatic systems. In general the denser the vegetative cover, the lower the rate of erosion (Dunne and Leopold, 1978). Roads are also a primary source of increased sediment inputs to aquatic systems via surface erosion. Beschta (1978) states that roads within approximately 200 feet of aquatic ecosystems dramatically increase sediment inputs from surface erosion. Areas of low erosion potential can also be significant sources of sediment, particularly for land uses that directly disturb soil. Till agriculture or bare fallow soil areas can increase surface erosion by 40 to 50 percent (Rapp et al., 1972). Erosion can be a water quality issue for infrequent higher intensity storms and in specific areas near water bodies or drainage ditches that drain to surface water features.

Bank Erosion

Streams, wetlands, and lakes can store sediment before it is transported farther downslope to estuaries and nearshore ecosystems. Channelization and floodplain disconnection cause loss of overbank sediment deposition in the floodplain during peak flows. Draining and filling depressional wetlands can also reduce sediment storage capacity on the landscape. Thus, alterations to surface water storage are also indicative of reduced sediment storage.

Changes in stream morphology brought on by altered sediment supply-transport processes in streams can include increased bank erosion and channel migration rates. Altered hydrology (increased flows) can cause channel enlargement and increased bank erosion. Loss of riparian vegetation also increases the susceptibility of streambanks to fluvial entrainment and mass failures. The alterations that indirectly influence bank erosion are discussed in other sections. Increases in bank erosion rates are noted where data are available.

3.3.2.5 Freshwater Process-intensive Areas

Process-intensive areas for hydrologic, water quality, organic matter, and sediment processes in Jefferson County often coincide (Table 3-7). These areas are depicted on Maps 2 through 7 in the accompanying map folio (Appendix C). The process-intensive areas are discussed generally and identified specifically for each WRIA in the following sections.

Table 3-7. Process-intensive Areas for Hydrologic, Water Quality, and Sediment Processes

Process	Process-intensive Area
Infiltration/recharge Groundwater flow/discharge Nutrient cycling Pathogen removal	Aquifer recharge areas
Surface runoff and peak flows Surface erosion	Bare ground/early seral stage vegetation cover
Surface runoff and peak flows Groundwater flow/discharge Surface erosion Sediment storage	Channel migration zones

Process	Process-intensive Area
Surface water storage Surface runoff and peak flows Groundwater flow/discharge Nutrient cycling Sediment storage	Floodplains
Surface water storage Sediment storage Nutrient retention/cycling	Lakes
Surface runoff and peak flows	Rain-on-snow and snow-dominated zones
Surface water storage Nutrient sink Sediment storage Pathogen removal Toxins/metals removal	Wetlands
Nutrient sink Toxins/metals removal Heat/light control	Riparian areas
Organic debris input Sediment delivery	Landslide-prone areas
Organic debris input Sediment delivery	Streambanks

Hydrologic Processes

Key areas for hydrologic processes (Maps 2 and 3) are influenced by soil permeability and precipitation, and include rain-on-snow zones, snow-dominated zones, channel migration zones, wetlands, lakes, and ponds. Areas with high levels of precipitation will increase the capacity of groundwater recharge through infiltration. Precipitation levels are higher west of the Olympic Mountains and foothills than in areas to the east. In Eastern Jefferson County, important areas for precipitation include the Fulton Creek, Spencer/Marple Creek, and Dosewallips/Rocky Brook basins (Ecology, 2007).

Areas with high infiltration and recharge capacity typically occur in glacial outwash and alluvial valleys such as the Hoh and Clearwater River valleys. These areas may contribute more infiltration and recharge per unit area compared to areas to the east because precipitation is higher. A study of the Nooksack River in Whatcom County showed that groundwater discharge occurs in areas containing permeable glacial outwash and alluvial fan deposits adjacent to the river valley (Cox et al., 2005). This suggests that the Chimacum Creek valley, Leland Creek valley, and similar areas may provide opportunities for groundwater discharge.

The Chimacum Creek valley has an extensive alluvial deposit on the valley floor, valley walls of exposed undifferentiated deposits, and highlands above consisting of lodgement till. The headwaters of this valley have large areas of recessional outwash, a relatively young deposit that has not been extensively eroded. Many marine bluff areas on the Toandos and Bolton Peninsulas have similar erosion patterns, with bluff faces composed of undifferentiated deposits, advanced outwash fringe toward the top, and lodgement till on upland areas. The landscape setting for these deposits, including how they have been shaped by wind, waves, and water erosion, determines the manner in which water moves across and through the land. For example, permeable outwash deposits on hillsides can be locations for groundwater discharge for wetlands and streams. On terraces, these deposits may act as recharge areas (Ecology, 2007).

Overall, the Lower and Middle Dosewallips River, the Toandos Peninsula West Shore, the Bolton Peninsula, and the Chimacum Creek East Fork were rated highest for groundwater processes (high precipitation, infiltration, percolation and recharge) by Ecology (Ecology, 2007).

The most widespread glacial deposit is lodgment till, which covers the majority of the upper portion of the lowland geographic units. In general this deposit is impermeable but does include some lenses of sand and gravel. Underlying this deposit is a relatively thick deposit of advance outwash, which has moderate to high permeability. Large quantities of water can be stored by this deposit, and it is both a principal source of potable water and a source of groundwater discharge for aquatic resources in the County. Advance outwash deposits are predominant in the northern portion of the study area but also present in surficial deposits in the Chimacum drift plain and the Toandos and Miller Peninsulas (Ecology, 2007).

An associated deposit is recessional outwash, which also has high permeability and water capacity and is of significant importance to water flow processes. Relatively large areas of this deposit are found on the west side of the Quimper Peninsula, in the Port Hadlock area, the Chimacum valley and West Chimacum Creek (upper portion), and above Squamish Harbor. Additionally, recessional outwash is found in the lower reaches of the rivers draining the Olympic Mountains area, with large deposits present near the mouth of the Big and Little Quilcene Rivers. In this landscape setting, recessional outwash would be critical to groundwater discharge to the Big Quilcene River.

Undifferentiated deposits consist of a variety of glacial and interglacial deposits including lacustrine and glaciolacustrine (very low permeability), outwash sands and other fluvial deposits (moderate to low permeability). These deposits vary greatly in their permeability and water holding capacity, but are generally considered to be of low permeability and to yield little to no water for potable water supplies (Ecology, 2007).

Overall, Ecology characterized the Lower Big Quilcene River, the Toandos Peninsula West Shore, the Bolton Peninsula, and the Chimacum Creek East Fork as the most important areas (highest scoring areas) for permeability (Ecology, 2007).

Most areas that are important for surface water storage are found in the lower watersheds of eastern Jefferson County, as well as the Hoh, Queets, and Quinault River floodplains. Wetlands are typically found along floodplains in areas of coarse outwash. In Jefferson County, small lakes occur in alpine and montane regions with larger lakes occurring in the lowlands.

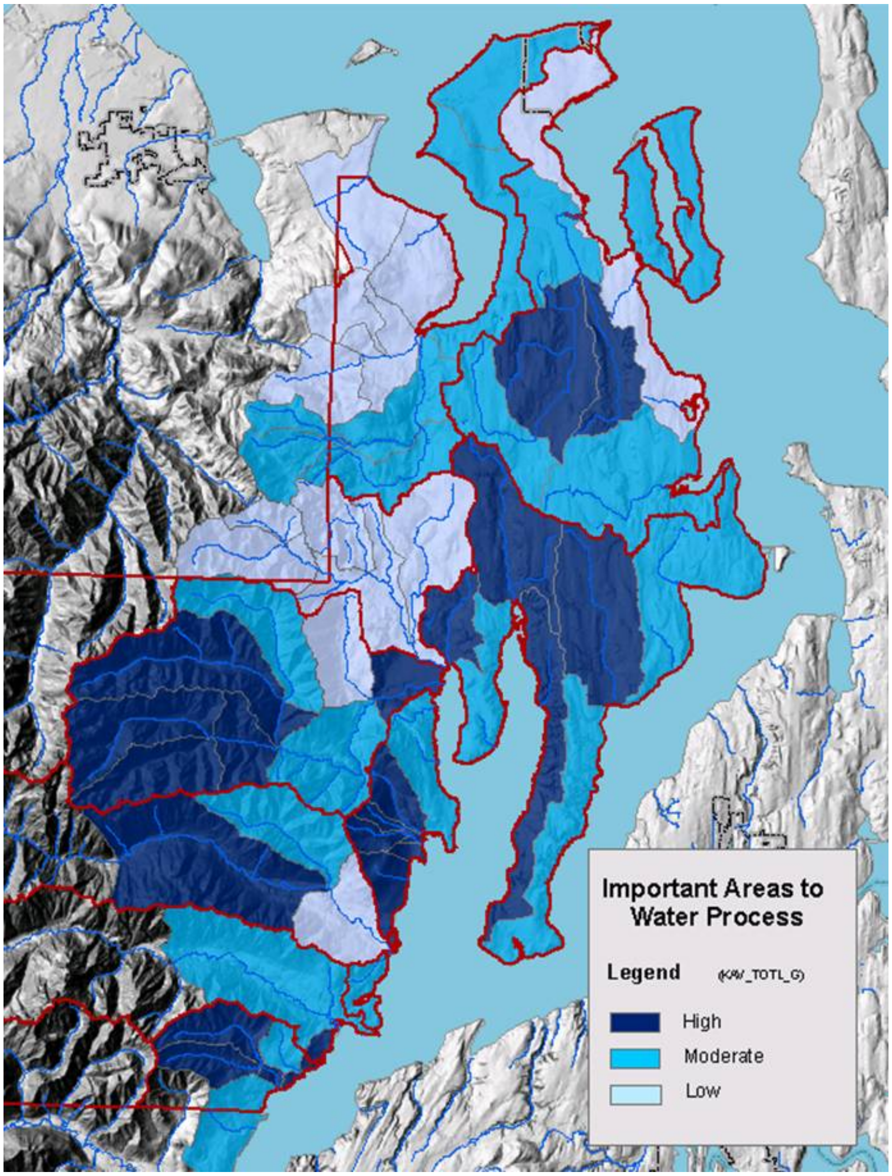
According to Ecology's (2007) watershed characterization, areas that scored highest overall for importance in surface water storage are in the following basins: Middle and East Fork Chimacum Creek, Tarboo Creek, Leland Creeks, the Lower Big Quilcene River, Spencer/Marple Creek, Turner/Walkers Creek, Fulton Creek, Middle Dosewallips, Rocky Brook, Big Quilcene Middle and Tunnel Creek.

Rain-on-snow and snow-dominated zones, which contribute to surface runoff and peak flow, are known to occur primarily in middle elevations above 1,400 feet in Jefferson County, principally on federal lands such as the ONP and ONF.

According to Ecology (2007) areas that received the highest relative score for combined water flow-related processes included the Olympic Mountains and the adjoining lowlands (Figure 3-9) (Ecology, 2007). This is due to the presence of higher precipitation (rain-on-snow, snow-dominated zones) and relatively large areas of permeable deposits in the lower portions of the watershed. The Little Quilcene River watershed was of lower overall importance due to a higher degree of impermeable deposits and lower relative rainfall.

The headwaters for the Chimacum drift plain and the upper watershed areas draining to Tarboo and Quilcene Bays also scored high relative to other areas for water flow processes. The high importance of the Chimacum area is primarily due to large areas of permeable deposits and moderate rainfall levels. The Tarboo and Quilcene Bay watersheds have less extensive permeable deposits but higher rainfall levels (Ecology, 2007). Other areas of lower importance were the small watersheds adjacent to the marine nearshore that are in areas of low rainfall and low permeability deposits.

Figure 3-9. Important Areas for Hydrologic Processes, Eastern Jefferson County (Ecology, 2007)



Water Quality Processes

Water quality processes such as nutrient cycling/uptake, pathogen and toxin removal, and heat and light control are influenced by wetlands, riparian areas, and surficial aquifers (Maps 4 and 5). Process intensive areas for removal and/or retention of fecal matter and associated pathogens are depressional wetlands and infiltrative soils. These areas are located primarily in lowland areas with outwash deposits as well as upland areas with marine sedimentary deposits.

Areas that provide nutrient retention and loss are concentrated in lowlands, while groundwater nutrient retention is associated with surficial aquifers. Valley bottoms provide functions such as nitrogen loss and some temporary storage of phosphorous. Upland areas or terraces are areas where nitrification (transformation) occurs. Headwater streams play a greater role in the temporary storage of nitrogen from biotic uptake and adsorption. Upland depressional wetlands provide storage (phosphorous, nitrogen), transformation (nitrogen) and loss (nitrogen). Areas with the full suite of loss/retention mechanisms occur primarily in the floodplains and to a lesser extent in the low-slope areas of WRIA 17.

Metals occur in trace concentrations in nature, but metals and other toxins are introduced by human actions as well. The process of metal/toxin inputs under natural conditions versus human input is not easily discernable. Storage of metals occurs through adsorption in wetlands with clay or organic soils. Information regarding wetland soil composition is not readily available. Therefore, it is assumed that wetlands throughout Jefferson County may provide increased rates of metal/toxin retention.

Sediment Processes

Process-intensive areas for sediment delivery and transport processes include landslide-prone areas and steep slopes with erodible soils (Maps 6 and 7). Areas of mass wasting are most common in the western Olympic Mountains and foothills, where relief is more extreme and precipitation is high. Surface erosion areas are mainly located in hilly areas along the Big and Little Quilcene Rivers, Dabob Bay, Hood Canal, and Tala Point. Streambanks and lakeshores are also important sediment sources.

In Jefferson County, much of the agricultural land is along the relatively flat areas of the Chimacum Creek valley and the Leland Creek valley where soils are typically quite permeable and precipitation usually falls at a low intensity. Nonetheless, the extent of agricultural land use and the level of associated soil disturbance make these areas a source of increased sediment supply. Bare areas can erode and redistribute sediment in the fields, but delivery to streams or wetlands is limited to areas near the water bodies because of the low runoff rates.

Organic Debris Inputs

Process intensive areas for organic debris inputs including LWD generally include riparian areas within 150 to 200 feet of aquatic resources or within the aquatic resource boundaries. Channel migration zones (CMZs) and areas of mass wasting also deliver LWD to streams. This includes designated CMZs on the Big and Little Quilcene Rivers, the Duckabush River, and the Dosewallips River in eastern Jefferson County (Klawon, 2004) as well as the CMZs identified on the Hoh River in western Jefferson County (USBOR, 2004; Perkins Geosciences and Terra Logic, 2004). Because the extent of the CMZs is not known for most streams and rivers in western Jefferson County, the Federal Emergency Management Agency (FEMA) 100-year floodplain was used to delineate the extent of potential LWD recruitment from channel migration and bank erosion.

WRIA 16

Process intensive areas important to infiltration and recharge are typically associated with surficial aquifers and alluvium in the lower Dosewallips and Duckabush River valleys. Surface water storage occurs in the lower river valleys as well, along with two small lakes identified near Black Point. The river corridors also support wetlands and CMZs, although the CMZs are disconnected in the lower watersheds where Highway 101 crosses the estuaries.

There are extensive areas of rain-on-snow and extensive snow-dominated areas within the ONP in this WRIA. Most of these areas are vegetated with late seral stage forest stands suggesting that runoff and peak flow patterns are relatively intact (Map 2) . Landslide-prone areas of the upper Dosewallips River watershed and steeper slope areas of the lower watersheds contribute to sediment transport processes, but road density on most subbasins is less than 1 mile per watershed square mile and most of the erodible and landslide-prone areas are covered with mature forest (Map 6).

WRIA 17

Process-intensive areas for hydrology include critical aquifer recharge areas associated with highly to moderately permeable soils and low slopes (Map 2). Surface water storage is found primarily along the floodplains of the lower Big Quilcene River, Snow Creek, Chimacum Creek, and Tarboo Creek. There are several lakes in this WRIA, mostly occurring in outwash plains and upland plateaus containing poorly drained till and fine-grained outwash. Rain-on-snow zones and snow-dominated are concentrated in the upper Big and Little Quilcene River watersheds within the ONP, and small areas of commercial forest and rural residential land in the Discovery Bay watershed (Map 6).

Wetlands are abundant along Chimacum Creek, as well as Snow and Tarboo Creeks, lower Little Quilcene River, Quilcene Bay, and inner Dabob Bay (Map 4).

CMZs on the Big Quilcene River, landslide-prone areas on steeper slopes in the mountains of Big Quilcene and Discovery Bay watersheds, and steep shorelines along Discovery Bay, Quilcene Bay, and Dabob Bay contribute to sediment processes in the WRIA. CMZs are disconnected in the lower Little Quilcene River due to Center Road crossing the estuary. Other floodplains/CMZs have also been impaired, such as Big Quilcene River and Salmon/Snow Creek (Todd, personal communication, 2006).

May and Petersen (2003) identified salmon nodal corridors as part of their comprehensive salmon refugia study. The report delineates freshwater refugia as one of two types: “Focal Sub-Watershed” or “Nodal-Riparian Corridor.” Generally, a “Focal Sub-Watershed” designation is more appropriate for headwater areas, while a “Nodal-Riparian Corridor” designation is more appropriate for lower reaches of a stream, or streams that are confined within steep-sloped valleys. One type is not necessarily "better" than the other; it is a matter of which type of refugia fits the specific situation in the field, and which type will be more effective for conserving salmon habitat (Figure 3-10)[3]

WRIA 18

The portion of this WRIA within Jefferson County falls entirely within the ONP. A large part of the watershed within the ONP is underlain by relatively impermeable bedrock. These generally mountainous areas receive large amounts of precipitation and, therefore, have the potential for large amounts of recharge. However, recharge in these areas is probably limited by the water-bearing and transmission properties of the bedrock rather than by precipitation amounts or soil-moisture characteristics (USGS, 2000). Process-intensive areas for infiltration and recharge, surface water storage, and groundwater flow generally occur outside of Jefferson County. Most of the recharge in the Elwha-Morse watershed is from precipitation (snow and rain), probably with some small local amounts by seepage from streams. The groundwater moves slowly from recharge areas to discharge areas such as lakes, springs, streams, wetlands, and the Strait of Juan de Fuca (USGS, 2000). Available information indicates that wetlands are associated with the Elwha River corridor, and rain-on-snow occurs in mid-elevations throughout the WRIA. No information was available on sediment transport and delivery or channel migration in the upper watersheds of WRIA 18.

WRIA 20

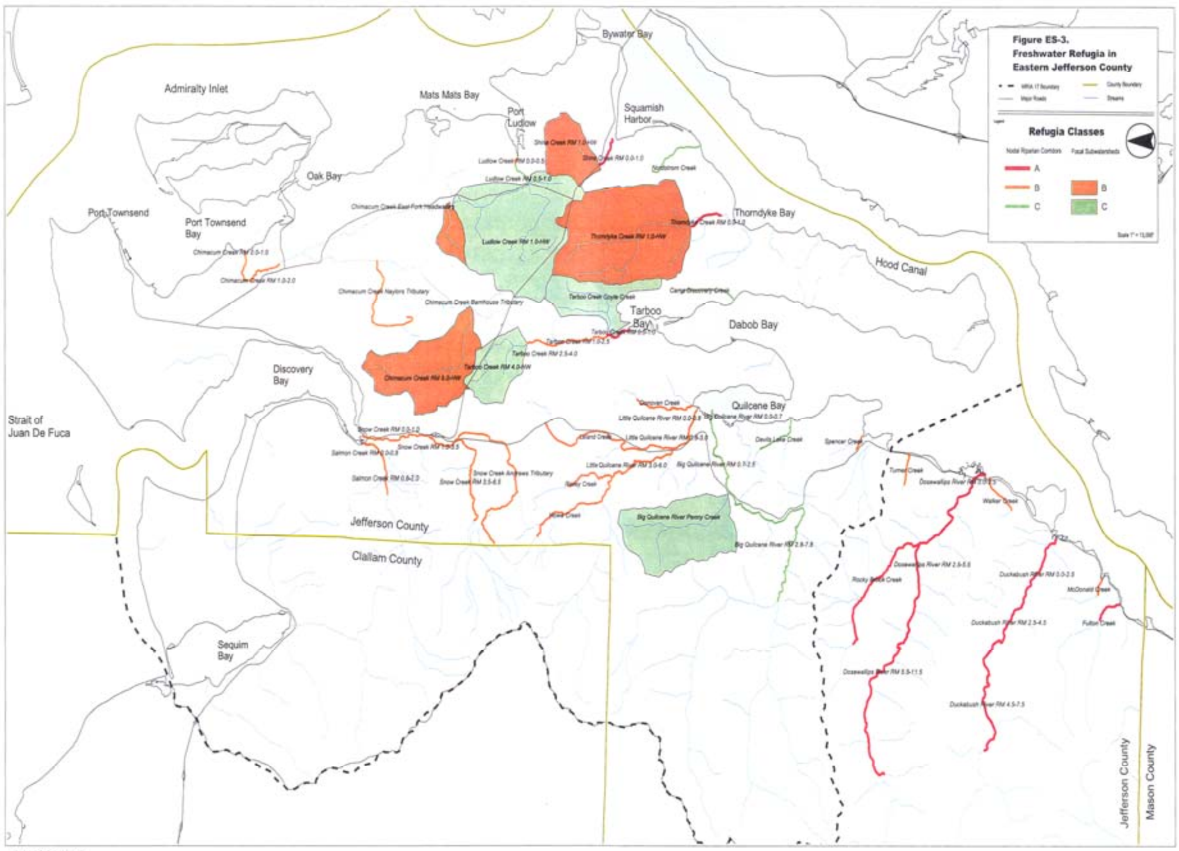
Approximately half of WRIA 20 within Jefferson County falls within the ONP, while the remainder is primarily commercial forest. Process-intensive areas for hydrology are primarily the floodplains of the Hoh and Bogachiel Rivers, Mosquito Creek, Goodman Creek, and Steamboat Creek. No lakes have been identified within this WRIA. Rain-on-snow zones have been identified in the middle to high elevations of the upper Bogachiel, upper and middle Hoh, and Hoh south fork watersheds.

Process-intensive areas for water quality include the wetlands along the Hoh River corridor, as well as around Goodman Creek, lower Bogachiel River, and middle Hoh watershed boundaries. Large coastal wetlands on the lower Hoh River also contribute to water quality processes.

Sediment transport and delivery processes are maintained by landslide-prone areas along the steep slopes of the Bogachiel River, middle Hoh River, and areas near Goodman Creek as well as along the coast. CMZ studies have not been conducted in WRIA 20; therefore, LWD recruitment and sediment storage, transport, and delivery processes remain uncharacterized.

[3] See section 3.3.2.2 for a description of the nodal corridor categories.

Figure 3-10. Salmon Nodal Riparian Corridor and Focal Sub-watershed for Eastern Jefferson County (May and Peterson, 2003)



WRIA 21

Approximately 70 percent of the Queets/Quinault WRIA 21 lies within the ONP/ONF. The remainder is primarily commercial and rural forest. Available information regarding process-intensive areas for hydrology indicates that infiltration and recharge may occur along highly permeable soils along the Queets River, Matheny Creek, and Clearwater River corridors. Surface water storage and water quality processes are likely to occur in wetland areas along the Queets and Quinault River, the lower reaches of the Clearwater River, and coastal wetland areas, as well as floodplains of the lower Queets and Clearwater Rivers. No large lakes have been mapped within this WRIA in Jefferson County, although smaller alpine lakes are likely to occur within the ONP. Rain-on-snow zones have been mapped in the middle to high elevations in the upper watershed of the Queets, Quinault, and Clearwater Rivers, primarily within the ONP.

Sediment transport and delivery processes are maintained by landslide-prone areas on the steep slopes of the upper Queets and Quinault Rivers and the Kalaloch Creek watershed, as well as areas of moderate soil permeability along the lower Queets River.

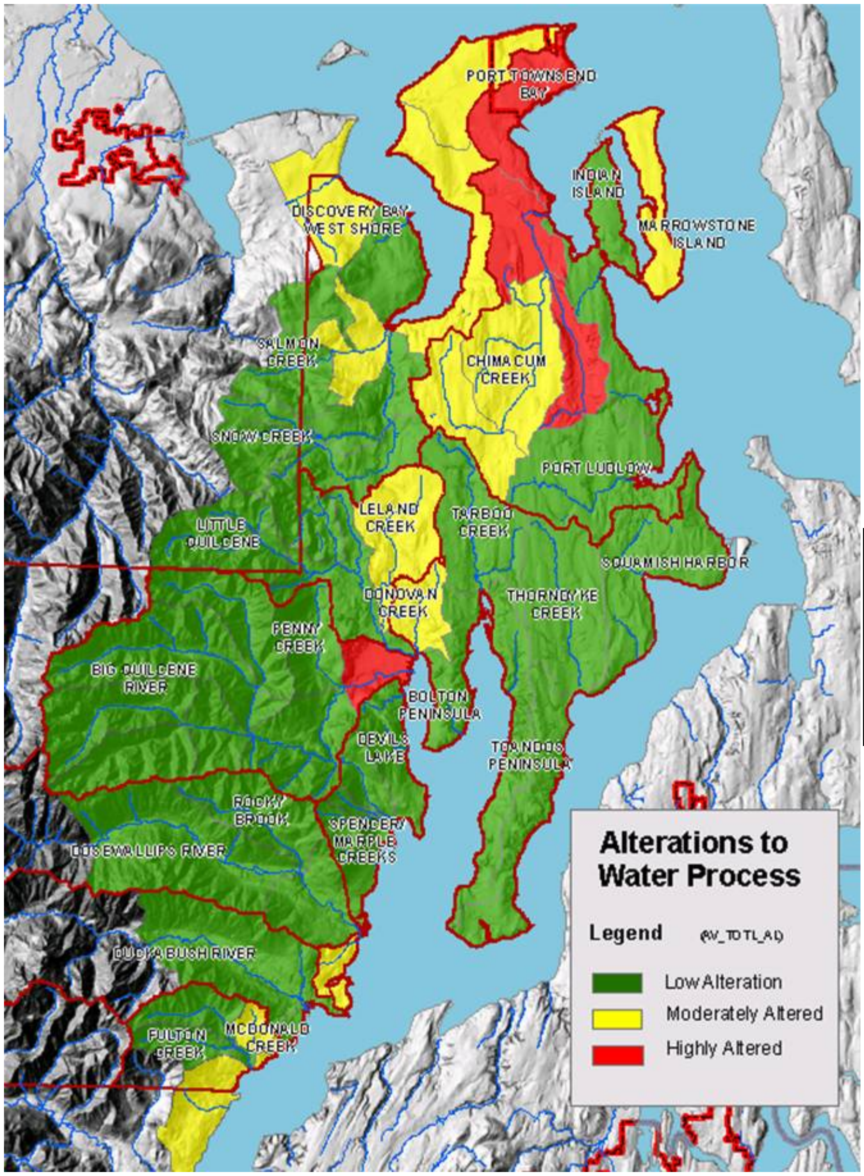
3.3.2.6 Freshwater Process Alterations

Land use and associated changes in land cover are the sources of altered processes that impair aquatic resources. The montane and foothill regions are subject primarily to forest practices, and forests are still the dominant land cover. The loss of hydrologically mature forest cover and the addition of roads are major causes of altered processes (Coffin and Harr, 1992 as cited in Stanley et al., 2005a). In addition, lost wetlands, particularly evident in the Chimacum Creek basin, and development on permeable deposits have altered processes in each WRIA (Maps 2 - 4). A number of urbanizing areas are located along the shorelines of east Jefferson County, including the City of Port Townsend and smaller pockets of urbanization such as Port Ludlow, Irondale, Hadlock, Quilcene, and Brinnon. Areas of high road density indicate potential for increased mass wasting. High road densities (more than 2 miles of road per square mile of watershed) can be found in half of the watersheds within the County. Surface erosion zones are indicated by areas where roads cross streams and by non-forested areas on erodible soils (Maps 6 and 7).

According to Ecology's watershed characterization, the Chimacum valley and Port Townsend area scored highest for relative degree of alteration of water processes compared to other areas of the east County (Figure 3-11) (Ecology, 2007). This is due primarily to forest clearing, wetland loss, and impervious surface from urban/suburban development. A significant portion of the lowland area scored "moderate" for alteration due primarily to forest clearing and wetland loss. The Olympic Mountains, Toandos and Bolton Peninsulas have large areas of low alteration, except for the mouths of the Little Quilcene and the Dosewallips Rivers due to impervious cover and forest clearing (Ecology, 2007).

The City of Port Townsend diverts water from the Big and Little Quilcene Rivers (2005 City of Port Townsend Annual Drinking Water Report available at http://www.cityofpt.us/NewsLetter/2005/05.pdf). The City and Crown-Zellerbach constructed the Big Quilcene diversion and 28.5 miles of transmission pipe between the Big Quilcene River and Port Townsend in 1927. The Little Quilcene River diversion was developed in 1956 as a supplemental supply to the Big Quilcene River. A diversion dam constructed on the Little Quilcene River conveys water via a pipeline to Lords Lake Reservoir.

Figure 3-11. Areas of High, Medium, and Low Alteration, Eastern Jefferson County (Ecology, 2007)



Hood Head is a protection area (color not shown)

WRIA 16

Process-intensive areas for infiltration/recharge are typically found in the lower watersheds of the large river valleys. Early seral stage vegetation and development (including impervious surface area) is seen in these areas, primarily north of the river mouths. The Duckabush and Dosewallips River floodplains are disconnected where Highway 101 crosses the estuaries. Rain-on-snow and snow-dominated zones are found primarily in the mountains and foothills. The peak runoff mechanism is altered where transitional areas occur in rain-on-snow zones. Generally, though, most rain-on-snow zones are within the ONP and at least partially forested.

Water quality alterations can occur from agricultural operations, failing septic systems, lost wetlands, and residential land use. Within WRIA 16, residential land use is concentrated near the marine shoreline, but septic systems are prevalent throughout the lower river valleys as well as along the marine shoreline. Large clearcuts, numerous roads, and often inadequate riparian vegetation buffer zones occur on state-owned and private forest lands. Mass wasting events in the lower Duckabush watershed have been directly linked to improper forest road construction, maintenance, and/or abandonment (Correa, 2003). Early seral stage vegetation is concentrated in the lower watersheds (Map 2);most of the watershed is characterized by late seral stage vegetation. Development on permeable deposits is apparent in the lower watersheds, particularly along the lower 2 miles of the north side of the Dosewallips River, several areas within a mile of the shore between the Dosewallips and Duckabush Rivers, and the vicinity of lower Fulton Creek.

Road density in WRIA 16 is generally low (less than 1 mile of road per watershed square mile) (Map 6). Road crossings of streams are abundant in the lower Dosewallips and Duckabush River watersheds, leading to alterations in sediment delivery processes in WRIA 16. Other factors are channel confinement of major streams, and localized loss of mature forest cover in erosion–prone areas (Map 6). Most of the WRIA is forested, and the areas outside of the ONP generally have low to moderate landslide potential (Map 4). Roads within 200 feet of streams are present throughout the WRIA, paralleling the mainstems of the major rivers in the upper watersheds and clustering near the coast. In addition, recent clearcut areas have been identified in the lower Duckabush River and Fulton Creek, adding to alterations of sediment and hydrological processes.

WRIA 17

Process-intensive areas of infiltration/recharge are found along the river corridors of the lower Big Quilcene River (Map 2). Early seral stage vegetation and human influence (including impervious surface area) is seen throughout the County, with high concentrations in the Little Quilcene and Snow Creek drainage basins. Other alterations within process-intensive areas include conversion of large areas of wetland in the upper Chimacum Creek drainage to agricultural use, and floodplain disconnection along the Little Quilcene River where Highway 101 crosses the estuary. Alterations to peak flow in the Snow Creek basin may result from early lack of forested areas within rain-on-snow zones. However, most rain-on-snow and snow-dominated zones are within the ONP and are mostly well forested.

Residential land use within WRIA 17 is concentrated in Port Townsend, Port Ludlow, and Quilcene. These areas generally do not coincide with process-intensive areas for hydrology. However, agriculture and septic systems are abundant outside of the urban areas, particularly along the Quimper Peninsula, Marrowstone Island, Chimacum Creek, and the shorelines of Hood Canal and Dabob and Quilcene Bays (Map 4). These are likely to alter water quality processes in wetlands and estuaries by introducing pathogens and nutrients. Large clearcuts and inadequate riparian zones occur on state-owned and private forest lands (Correa, 2002). Early seral stage vegetation occurs throughout the WRIA, but is primarily concentrated in the lower elevations. Development on permeable deposits is apparent in patches throughout the WRIA, but large areas of human disturbance are apparent along Snow Creek and the Discovery Bay shoreline, Port Townsend, Irondale and Chimacum Creek, and Port Ludlow.

Road density is relatively high (greater than 2 miles of road per watershed square mile) throughout WRIA 17. Consequently, roads within 200 feet of streams are abundant throughout the WRIA. As in WRIA 16, road crossings of streams, channel confinement, and localized removal of mature forest are key factors leading to alterations in sediment delivery processes in WRIA 17 (Map 4). Much of the WRIA remains forested, and most areas have little to low landslide potential. Mass wasting events in the Snow Creek and Chimacum Creek watersheds have been directly linked to improper forest road construction, maintenance, and/or abandonment (Correa, 2002).

WRIA 18

No alterations have been identified within WRIA 18 in Jefferson County. This area falls entirely within the ONP, and is either forested or glaciated. In Jefferson County, few roads within 200 feet of streams have been identified; a few were mapped along the Elwha and Dungeness River mainstems.

WRIA 20

Process-intensive areas of infiltration/recharge are typically found in the lower watersheds of the large river valleys. Overall, because much of WRIA 20 supports federal lands and forestry, alterations to infiltration/recharge are not likely to be as significant as other hydrology alterations. Early seral stage vegetation is seen primarily in logged areas within the Hoh River watershed. Human influence (including impervious surface area and septic systems) is limited to small settlements along the middle and lower Hoh River (Map 3) and Clearwater Village.

Floodplain connectivity in the Sol Duc basin is at risk. Impacts such as fill for road construction, and vegetation changes due to logging, agriculture, and development are reducing these already limited habitats (U.S. Forest Service, 1995 as cited in Smith, 2000).

Channel migration zones have been identified on various reaches of the Hoh River by Perkins Geosciences and TerraLogic GIS (2004), the U.S. Bureau of Reclamation (2004), and Herrera Environmental Consultants and Northwest Hydraulics (2002). These CMZs are important for sediment and hydrologic processes and for maintaining habitat. The studies were conducted in part to help identify management strategies for maintaining infrastructure, responding to flooding, and restoring habitat conditions for salmon and other species. Figures 3-12 and 3-13 depict a portion of the identified CMZ. Readers are encouraged to review the individual reports for additional information.

Channel incision within the North Fork Calawah and lower Bogachiel basins due to a combination of excessive sedimentation and a lack of LWD has resulted in ratings of “poor” for floodplain condition along the North Fork Calawah River and lower Bogachiel mainstem (Smith, 2000). Most rain-on-snow and snow-dominated zones are within ONP and at least partially forested (Map 3).

Figure 3-12. Lower Hoh River CMZ, Jefferson County (Perkins GeoSciences and TerraLogic 2004)

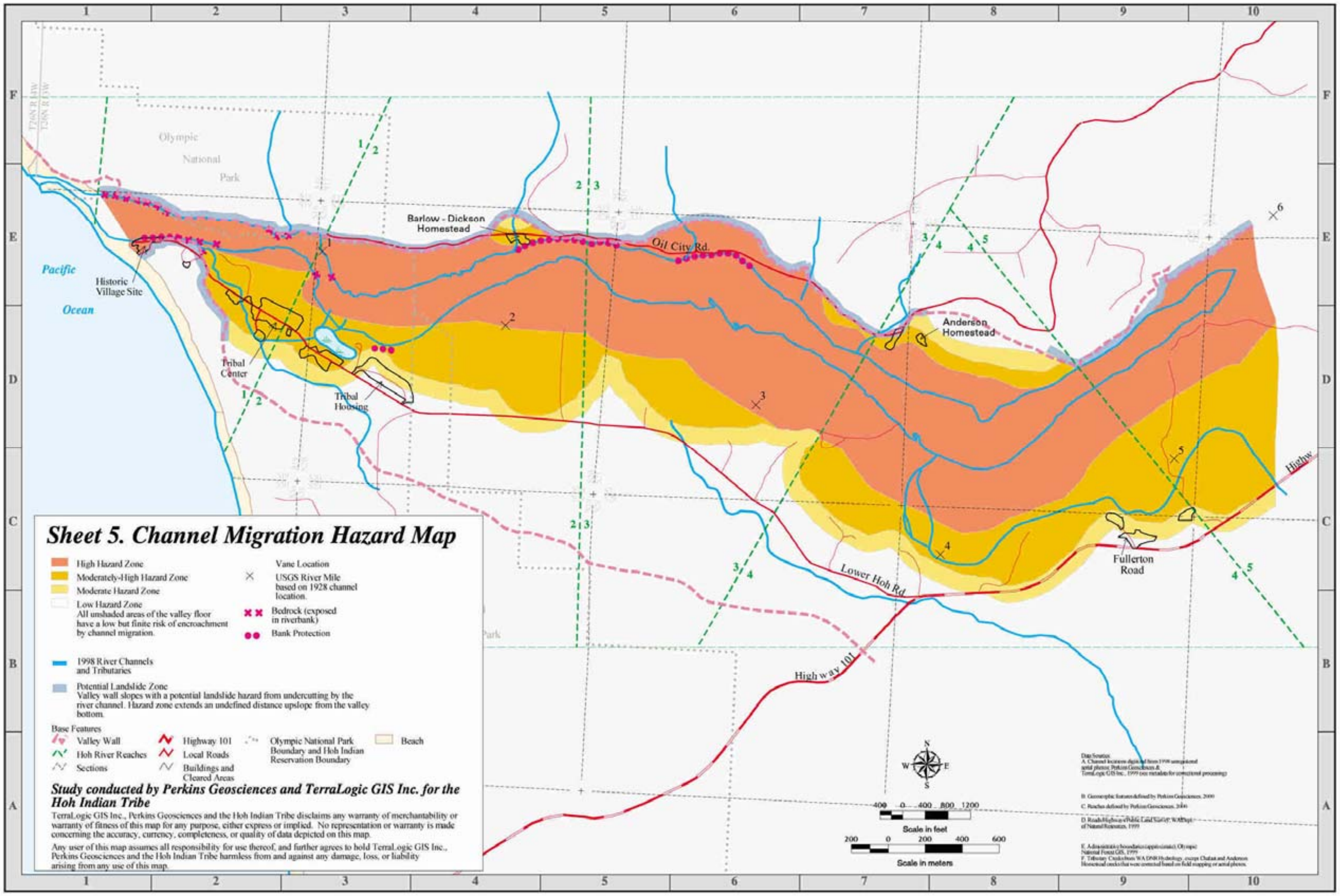
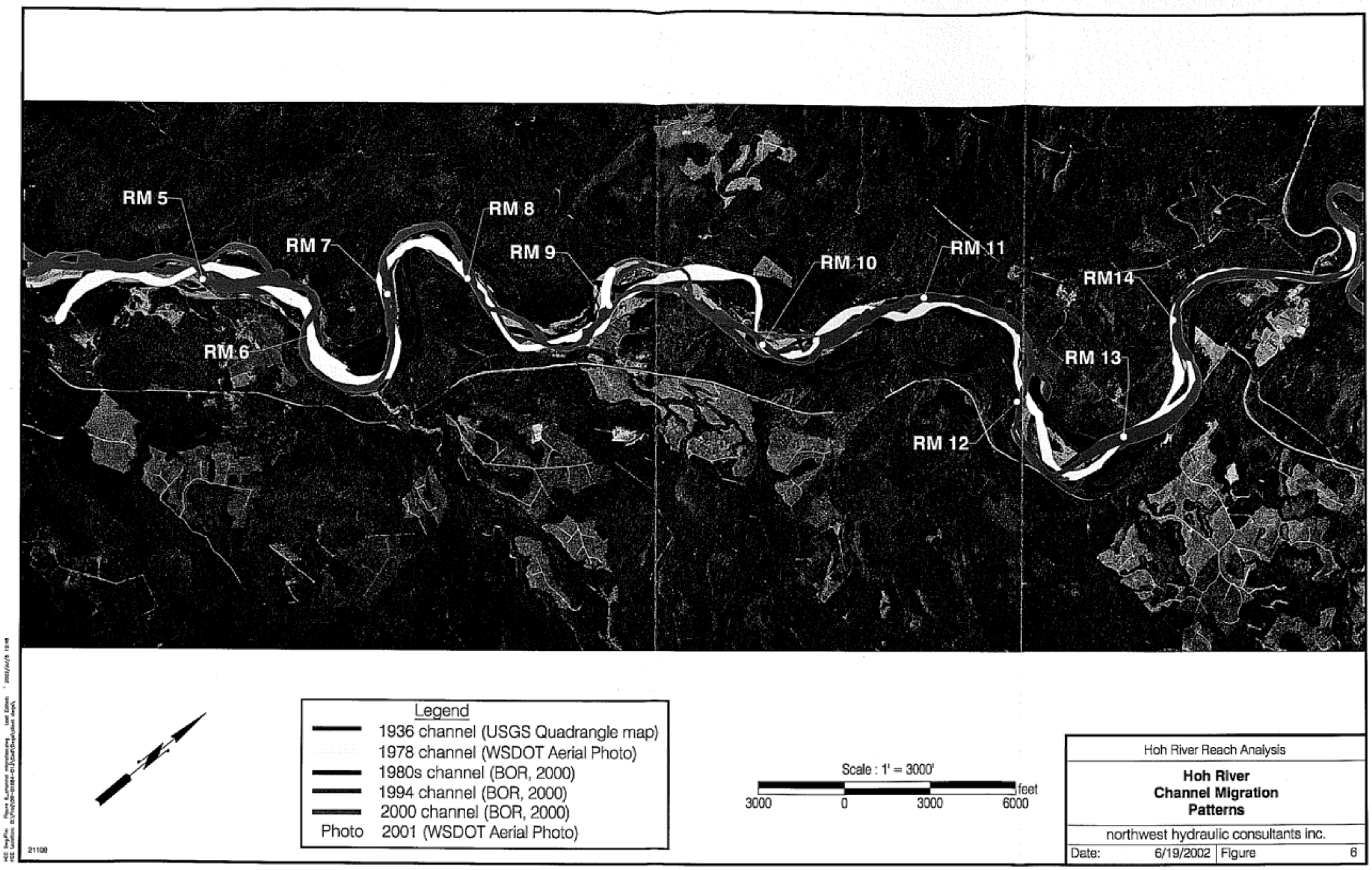


Figure 3-13. Hoh River CMZ, RM 5 to RM 14, Jefferson County (Herrera and Northwest Hydraulics 2004)



Road density is relatively high (greater than 2 miles of road per watershed square mile) in the lower elevation watersheds of WRIA 20 (Map 7). Consequently, road crossings of streams are a major factor leading to alterations in sediment delivery processes in WRIA 20. Roads within 200 feet of streams are extremely common, particularly along Goodman Creek and the lower Bogachiel River. Much of the WRIA falls within ONP and tribal land, and there are few potential landslide areas outside of this, with the exception of the Bogachiel River. Recent clearcut areas have been identified in the middle and lower Hoh River watersheds, further contributing to sediment delivery process alterations. LWD processes and riparian conditions have been classified as poor for most of the lower basins within this WRIA (Smith, 2000).

WRIA 21

Process-intensive areas of infiltration/recharge are typically found in the lower watersheds of the large river valleys. Overall, because much of WRIA 21 supports federal lands and forestry, alterations to infiltration/recharge are not likely to be as significant as other hydrology alterations. Early seral stage vegetation is seen primarily in logged areas within the lower Clearwater River and lower Queets River watersheds (Map 3). Human influence (including impervious surface area and septic systems) is limited to the town of Queets, as well as septic systems within the highly permeable floodplain area of the Clearwater River. Most rain-on-snow zones are within the ONP and are forested.

Road density is high (greater than 2 miles of road per watershed square mile) in the lower elevation watersheds of WRIA 21 (Map 7). Consequently, road crossings of streams are a major factor leading to alterations in sediment delivery processes. Roads within 200 feet of streams are densely distributed throughout the WRIA, but particularly in the Clearwater River, lower Queets River, and Matheny Creek basins.

A majority of the WRIA falls within federal and tribal land, and there are few potential landslide areas outside of this. The increased incidence of landslides and debris flows has affected tributary habitat in the Matheny Creek watershed (Smith and Caldwell, 2001). Soil erodibility has not been mapped for this WRIA.

Bank armoring is not a major concern within the Queets River basin, but road crossings in the lower watershed and Matheny Creek have disconnected floodplains and increased sedimentation in the river. No information is available on floodplain connectivity in the Clearwater River and Kalaloch Creek watersheds (Smith and Caldwell, 2001). Riparian conditions for the upper Quinault River have been classified as “good.” Conditions are mostly “good” throughout the Queets basin, except in the lower Queets and lower Clearwater River and Kalaloch Creek basins, where conditions are mixed (Smith and Caldwell, 2001).

4.0 REACH INVENTORY AND ANALYSES

This chapter builds on the watershed overviews provided in Chapter 3 and describes conditions directly adjacent to individual shoreline segments (or reaches). According to the state shoreline guidelines (WAC 173-26-201(3)(c)), local governments are required to inventory and report available information at the shoreline reach scale as follows:

- Shoreline and adjacent land use patterns and transportation and utility facilities, including the extent of existing structures, impervious surfaces, vegetation, and shoreline modifications within shoreline jurisdiction;
- Critical areas, including wetlands, aquifer recharge areas, fish and wildlife habitat conservation areas, geologically hazardous areas, and frequently flooded areas;
- Degraded areas and sites with potential for ecological restoration[1];
- Areas of special interest, such as priority habitats, developing or redeveloping harbors and waterfronts, previously identified toxic or hazardous material clean-up sites, dredged material disposal sites, or eroding shorelines;
- Conditions and regulations in shoreland and adjacent areas that affect shorelines, such as surface water management and land use regulations;
- Existing and potential shoreline public access sites, including public rights-of-way and utility corridors;
- General location of channel migration zones (CMZs) and floodplains; and
- Known cultural, historical, and archeological resources.

This section describes pertinent information for planning area reaches for each shoreline water body under SMA jurisdiction, to the extent that such information is readily available. Shoreline areas are grouped according to WRIAs and to general geographic areas (i.e., Southern Toandos Peninsula). Subwatershed names are listed parenthetically as shown on maps 1a and 1b. Each nearshore reach is assigned a unique alpha designation, and each freshwater reach has a numeric designation for purposes of this study. Nearshore reaches are also identified according to the corresponding alpha-numeric drift cell identifier as reported by various sources and documented in the Washington Coastal Atlas and shown on maps in Appendix B (maps from the County's 2005 Shoreline Inventory).

Maps depicting inventory information are provided in the map folio that accompanies this report (Appendix C). Maps 8 through 28 depict shoreline reach attributes as indicated in Table 4-1. Data sources for the inventory attributes reported in this Chapter are indicated in Table 2-3 or otherwise cited in the text.

[1] Potential restoration areas and opportunities are also described in the Draft Restoration Plan, which is being prepared under a separate cover.

Table 4-1. Map Locations for Reach-scale Attributes

Theme	Map Name/ No.
Shoreline Reaches Shoreline Planning Area Watersheds Wetlands Floodplains CMZs	Maps 8, 9, and 10 Aquatic Resources and Shoreline Reaches
Shoreline Modifications (nearshore) Shore Form Type Feeder Bluffs (not mapped)	Maps 11, 12, and 13. Coastal Processes and Modifications
Drift Cells Landslide Hazard Landslide Hazard Zonation Erosion Hazard	Maps 14, 15, and 16. Critical Areas
Priority Fish Presence Priority Habitat Areas Marine Resource Species (geoduck, urchin, oyster, crab, clam, razor clam, surf smelt, sand lance, herring)	Maps 17, 18, and 19. Critical Shoreline Habitat
Eelgrass Kelp	Map 20. Aquatic Vegetation
Land Use / Land Ownership Shoreline Features Zoning Publicly Owned Tidelands	Maps 21, 22, and 23. Land and Shoreline Use Patterns
Commercial Shellfish Growing Areas Biotoxin Closure Zones Recreational Harvest Beaches	Map 24. Shellfish Harvesting
Forest Cover Impervious Surface	Map 25. Forest Cover and Impervious Surface
Marine Shoreline Geomorphic Landforms Lagoons, Salt Marshes, and Intertidal Wetlands Shoreline Slope Stability Landslide Hazard Erosion Hazard	Maps 26 and 27. Geomorphic Classes

As discussed in Chapter 1, shorelines of the state were originally codified by Ecology in the early 1970s in WAC 173-18 and 173-20. This list had not been updated until recently, when Ecology revised the list of shoreline streams using data from several regional flow studies conducted by the U.S. Geological Survey (USGS 1998)[2]. The results of the USGS study showed that numerous streams that are not currently designated as shorelines of the state may actually meet the 20 cfs mean annual flow criterion and should be regulated as state shorelines. In other

[2] The revised list has not been codified, but Ecology is currently in the process of revising state jurisdiction regulations to allow for incorporation of new data during the local SMP amendment process.

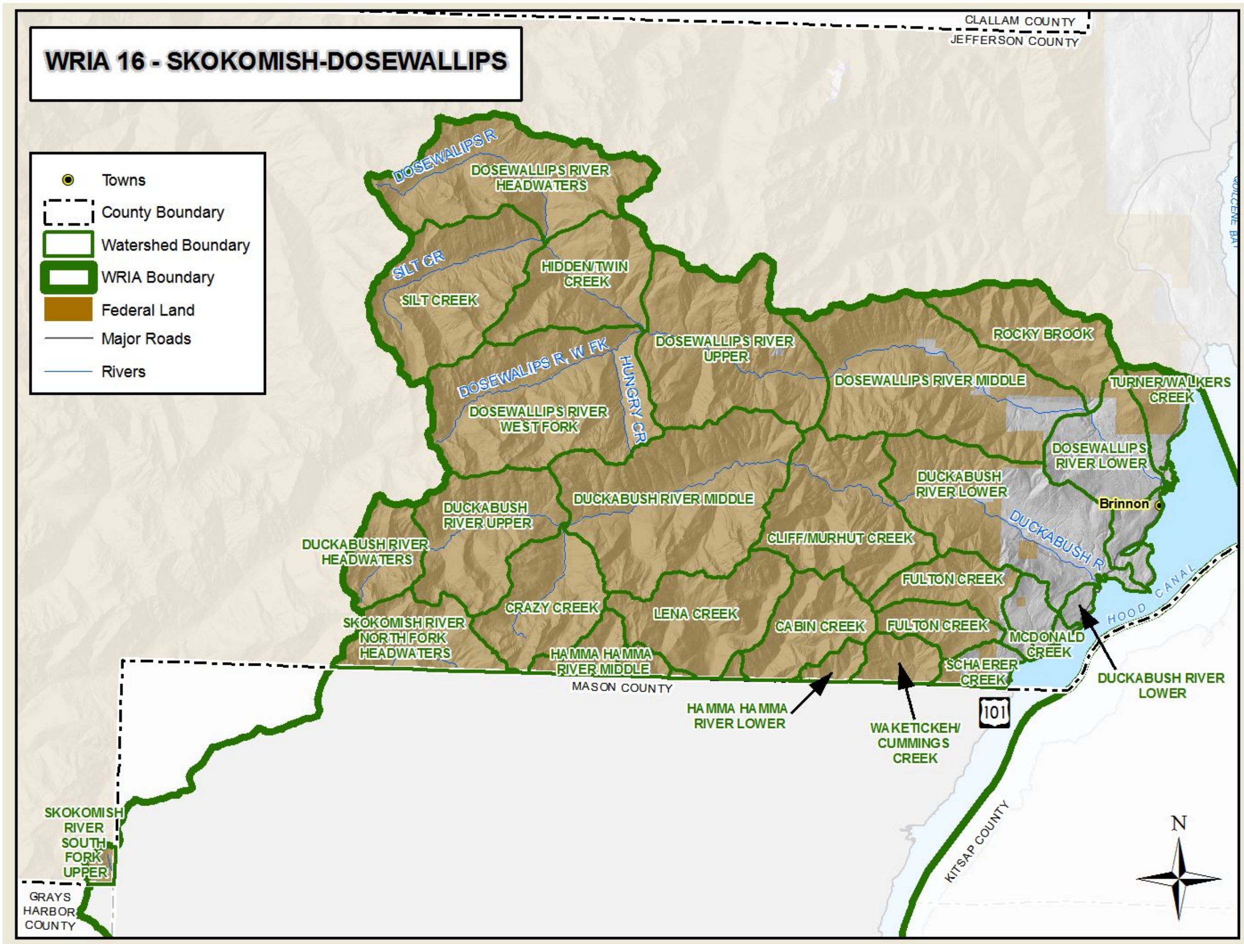
cases, the USGS study relocated the upstream boundary of the 20 cfs point further upstream or downstream from its WAC-designated location. In many cases the new stream flow data show the 20 cfs points in headwaters areas on federal lands, which may or may not be subject to County SMP jurisdiction. The revised list of streams in Jefferson County meeting the 20 cfs mean annual flow criterion is provided in Table 1-1. Mapping of rivers and streams depicted on Maps 1A and 1B in Appendix C have been updated to account for the USGS 1998 study, with most revisions to the codified list of WAC 173-18 and 173-20 occurring on streams located in the western portion of Jefferson County. For comparative purposes, Map 1C depicts shorelines of the state as designated by WAC 173-18 and 173-20 with the updated mapping of shorelines of the state using the USGS 1998 information. All maps in Appendix C depicting the shoreline planning area associated with shorelines of the state include mapping updated per the 20 cfs information (USGS 1998).

Within Chapter 4, the additional streams and lakes are not discussed within the text. Alternatively, Appendix D provides general inventory information for newly added streams and lakes known to be under County jurisdiction. Refer to WRIA information within Appendix D to determine the appropriate section of the following discussion that applies most directly to any feature.

4.1 WRIA 16 - SKOKOMISH-DOSEWALLIPS

The Skokomish-Dosewallips basin encompasses an area of about 660 square miles in northwestern Mason County and southeastern Jefferson County (Figure 4-1). The physiography ranges from the peaks of the Olympic Mountains in the western portion of the basin, to the flatlands of the Skokomish River valley. Principal drainages in the basin are the Dosewallips, Duckabush, Hamma Hamma, and Skokomish Rivers, with many smaller streams along Hood Canal. There are 557 identified streams providing over 825 linear miles of rivers, tributaries, and independent streams in the basin. Main streams and rivers within Jefferson County include Fulton Creek, McDonald Creek, Duckabush and Dosewallips Rivers, and Turner Creek.

Figure 4-1. WRIA 16 in Southeast Jefferson County



In WRIA 16, high-elevation snowfields in the Olympic Mountains direct runoff of precipitation, and groundwater baseflows maintain stream flows. Natural storage of water occurs in snowpack, lakes, wetlands, and groundwater, which collectively function to moderate extreme high- and low-flow stream conditions. Sixty percent of the land area in WRIA 16 is located within the ONP and ONF. The remaining 40 percent is state and privately owned. Commercial forestry is one of the primary land uses in the basin. Hydroelectric dams have significantly changed the streamflow regime of the North Fork of the Skokomish River. Development in the basin is concentrated along the coast. Agricultural activity is concentrated in the lower Skokomish River valley. Shellfish in Hood Canal are important to both tribal interests and the private sector (Golder Associates, 2002).

4.1.1 Fulton Creek Nearshore (Hood Canal West Shore Lower)

4.1.1.1 Overview (Map 1a)

Fulton Creek flows out of the foothills of the Olympic Mountains into Hood Canal north of Triton Cove. Most of the upper watershed is within the ONF. This nearshore segment extends from the Mason/Jefferson County line, just north of Triton Cove, to the north side of McDaniel Cove. The estuary of Fulton Creek provides significant habitat for salmonids and other wildlife, and there is a small estuary where McDonald Creek enters McDaniel Cove. Notable human impacts to the shoreline in this segment are vacation homes with associated shoreline armoring and docks, and Highway 101.

4.1.1.2 Nearshore Reaches (Map 8)

Reach A: County line north to the terminus of drift cell JE-30.

Reach B: Drift cell JE-29/JE-30.

Reach C: Drift cell JE-29.

4.1.1.3 Physical Environment (Maps 11, 14 and 26)

North of the Mason County line, Reach A is an area of no appreciable drift. This reach is composed of about 400 meters of basalt from the Crescent Formation dating from the Middle Eocene (Ecology, 1978). To the north begins drift cell JE-30, with net shore-drift to the northeast for 1.7 kilometer (km). This drift cell contains two areas of significant fluvial input, Fulton Creek and a smaller, unnamed drainage approximately 0.5 mile south of Fulton Creek. The drift cell terminates 550 yards to the northeast of where Fulton Creek passes under Highway 101 (Johannessen, 1992). Uplands within this drift cell are composed largely of Vashon lodgement till and an area of Vashon Recessional Outwash around Fulton Creek. The bluffs in this drift cell are considered unstable south of Fulton Creek, and there is at least one area of recent landsliding (Ecology, 1978).

The Reach B shoreline is composed of basalt for 0.5 mile to the northeast, and there is no appreciable net shore-drift (Johannessen, 1992).

Reach C, or drift cell JE-29, originates 0.5 mile northeast of the mouth of Fulton Creek. Net shore-drift continues for 640 yards to the McDaniel Creek delta. Indications of northeasterly drift include sediment accumulations along the southwestern side of numerous rock outcroppings, which partially interrupt the flow of sediment in this cell, and a decrease in sediment size over the length of the cell (Johannessen, 1992). The uplands along this drift cell are composed of basalt with some overlying glacial till deposits (Ecology, 1978).

Much of the shoreline in this area is mapped as landslide hazard area with unstable slopes.

4.1.1.4 Biological Resources (Maps 17, 20, 24 and 26)

Eelgrass is patchy throughout Reach A, and there is little or no overhanging riparian vegetation. Eelgrass is continuous for 360 yards to the south of the unnamed drainage 0.5 mile south of Fulton Creek. Riparian vegetation is largely absent from the southern portion of Reach A. Twenty percent of the upland planning area of Reach A is wetland, with estuarine – intertidal (mix of aquatic bed/unconsolidated shore and unconsolidated shore) as the primary wetland classifications.

Eelgrass beds and *Sargassum* are patchy throughout Reach B. Riparian vegetation increases to the north, covering approximately 40 percent of the northern part of Reach B. Within the upland planning area of Reach B, 4 percent of the land area is unconsolidated shore wetland.

The Fulton Creek delta has numerous salt marsh habitats and tidal streams. Coho, fall chum, cutthroat trout, steelhead, and pink salmon spawn in Fulton Creek. In addition, the estuary was found to be important habitat for juvenile coho, chum, and Chinook salmon. May and Peterson (2003) classified the Fulton Creek estuary as an NSE Category B refugia. Some of this fish use is clearly non-natal and indicates the importance of this estuary as part of the regional salmonid migratory corridor (Hirschi et al., 2003a).

The estuary is an approved shellfish harvest area and the shoreline north of Fulton Creek has patchy oyster and mussel beds and abundant although patchy *Sargassum*, although there is a shellfish harvest advisory in effect in Reaches A and B. There is patchy eelgrass along Reach C south of McDaniel Cove and little riparian vegetation. *Sargassum* is continuous throughout this reach. Within the cove there are oysters. Coho, cutthroat, and fall chum spawn in McDonald Creek. Within the planning area of Reach C, 7.5 percent of the land area is wetland, with estuarine – intertidal (mix of aquatic bed/unconsolidated shore and unconsolidated shore) the primary wetland classifications.

4.1.1.5 Land Use and Altered Conditions (Maps 11 and 21)

Land Use and Zoning

The primary land use in the shoreline planning area is rural residential. Within Reaches A and B, 100 percent is zoned Rural Residential, while in Reach C, 75 percent is zoned Rural Residential and the remaining 25 percent is zoned Local Agriculture.

Transportation and Utilities

Within Reaches A, B, and C, Jefferson County and WDNR have mapped 3.1 miles and 2.7 miles of road, respectively. Roadways include Highway 101, with two lanes and shoulder areas, and several intersecting property access roads.

Shoreline Modifications

There is a boat ramp at Triton Cove State Park and numerous private staircases in this area. There is extensive bulkheading and fill where the unnamed drainage south of Fulton Creek enters Hood Canal. This has restricted the access of the stream to the historical delta by pushing the stream channel to the southern edge of the bulkhead.

Just south of the Fulton Creek delta, a cabin is built onto fill fronted by a bulkhead. The northern part of Fulton Creek delta is filled, atop which sits a parking lot for a private club. There is fill on the southern part of the McDaniel Cove estuary and a large berm that juts out from the southern shore. Fill in the intertidal zone eliminates shallow water habitat for migrating juvenile salmon. Highway 101 has restricted channel migration where it crosses Fulton Creek and McDonald Creek, again impacting estuary habitat. A rock jetty that appears to serve no purpose extends northward near the mouth of McDaniel Cove in the McDonald Creek estuary.

4.1.1.6 Public Access (Map 21)

At the small delta created by the unnamed tributary south of Fulton Creek there is a public access shellfishing site. There is public access to the shoreline at Triton Cove State Park as well as a boat ramp. The WDFW tideland south of Fulton Creek has public access at a turnout off of Highway 101. The north side of McDaniel Cove is public tideland with boat access only.

4.1.1.7 Restoration Opportunities

Removing fill in the Fulton Creek delta, the delta of the unnamed stream south of Fulton Creek, and from McDaniel Cove would increase shallow water estuarine habitat for migrating juvenile salmonids. The fill around the mouth of the unnamed stream south of Fulton Creek is owned by WDFW and used as a parking area for a shellfishing site. Therefore, it is a good candidate for restoration, as the state already owns the property. Removing or modifying the filled parking area could create a more functional estuary for the small stream and improve alongshore drift processes. Removing the jetty at McDonald Creek could also help restore natural processes.

4.1.2 Fulton Creek

4.1.2.1 Overview (Map 1a)

Fulton Creek flows into Hood Canal north of Triton Cove. Steep concave headwaters drain bedrock slopes, followed by a reduced gradient channel flowing through a series of glacially deposited benches. A steep confined section follows downstream, with steep cascade reaches emptying into a short alluvial fan (Correa, 2003a). This watershed is a designated shoreline of the state below the point where the South Fork of Fulton Creek meets the mainstem at river mile (RM) 1.05 (WAC 173-18-200). Of a total of 5,353 acres of watershed, 4,845 acres are within the ONF.

4.1.2.2 Freshwater Reaches (Map 8)

Fulton Creek 1: From the stream mouth to the falls.

Fulton Creek 2: From the falls to the confluence of Fulton Creek and South Fork Fulton Creek.

4.1.2.3 Physical Environment (Maps 14, 21, and 25)

Land cover in the planning area is 49 percent evergreen forest and 47 percent mixed forest in Reach 1, and 100 percent evergreen forest in Reach 2. The area surrounding Fulton Creek is considered to be a landslide hazard area and unstable slopes occur along Reach 1. The Fulton Creek shoreline is also within a critical aquifer recharge area. There are no mapped or designated CMZs on Fulton Creek.

Upland vegetation near the Highway 101 crossing, including exotic vegetation, is now displacing former salt marsh upstream of the highway crossing. The former remnant salt marsh upstream of the highway appears to have been dredged, possibly due to fill in the intertidal area on the opposite side of the highway. A minimal amount of low-elevation salt marsh now appears seaward of the highway crossing (Todd et al., 2006).

Riparian habitat is in good condition, with 72 percent of this watershed being hydrologically mature (i.e., greater than 70 percent crown coverage and less than 75 percent of crown coverage in hardwoods or shrubs) (Correa, 2003a). Nonetheless, LWD is largely absent from the section of the stream below the falls (Correa, 2003a). Sediment data for this watershed are lacking, although sediment supply is likely within historical levels (Correa, 2003a).

Low summer flows within the stream limit salmonid rearing. In addition, Fulton Creek is listed as a Category 5 water for temperature according to Ecology's 2004 Water Quality Assessment.

4.1.2.4 Biological Resources (Map 17)

Fulton Creek supports coho, fall chum, and pink salmon spawning, as well as cutthroat and steelhead trout. There are no known artificial barriers to anadromous fish in this section of the stream; however, there is a barrier at the natural falls at RM 0.9 (Correa, 2003a). The available habitat below the anadromous barrier has supported up to 100 coho and 1,000 fall chum as recently as 1996, but these numbers of spawners have not been seen since. Escapement goals have not been set for this watershed (Correa, 2003a). There are very few pieces of LWD in the lower reach to the falls (Todd, 2003 as cited in Correa, 2003a). May and Peterson (2003) listed Fulton Creek as a Class A Nodal Riparian Corridor in their study of salmonid refugia in Jefferson County. A Nodal Riparian Corridor is one in which natural ecological integrity has been retained and the historical population and diversity of salmonids remain largely intact. Therefore, this stream continues to have some of the best remaining habitat for salmon in east Jefferson County (May and Peterson, 2003). There are 1.4 acres of wetlands located near the mouth of Fulton Creek, all classified as palustrine scrub/shrub (Correa, 2003a).

4.1.2.5 Land Use and Altered Conditions (Maps 21 and 25)

Land Use and Zoning

The planning area is zoned 57 percent Commercial Forest and 43 percent Rural Residential in Reach 1, and 100 percent Commercial Forest in Reach 2.

Transportation and Utilities

WDNR has mapped 0.2 mile of road within the Reach 1 planning area.

Shoreline Modifications

There are four areas of bank armoring and/or diking in the lower watershed, including bank armoring and dredging just upstream of the Highway 101 crossing (Todd et al., 2006). This results in a loss of floodplain habitat. However, the dredged area now serves as a lagoon habitat supporting chum salmon spawning (Ron Hirschi, personal communication, as cited in Todd et al., 2006). Fill associated with and immediately downstream of Highway 101 eliminates some estuary habitat (Correa, 2003a; Ecology, 2001).

4.1.2.6 Public Access (Map 21)

None identified.

4.1.2.7 Restoration Opportunities

Restoration opportunities identified for Fulton Creek within the Habitat Limiting Factors Analysis include restoring estuary function, removing the old levee near RM 0.4, replacing culverts in the upper watershed, and protecting and restoring riparian function in the lower reach to the falls (Correa, 2003a).

4.1.3 Duckabush River and Black Point Nearshore (Duckabush River)

4.1.3.1 Overview (Map 1a)

From the northern edge of McDaniel Cove to the northern edge of Pleasant Harbor is a marine shoreline that encompasses the major estuary of the Duckabush River and Black Point. The area south of the Duckabush River is primarily a basaltic shoreline with a few pocket beaches. Residential development is concentrated just south of the Duckabush delta and on the north and east sides of Black Point and around Pleasant Harbor. There is a marina in the naturally protected anchorage of Pleasant Harbor. Significant habitats in this area include the sparsely developed marine shoreline north of McDaniel Cove, the Duckabush River and delta, the south side of Black Point, and Quatsap Point spit. The Duckabush River Bridge is on the National Register of Historic Places.

4.1.3.2 Nearshore Reaches (Map 8)

Reach D: North shore of McDaniel Cove (terminus of drift cell JE-29) to start of drift cell JE-28.

Reach E: Duckabush delta to the edge of Quatsap Point (drift cell JE-28).

Reach F: From the origin of drift cell JE-27 to the tip of Quatsap Point spit.

Reach G: Area of no net drift around Black Point.

Reach H: From north to south entrances of Pleasant Harbor.

4.1.3.3 Physical Environment (Maps 11, 14 and 26)

The Duckabush River estuary formed following the most recent glaciation, when large volumes of sediment were carried downstream through a glacially carved valley to form the delta fan at Hood Canal. Historically there were at least two distributary channels within the delta fan. The northernmost branch is now a blind channel that has been disconnected from the current main channel, probably since the Highway 101 causeway was built in the 1930s (Todd et al., 2006). No appreciable net shore-drift occurs within Reach D. In this reach the shore consists of basalt and isolated pocket beaches (Johannessen, 1992).

Within Reach E, the next drift cell, JE-28, begins at the central portion of the Duckabush River delta and continues to the cuspate spit at the tip of Quatsap Point. On this high bluff shore, the abundant sediment sources for the drift cell are alongshore, from the feeder bluff on the south side of Quatsap Point, and fluvial sources from the Duckabush River (Johannessen, 1992). The feeder bluff, which is composed of Vashon till overlying older undifferentiated stratified glacial sediment, is an area of numerous landslides (Ecology, 1978, 2001). The intertidal zone in the delta is about 750 feet wide and narrows around the south side of Quatsap Point to a 30-foot-wide beach (WDNR, 2001).

Reach F extends across the first drift cell to the north of Quatsap Point, JE-27, which originates at the northeast portion of Black Point and has a southward net shore-drift for a mile along a sinuous shore to Quatsap Point. This area is exposed to northerly and northeasterly fetch that controls net shore-drift. Evidence of this includes a southward sediment size decrease, southeastward stream mouth offset, and southeastward progradation of Quatsap Point spit. The cell terminus is located at Quatsap Point (Johannessen, 1992). Bluffs on the northern half of this drift cell are composed of Vashon lodgement till and are stable, whereas the bluffs composed of Vashon advance outwash in the southern half of the drift cell (except for the spit) are unstable and feed abundant sand and gravel to the intertidal zone. A small drainage that flows through a tidal lagoon in the middle part of Reach F also contributes fluvial sediment to the intertidal zone (Ecology, 1978). This lagoon is an unusual tidal feature that is essentially a kettle lake with an intertidal inlet (Labbe, personal communication, 2004). Kettle lakes are formed when glacial recessional outwash buries or partially buries large blocks of ice. When the ice melts, if the depression is not filled with sediment, it can become a pond or lake. Several other kettle type depressions occur inland on Black Point.

The reach south of Black Point (Reach G) consists of several basalt outcroppings separated by pocket beaches. There is no net drift in this area.

Pleasant Harbor (Reach H) is a natural harbor bounded on the northwest by Vashon lodgement till, which is intermediately stable, and on the south by Vashon advance outwash that is classified as unstable. To the east the shore is composed of Vashon lodgement till and basalt. There is an accretionary beach at the head of the harbor and beach deposits on both sides of the mouth of the harbor.

Wetlands compose 23 percent and 49 percent of the planning area in Reaches D and E, respectively. Fourteen percent or less of the area within all other reaches is composed of wetland. A majority of the wetlands are estuarine – intertidal, with a mix of aquatic bed/unconsolidated shore, emergent, and unconsolidated shore composing the remaining wetlands.

Landslide hazards and/or unstable slopes occur along Reaches D, E, F and H.

4.1.3.4 Biological Resources (Maps 17, 20, 24, and 26)

Between the northern edge of McDaniel Cove and the Duckabush delta, there are several areas of patchy and continuous eelgrass beds, as well as patchy areas of kelp and *Sargassum*. This basaltic shoreline supports little riparian vegetation. Riparian vegetation increases to 20 percent just south of the Duckabush delta, but appears to have been adversely affected by residential clearing (WDNR, 2001).

The Duckabush delta, the south side of Black Point, and Quatsap Point provide abundant quality habitats. This estuary and delta are used by trumpeter swans and bald eagles, and support regionally significant winter waterfowl use. Harbor seals haul out here throughout the year and pupping occurs in the winter. The extensive mud and gravel flats contain rich shellfish beds with millions of harvestable oysters and clams (Speck, personnel communication, 2003). Salt marsh habitat dominates the higher areas of the Duckabush delta. In the lower intertidal and subtidal zones, eelgrass beds are continuous from the delta to Quatsap Point. Herring use this eelgrass for spawning (Penttila, 2000). There is abundant riparian vegetation just to the northeast of the delta. The Duckabush River estuary has been placed on the Washington State Department of Health 2006 list of Shellfish Areas of Concern due to elevated bacteria levels at two stations (WDH, 2006a). At the Reach F terminus at Quatsap Point an exemplary cuspate spit forms, enclosing a high salt marsh.

Eelgrass beds are patchy throughout Reach F (drift cell JE-27) and herring spawn along the entire shore (Penttila, 2000). Dune grasses are found at the terminus of the cell. The swimming lagoon has a unique biology and intertidal community (Hirschi, personal communication, 2003). The inlet to the lagoon is fringed with salt marsh. The beach north of the outlet is used by sand lance for spawning. Overhanging riparian vegetation is present over about half of this drift cell (WDNR, 2001). Surf smelt spawn on the beaches on the north and south sides of Quatsap Point.

Within Reach G, the central pocket beach south of Black Point is a documented sand lance spawning site (Penttila, 2000). Pacific herring spawn just offshore throughout this area and into Pleasant Harbor (Reach H) (Bargmann, 1998).

Within Reach H, patchy eelgrass is found throughout Pleasant Harbor, and a narrow eelgrass bed lines the northern side of the harbor (Correa, 2003a). Salt marsh habitat is found on the north side of the mouth and at the head of the harbor (WDNR, 2001; Ecology, 1982). Pleasant Harbor is not listed on Ecology's 2004 303(d) list; however, the Washington State Department of Health has prohibited commercial and recreational shellfish harvest in this area (WDH, 2006a, 2006b).

The nearshore area is listed as a Category 2 water of concern for fecal coliform according to the 2004 Ecology Water Quality Assessment. Potential sources of fecal coliform are septic systems or coliform associated with sediment runoff (Golder Associates, 2002).

4.1.3.5 Land Use and Altered Conditions (Maps 11 and 21)

Land Use and Zoning

A majority of the planning area is zoned Rural Residential, with a small percentage represented by Local Agriculture and Water.

Transportation and Utilities

Roadways include Highway 101 (including two lanes and shoulder areas) along the Duckabush estuary shoreline and the north shoreline of Pleasant Harbor, and several intersecting property access roads within Reaches E, F, and G.

Shoreline Modifications

South of the Duckabush River there are several rail boat launches. Built on fill, Highway 101 cuts across the extensive estuary of the Duckabush River, restricting access to side channels and limiting channel migration. Several side roads in this vicinity also constrict channels in the estuary. On the northern edge of the estuary there is cement bulkheading and possible fill of salt marsh habitat. Some of the homes behind the bulkhead may be built on fill placed over salt marsh.

Just north of Quatsap Point, bulkheads front a small housing development at Lackawanda Beach. The bulkhead and adjacent dock may have some effect on the longshore transport of sediment within drift cell JE-27 to Quatsap Point. Some of these bulkheads front fill and do not appear to be protecting structures. Farther north, closer to the origin of this drift cell, numerous staircases lead onto the beach. Approximately 13.8 percent of this drift cell is bulkheaded, primarily in the sediment transport zone (Hirschi et al., 2003b).

Historically a small salt marsh was located just north of the tidal inlet from the kettle lake, but it has been filled by residential development (Todd et al., 2006). Within Pleasant Harbor there are numerous private docks on the south side of the harbor along with two marinas: one smaller marina just inside the spit, and a larger marina along the north shore. A launch ramp and parking area also occur at the head of the bay. Shoreline modifications to this drift cell include about 21 percent bulkheading and a number of docks and stairways along the shoreline (Hirschi et al., 2003b as cited in Todd et al., 2006). In general, shade created by docks can have adverse effects on eelgrass.

A large infestation of invasive tunicates (invertebrates commonly known as “sea squirts”) has been documented within Pleasant Harbor (Lambert, 2005). The club tunicate (*Styela clava*), native to Korea and Japan, can breed rapidly and form highly dense populations that overtake and crowd out other forms of marine life.

4.1.3.6 Public Access (Map 21)

The Duckabush delta is owned by WDFW and is accessible from Highway 101. Part of the shoreline on southern Black Point is owned by WDNR and is accessible by boat. There is a state park with a boat ramp in Pleasant Harbor.

4.1.3.7 Restoration Opportunities

Modifying the Highway 101 crossing of the Duckabush delta would allow for more tidal exchange and channel migration, and would increase salt marsh estuarine habitat. Bulkheads at Lackawanda Beach that are not protecting structures could be removed to increase upper intertidal habitat.

Eradication of invasive tunicates in Pleasant Harbor could protect the diversity of native invertebrates in this area. A November 5, 2005 effort to remove all *Styela clava* from floating docks and moored boats from Pleasant Harbor Marina was not completely successful (Lambert, 2005). Divers contracted through WDFW during summer 2006 removed more than 90 pounds of tunicates from 150 recreational boats at Blaine, Semiahmoo, Pleasant Harbor, and Home Port marinas. They also surveyed about 30,000 square meters of docks in the infested marinas, cleaned about 25 percent of the area, and removed about 2,000 pounds of invasive tunicates (PSAT, 2006). Future restoration opportunities may include additional invasive tunicate surveys and removal efforts.

4.1.4 Duckabush River (Duckabush River)

4.1.4.1 Overview (Map 1a)

The Duckabush River is one of the largest rivers flowing into Hood Canal. Its watershed covers approximately 75 square miles of the eastern Olympic Mountains. The Duckabush mainstem is 24.5 miles long, with 50 tributaries contributing an additional 94.3 stream miles. Average annual discharge is 411 cfs at RM 4.9 (Correa, 2003a). Summer stream low flows are supported primarily by snowpack melt. Groundwater-supported baseflow is minimal as a result of the dominance of bedrock geology (Golder Associates, 2002).

The upper portion of the watershed is protected in the ONP and as USFS wilderness. Shoreline designation currently stops at the edge of the ONF at RM 2.3; however the County's jurisdiction extends to private inholdings within the National Forest. The furthest upstream extent of these inholdings is just downstream from the gauging station at RM 4.9. In this lower section, the Duckabush River valley is characterized by steep walls and a relatively wide floodplain.

4.1.4.2 Freshwater Reaches (Map 8)

Duckabush River 1: From the mouth to the National Forest boundary.

Duckabush River 2: From the National Forest boundary to the edge of the last private inholding.

4.1.4.3 Physical Environment (Maps 14, 21, and 25)

The lower two-thirds of the watershed is within the basalt-rich Crescent formation. Limited alluvial deposits are found along the lower 6 miles (WDFW and PNPTT, 2000 as cited in Correa, 2003a). The river valley walls are generally steep throughout, with a broad floodplain below RM 5.0.

Land cover within the planning area is composed of 60 percent evergreen forest, 28 percent mixed forest, and 7 percent urban/recreational grasses, with acreages/rural residential representing the remaining land cover. The slopes of either side of the Duckabush River valley are mapped as landslide and erosion hazard areas and the CMZ encompasses much of the floodplain.

Within the ONF, the river is within a riparian reserve program that preserves floodplain riparian vegetation (Correa, 2003a). Hydrological maturity of the lower 8 miles of watershed is as follows: approximately 16 percent (181 acres) of the lower watershed is less than 30 years old, 67 percent (7,458 acres) is between 31 and 95 years old, 9 percent (1,022 acres) is between 96 and 297 years old, and 0.3 percent is greater than 297 years old (USFS, 1998). There are recent clearcuts in the lower 2 miles of the watershed (Correa, 2003a).

Wetlands identified in Reach 1 are 71 percent palustrine forested, 13 percent estuarine - intertidal (associated with river mouth), and 5.5 percent palustrine scrub/shrub.

Portions of the Duckabush River above Reach 1 are listed as a Category 5 water for temperature according to Ecology's 2004 Water Quality Assessment.

4.1.4.4 Biological Resources (Map 17)

The Duckabush River riparian corridor below RM 7.5 was designated a Class A Nodal Riparian Corridor by May and Peterson (2003). Chinook, coho, fall and summer chum, pink salmon, and steelhead and sea-run cutthroat trout use the entire lower segment of the Duckabush River. There are no artificial barriers to anadromous fish in this stretch of river. Two large side channels upstream from the Bonneville Power Administration (BPA) power lines are used heavily by chum salmon for spawning. The river has recently broken through the head of one of these side channels and it may become the new main channel (Correa, 2003a). Of the salmon stocks in the Duckabush River, Chinook salmon are rated critical; summer chum, pink salmon, and winter steelhead are considered depressed; and fall chum and coho salmon are considered healthy according to the Salmon and Steelhead Stock Inventory (SASSI) (WDFW, 2000b).

4.1.4.5 Land Use and Altered Conditions (Maps 21 and 25)

Land Use and Zoning

Timber harvest is the dominant land use in the lower watershed, both on National Forest lands and private lands. Between the USFS boundary and the mouth of the river, zoning is Commercial and Rural Forestry with some Rural Residential.

Transportation and Utilities

Overall, road density in the watershed is low at 0.6 mile of road per square mile of habitat. However, in the lower Duckabush, road density is 2.2 miles of road per square mile of watershed (WDFW and PNPTT, 2000 as cited in Correa, 2003a). Within the planning area of Reach 1, Jefferson County and WDNR have mapped 1 mile and 1.2 miles of road, respectively.

Shoreline Modifications

Streambank armoring restricts the floodplain downstream of the National Forest boundary. Boundaries to the channel migration zone for the Duckabush River were identified as River Drive, Mountain Trail Road, Kelly Road, Highway 101, and the south bank revetment just west of the Highway 101 bridge (Perkins and Klawon, 2004). Floodplain connectivity rates fair overall but poor in the lowest half mile of the river. Below RM 3.0, removal of LWD and rural residential development have confined the river to a single channel, limiting side channel spawning and rearing habitat for salmonids.

In the lower Duckabush watershed, roads have contributed to 31 mass wasting events (33 percent of the total) in the lower 8 miles of watershed. It is estimated that 78 percent of these events contributed sediment to the river (USFS, 1998). In the lower reaches of the river below the ONF, impacts of development are evident: 25 percent of the riparian zone (by area) is developed below

RM 3.0 (12 percent urban/commercial, 9 percent rural residences, and 3 percent dikes and roads). Approximately 32 percent of the riparian zone contains small trees less than 12 inches in diameter; 66 percent contains trees of medium diameter between 12 and 20 inches; 2 percent has no trees; and there are no large trees over 20 inches in diameter (Correa, 2003a).

4.1.4.6 Public Access (Map 21)

None identified. Some of the tidelands at the mouth of the river are publicly owned.

4.1.4.7 Restoration Opportunities

Restoration opportunities include improving road management practices to mitigate altered sediment processes, enhancing riparian vegetation to improve cover and LWD recruitment potential, and reconnecting floodplain wetlands and side channels to restore natural channel forming processes and improve habitat.

4.1.5 Dosewallips River and Brinnon Nearshore (Dosewallips River)

4.1.5.1 Overview (Map 1a)

This marine shoreline extends from the northern edge of Black Point to the head of Right Smart Cove north of Brinnon. It includes three drift cells and the large estuary and river delta of the Dosewallips River. The Dosewallips River is the largest river in eastern Jefferson County with a watershed draining the northeastern Olympic Mountains. The town of Brinnon is located north of the lower Dosewallips River. There is a small commercial district in Brinnon and several residential neighborhoods. There are numerous residential and vacation homes both north and south of Brinnon on Hood Canal.

4.1.5.2 Nearshore Reaches (Map 8)

Reach I: Drift cells JE-26 and JE-25, northeastern edge of Pleasant Harbor to south edge of Dosewallips River delta.

Reach J: Dosewallips River delta to the start of drift cell JE-24 in Right Smart Cove.

4.1.5.3 Physical Environment (Maps 11, 14 and 26)

Drift cell JE-26 is a short (550-yard) drift cell within Reach I. This drift cell begins at the northeasternmost basalt outcropping and has a westward and then southwestward net shore-drift across the northern portion of Black Point and then into Pleasant Harbor. Drift sediment is derived from Vashon till overlying basalt.

Drift cell JE-25 extends between the Dosewallips River and Pleasant Harbor. It originates at the southern edge of the Dosewallips River delta, with net shore-drift to the southeast for 2.1 km to Pleasant Harbor. Northeastward fetch becomes the controlling factor in this area because this area is sheltered from south winds by Black Point. Southwestward net shore-drift is indicated by minor southwestward beach width increase, sediment size decrease, and southwestward spit progradation just inside the mouth of Pleasant Harbor. The end of this spit is the cell terminus

(Johannessen, 1992). There is an abundant fluvial sediment source at the beginning of the cell, and moderately abundant alongshore sediment in the remainder of the drift cell. Most of the shoreline of this drift cell is composed of Vashon lodgement till and is considered of intermediate stability. There is an area of unstable bluff face about 450 meters south of the southern edge of the Dosewallips delta (Ecology, 1978).

Within Reach J, the Dosewallips estuary includes a deltaic fan with fluvial sediment deposits and a well-developed tidal marsh system. Spit features mark the outer edge of salt marsh in the north part of the delta. The forming of the Dosewallips estuary likely occurred with the fluvial transport of large volumes of sediment down the glacial valley following the retreat of glaciers (Barnard, 2005 as cited in Todd et al., 2006). The delta historically occupied 0.7 square mile (1.8 square km) (Correa, 2003a). Wolcott Slough is the most dominant feature located in the north section of the estuary. The slough is fed by a network of small freshwater streams west of Highway 101 in the Brinnon Flat.

The southern portion of Reach J is an area of divergence between drift cell JE-25 to the south and JE-24 to the north. It is also the active part of the delta where the river flow meets the sea. Large amounts of fluvial sediment create, on average, a 150-meter-wide intertidal zone primarily of sand and gravel (WDNR, 2001; Correa, 2003a). The Washington State Department of Health has classified this area as a restricted shellfish harvest area due to water quality concerns (WDH, 2006a).

Drift cell JE-24 begins at the northern edge of the Dosewallips delta, with net shore-drift continuing 3.3 miles north of Brinnon into Right Smart Cove. Slope stability is intermediate to stable throughout this drift cell, with Vashon till overlying basalt. The exception is about 0.5 mile of unstable Vashon Recessional Outwash just north of the Dosewallips delta. A substantial portion of the nearshore sediment in this drift cell appears to originate from the Dosewallips River. Evidence of northward drift includes a general increase in beach width, accumulation of sediment on the south side of a riprap seawall and boat ramp at Seal Rock, and the northerly directed mouth of Turner Creek.

The drift cell terminus is located at Right Smart Cove at the eastern end of a spit that encloses a large tidal lagoon (Johannessen, 1992; Ecology, 2001). The lagoon supports native high-marsh vegetation such as pickleweed (*Salcornia virginica*) and sea arrow grass (*Triglochin* spp.). Native forest that originally surrounded the lagoon has been eliminated, and invasive species such as Scot's broom and blackberries have taken its place in many areas (Correa, 2002; Todd et al., 2006). A small stream drains into the lagoon from a large pasture to the north. Tidal connectivity between the tidal lagoon and channel remains functional (Todd et al., 2006), though some of the salt marsh associated with this lagoon has been filled for homes to the east of the tidal inlet.

4.1.5.4 Biological Resources (Maps 17, 20, 24, and 26)

Within Reach I, over half of drift cell JE-25 has overhanging vegetation. There are patchy eelgrass beds near the southern terminus of the drift cell. Patchy areas of *Sargassum* are mapped within Reach I. Sand lance spawn on the beaches just north of Pleasant Harbor's mouth (Penttila, 2000).

The Dosewallips delta contains many tidal channels and large amounts of salt marsh habitat. The estuary is an important nursery habitat for summer chum and pink salmon as well as Chinook, coho, and coastal cutthroat trout (May and Peterson 2003). The adjacent nearshore areas provide quality salmonid rearing and migration habitat. Juvenile pink and chum salmon have been found in Wolcott Slough (Hirschi et al., 2003a). May and Peterson (2003) classified the estuary north of the river mouth as a Category A NSE refugia and the area south of the river mouth as a Category D NSE refugia. The Dosewallips River supports runs of pink, Chinook, fall and summer chum, and coho salmon as well as steelhead and cutthroat trout. This area is also an important recreational and tribal shellfish site (see Figure 3-3). Bald eagles and great blue herons nest in Dosewallips State Park.

Within Reach J herring spawn in the eelgrass from the mouth of Turner Creek up into Right Smart Cove. Patches of barnacles and oysters are found along this entire segment of shoreline. Patchy areas of *Sargassum* are mapped within Reach J. Sand lance spawn on the beach at the terminus of this drift cell (Penttila, 2000; Long et al., 2005).

Invasive clubbed tunicates (*Styela clava*) have recently been discovered in a number of locations around Puget Sound, including on docks and the hulls of boats in Pleasant Harbor Marina (WDFW, 2006). These tunicates, which are native to Asia, have no known predators in Puget Sound and can quickly blanket hard surfaces and out-compete or suffocate other types of sea life, including native clams, mussels, and oysters.

4.1.5.5 Land Use and Altered Conditions (Map 11 and 21)

Land Use and Zoning

Land used in the planning area is mainly Rural Residential, Commercial Forestry, Rural Forestry with scattered Agriculture and a small area zoned Rural Village Center.

Transportation and Utilities

Within Reaches I and J, Jefferson County and WDNR have mapped 5 miles and 5.4 miles of road, respectively. Roadways include Highway 101 (with two lanes and shoulder areas) and several intersecting property access roads.

Shoreline Modifications

Although there is relatively little bulkheading within drift cell JE-26, there are 11 stair structures within its 787 yards.

North of Pleasant Harbor there is a residential area with numerous staircases, some with large decks and small boathouses built on the upper intertidal zone. Approximately 21.2 percent of this drift cell is bulkheaded (Hirschi et al., 2003b). Although much of the sediment for this drift cell is fluvial in nature from the Dosewallips River, the armoring can have significant impacts on the transport of alongshore sediment. In addition, the upper intertidal structures can decrease the amount of beach habitat available for forage fish spawning and reduce shallow water habitat available to migrating juvenile salmonids.

At least six diked areas protected by four tide gates now occupy approximately 15 percent of the Dosewallips estuary, with another 2.5 acres of fill associated with residential and agricultural activities (Correa, 2003a). In the southern part of the Dosewallips delta, there is a derelict barge or backfilled wooden bulkheaded area that has affected shallow water habitat. Highway 101 truncates several sloughs and restricts channel migration near the mouth of the Dosewallips River. Other diked and filled areas occur in the Dosewallips State Park campground and to the north of the main river channel.

North of Brinnon, drift cell JE-24 is 17.1 percent bulkheaded, including several sections of bulkhead extending below the high water mark (Hirschi et al., 2003b). This can decrease shallow water habitat and the recruitment of sediment into the nearshore. It can also impact the longshore transport of sediment, particularly in the area just north of Seal Rock Campground where there are numerous private boat ramps (Ecology, 2001).

The cumulative impacts of the Brinnon Flat armoring and floodplain modifications, the State Park campground infrastructure and bank armoring (upstream and downstream of the highway), the Highway 101 bridge and causeway, and a long history of wood removal have impaired the connectivity between the mainstem river channel and impeded the development of new distributaries. These modifications have also affected the function of other estuarine channels and associated tidal marsh habitats. Sea dikes have eliminated or altered the hydrology of tidal marsh habitat, mainly to the north of the current active channel.

Fecal coliform contamination is a problem in the nearshore marine environment of the Dosewallips River and as a result the nearshore area is a Category 5 water according to the 2004 Ecology Water Quality Assessment. Potential sources of fecal coliform are wastewater and soil coliform associated with sediment runoff (Golder Associates, 2002).

4.1.5.6 Public Access (Map 21)

Dosewallips State Park offers public camping and access to the delta and uplands at the mouth of the Dosewallips River. ONF's Seal Rock Campground is north of Brinnon and offers camping and shoreline access.

4.1.5.7 Restoration Opportunities

The Dosewallips estuary and its lower river corridor have recently become a focus of major habitat restoration planning and implementation. A large portion of the sea dike, visible at least as early as 1939, located near the center of the estuary within the State Park was removed during fall 2004. Additional habitat restoration projects that affect the Dosewallips estuary are currently in the planning and design phases (Todd et al., 2006).

Removing or replacing bulkheads with soft bank protection methods would improve longshore transport of sediment north and south of Brinnon, as would the removal of boat ramps. Several dikes are currently being removed or are proposed for removal from the Dosewallips estuary, which will improve and increase estuarine habitat. The Highway 101 crossing of the Dosewallips River delta truncates and restricts river and tidal channels; restoring the hydrologic function of these channels presents a restoration opportunity.

There have been four known infestations of spartina within Hood Canal, at Dosewallips State Park, Bywater Bay, Tarboo Bay, and Thorndyke Bay (WSDA 2001). As of 2006, state eradication efforts have been successful at all locations except Dosewallips State Park, where a small area of spartina remains. The Washington Department of Agriculture intends to continue eradication and post-eradication monitoring at Dosewallips State Park and Thorndyke Bay (WSDA 2007).

4.1.6 Dosewallips River (Dosewallips River)

4.1.6.1 Overview (Map 1a)

The Dosewallips River drains the eastern Olympic Mountains from the river's headwaters in the vicinity of Mt. Claywood, emptying into Hood Canal at the town of Brinnon. The watershed covers approximately 78,000 acres or 122 square miles (USFS, 1999). The mainstem of the Dosewallips River is 28.3 miles long with 140 miles of tributaries. Overall, the tributaries are steep and the lower mainstem relatively gradual with meanders (Correa, 2003a; USFS, 1999). Private inholdings (and hence County jurisdiction) end at about RM 9, located 1 mile downstream from the Steelhead Campground. The upper 60 percent of the watershed is in ONP, the middle 30 percent is in the ONF, and the lower 10 percent is in private ownership.

Annual average discharge of the river is 446 cfs at the gauging station at RM 7.1. There are two runoff peaks: one associated with the winter rains between November and February, and another associated with snowmelt in May and June (USFS, 1999; Correa, 2003a). Groundwater-supported baseflow is minimal as a result of the dominance of bedrock geology (Golder Associates, 2002).

4.1.6.2 Freshwater Reaches (Map 8)

Dosewallips River 1: From the mouth to the ONF boundary.

Dosewallips River 2: From the ONF boundary to the upstream extent of private inholdings.

Dosewallips Tributary 1: Rocky Brook from the confluence at Dosewallips to the impassable falls.

4.1.6.3 Physical Environment (Maps 14, 21, and 25)

Dominant vegetation along the mainstem river floodplain includes forests of black cottonwood (*Populus trichocarpa*) and red alder (*Alnus rubra*) (Labbe et al., 2005). A riparian forest assessment of the lower 8.7 miles of the mainstem reports 51 percent of the riparian zone has a stand diameter of less than 12 inches, 45 percent has a diameter between 12 and 20 inches, and there are no large trees with a diameter greater than 20 inches. Four percent has no riparian buffer (USFS, 1999 as cited in Correa, 2003a).

Land cover in the planning area is 43 percent evergreen forest and 26 percent mixed forest, with the remainder being urban/recreational grasses, acreages/rural residential, recent clearcut, transitional, and low intensity residential.

Within Dosewallips River Reach 1, approximately 33 percent of the planning area is wetland, with palustrine forested (41 percent) and riverine upper perennial (33 percent) being the primary wetland classifications.

Though much of the lower river floodplain has been modified or developed, a reach lying between the BPA powerlines and the Lazy C housing development is relatively intact, with abundant large wood deposits and off-channel habitat. Removal of the riparian/floodplain forest vegetation, primarily conifers, has decreased the future LWD recruitment potential (Labbe, personal communication, 2003 as cited in Correa, 2003a). The USFS ownership begins at RM 6.1 and extends to RM 14.0. A riparian reserve program along the river corridor improves LWD recruitment potential for Reach 2.

Ecology's 2004 Water Quality Assessment lists the Dosewallips River (at the mouth) as a Category 5 water for temperature.

Habitat within approximately 0.5 mile upstream from the Highway 101 Bridge appears to be a zone of deposition with large gravel bars, multiple channels, and LWD with greater abundance than adjacent reaches. Farther upstream, the channel and migration zone are frequently confined by bedrock or directed bedrock outcroppings (Klawon, 2004). The lower 0.2 mile of Rocky Brook contains excellent spawning gravels. Between 1920 and 1990, approximately 65 percent of the Rocky Brook subwatershed was clearcut. Forty-five mass wasting events have occurred in the Rocky Brook watershed. Within Rocky Brook, LWD recruitment is poor due to the extensive logging in the watershed (Correa, 2003a).

4.1.6.4 Biological Resources (Map 17)

The Dosewallips River supports Chinook, fall and summer chum, pink, and coho salmon as well as steelhead and cutthroat trout spawning (Correa, 2003a; May and Peterson, 2003). The river has very few significant salmon-bearing tributaries, but the tributaries do provide important off-channel areas for juvenile salmonids (May and Peterson, 2003). The Chinook salmon in this system are part of the Mid-Hood Canal stock and according to SASSI are rated as critical, with escapement below the critical threshold of 400 fish for the stock (WDFW, 2000b). The Mid-Hood Canal stock includes Chinook in the Hamma Hamma, Duckabush, and Dosewallips Rivers. Spawning takes place in the lower 12 miles of river between September and October with most spawning taking place below RM 6.7 (Correa, 2003a).

Summer chum spawn in the lower 2.3 miles of river from mid-September to mid-October. They are rated as a depressed stock in the SASSI (WDFW, 2000b) and are federally listed as threatened under the Endangered Species Act. Summer chum is a native stock with wild production. Dosewallips summer chum declined in the 1980s but have recently improved (Correa, 2003a). Fall and late-fall chum also spawn in the Dosewallips and these stocks are rated as healthy.

Coho spawn primarily in the lower 12 miles of the mainstem and in the lower reaches of numerous tributaries. This coho stock is wild production of mixed composition due to past hatchery releases. Its SASSI stock status is rated as unknown. Pink salmon are rated as depressed after a decline in returns ranging from 400,000 to 100,000 spawners in the 1960s to 10,000 to

40,000 spawners in the 1980s, to low returns in the late 1990s of about 2,000 to 3,000 spawners. Spawning takes place in the lower 7 miles of the mainstem. Summer steelhead stocks are rated as unknown in the SASSI, and winter steelhead are rated as depressed (Correa, 2003a).

There are no artificial barriers to anadromous fish in the Dosewallips River, although a natural falls is a complete barrier at RM 12.5. The Dosewallips, below the anadromous fish barrier at RM 12.5, was found to harbor some of the best remaining refuge habitat for salmonids in eastern Jefferson County (May and Peterson, 2003). In particular, several reaches are noted for the high quality of spawning habitat: RM 0 to 1.8 (Brinnon flats to Lazy C flats), RM 4.5 to 5.3 (Walcott Flats), and RM 7 to 7.8 (Middle River flats).

The lower, middle, and upper Dosewallips river reaches are identified as Category A Nodal Corridors according to May and Peterson (2003). Rocky Brook is also a Category A RNC.

4.1.6.5 Land Use and Altered Conditions (Maps 21 and 25)

Land Use and Zoning

Land use in the basin is dominated by residential development, pastureland, and timberland. From the mouth to RM 3.6, the broad floodplain is zoned Agriculture (3 percent), Forestry (3 percent), Commercial (6 percent), and Rural Residential (7 percent). Dosewallips State Park lies on the south side of the river and estuary, and the town of Brinnon is to the north. Both are within the floodplain-delta area (Correa, 2003a). The USFS ownership begins at RM 6.1 and extends to RM 14.0.

Transportation and Utilities

Within the planning area of Dosewallips River Reach 1, Jefferson County and WDNR have mapped 3.5 miles and 3.9 miles of road, respectively. A County road extends along the left bank of the river from the mouth to RM 3.6. The Highway 101 causeway restricts estuary function and has disconnected some of the side channels from the main river channel (Correa, 2003a).

Dosewallips Tributary Reach 1 has a road density of 3.7 miles of road per square mile of watershed (USFS, 1999 as cited in Correa, 2003a).

Shoreline Modifications

Logging in the Dosewallips watershed began in 1859. A splash dam built by the Sims Logging Company at the head of the Dosewallips canyon in 1917 was in operation for 9 to 10 years. When water was released, most logs that had been accumulated behind the dam were flushed all the way to Hood Canal; the erosive power of these releases was likely catastrophic for salmon and their habitat in the lower river (Labbe et al., 2005). In addition, starting in the 1880s, development transformed the lower river from a valley with many side channels, wetlands, and logjams to a channelized river with adjacent farmland.

Boundaries to the channel migration zone for the Dosewallips River were identified as the town of Brinnon, from Highway 101 to as far west as the existing revetment; Dosewallips State Park east (downstream) of the large levee; and Highway 101 (Perkins and Klawon, 2004). Diking restricts access to major side channels and floodplain in the lower mile, at RM 2 at the Lazy C housing development. In the vicinity of RM 5 a mile-long side channel has been isolated from the main channel. Loss/destruction of side channels has a major adverse effect on spawning areas and overwintering areas for salmonids (Correa, 2003a; May and Peterson, 2003). Though splash damming, floodplain development, and bank armoring have contributed to extensive habitat loss and degradation at Lazy C, the reach immediately downstream has experienced only limited riparian logging and LWD removal from the active channel.

Wood removal from gravel bars is still occurring in the Brinnon Flat reach, and recent surveys indicate that the low amounts of wood occurring in this reach and in the immediately downstream estuarine reach of the mainstem are responsible for the girth of pool habitat and lack of complexity found in these reaches (Labbe et al., 2005).

4.1.6.6 Public Access (Map 21)

Dosewallips State Park provides access to 5,400 feet of Dosewallips River shoreline between the river estuary and RM 0.9. The 425-acre park extends southwest of the river and also includes marine shoreline. In addition to year-round camping, the park includes 5 miles of hiking and biking trails and extensive shoreline access (WSP, 2006).

4.1.6.7 Restoration Opportunities

Restoration opportunities in the Dosewallips reaches include opening up side channels and reconnecting floodplain habitat by removing bank armoring. A recent property acquisition by Jefferson County in the vicinity of the Lazy C development will allow for the creation of natural side channels. In the lower river estuary, Washington Trout is leading an effort to remove a dike, restore river-estuary connectivity, and improve tidal exchange in a blind tidal slough through culvert replacement. Meanwhile, Jefferson County, Washington State Parks, and the Port Gamble S'Klallam Tribe are collaborating to acquire and permanently protect privately owned, undeveloped riparian-floodplain properties from RM 1.2 to 2.1 (Labbe et al., 2005). As mentioned above, in the nearshore segment, there are opportunities in the lower Dosewallips and estuary to restore a natural estuary with side channels and salt marshes.

4.2 WRIA 17 - QUILCENE-SNOW

WRIA 17, located on the northeastern Olympic Peninsula, includes portions of Jefferson and Clallam Counties (Figures 4-2 and 4-3). It encompasses direct drainages to Puget Sound from Jimmycomelately Creek in the northwest to the Quilcene River in the south. The watershed also contains portions of Hood Canal and the Strait of Juan de Fuca, and the northeast flank of the Olympic Mountains.

Figure 4-2. WRIA 17 (north) in Northeast Jefferson County

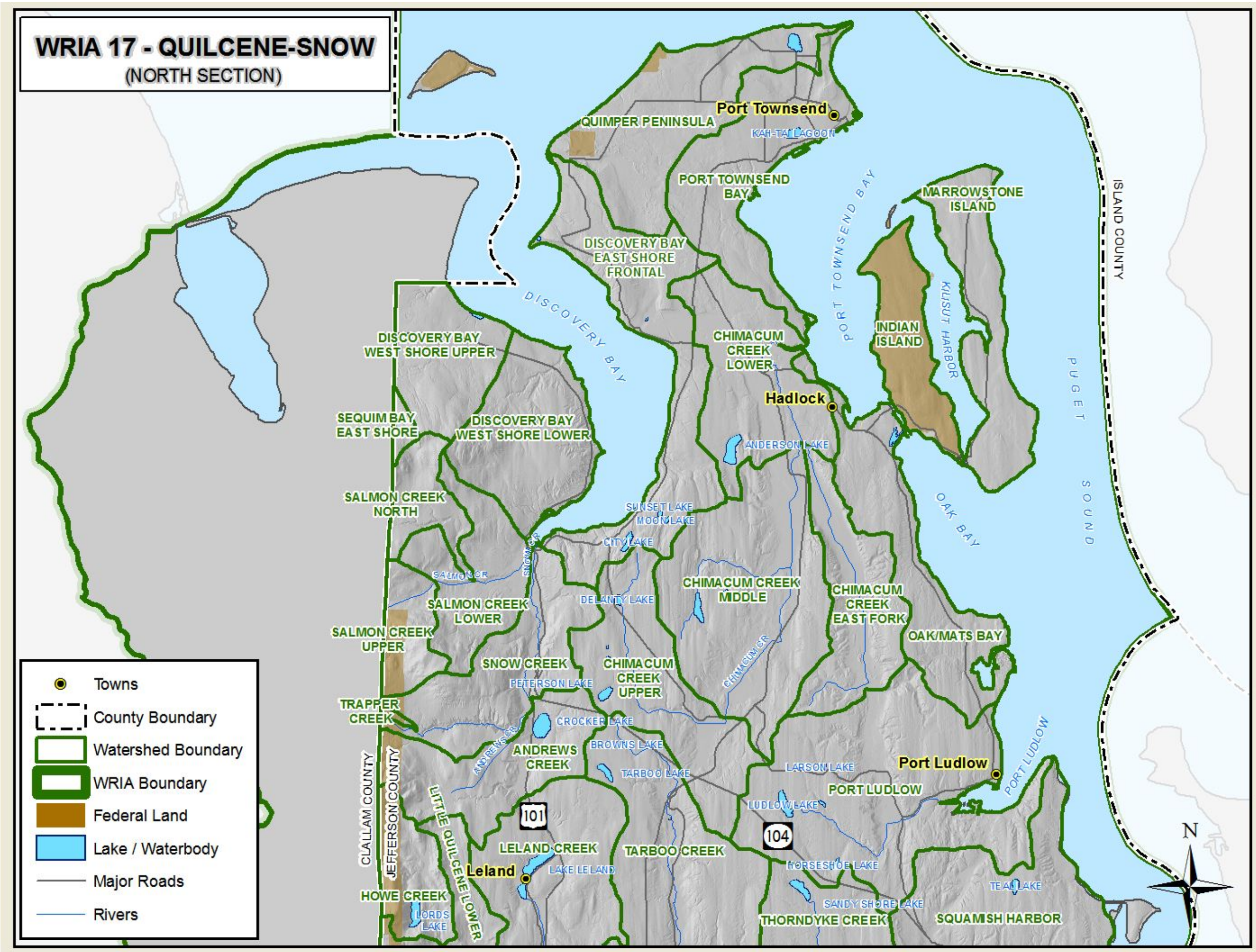
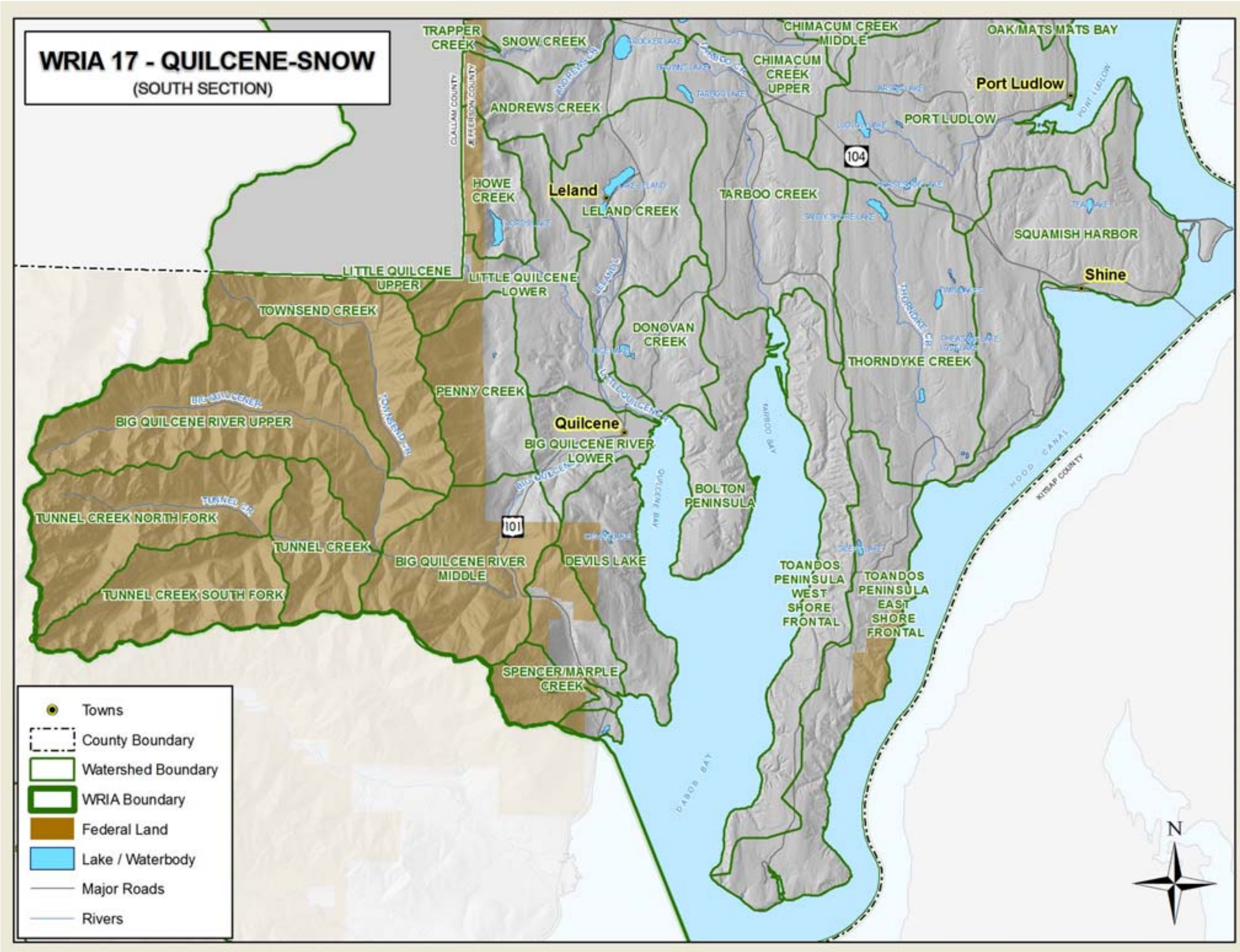


Figure 4-3. WRIA 17 (south) in Northeast Jefferson County



Glaciers shaped the terrain in this WRIA, which includes the steep slopes of the Olympic Mountains and coastal lowlands drained by high-gradient streams. Characteristic soils are deep to moderately deep loams and areas of silt and clay. Within WRIA 17, annual precipitation increases to the south and west. The Quimper subbasin on the eastern edge of the watershed receives 15 to 20 inches of rainfall annually, while the foothills of the Olympic Mountains in the western side of the watershed receive 70 to 80 inches annually. Precipitation also tends to increase as elevation increases. In lowland valleys, pasture vegetation is common, while at higher elevations alders and conifers predominate (Correa, 2002; Parametrix, et al., 2000).

Nearly 40 percent of the 256,783 acres in WRIA 17 is devoted to forestry, including national forests, commercial forest, and inholdings. The Big Quilcene, Salmon-Snow, and Dabob-Thorndyke subbasins have large forested areas. Rural residential is the second most common land use in WRIA 17, with nearly 70,000 acres. Agricultural lands occupy over 4,000 acres, many of which are in the Chimacum subbasin. The majority of the WRIA's commercial and industrial lands are in the Quimper subbasin, where Port Townsend is located. The U.S. Navy has an installation on Indian Island, part of the Indian-Marrowstone subbasin.

More than 70 percent of the WRIA is privately owned; the federal government owns 20 percent and state government owns the remaining 10 percent. Approximately 26,835 people lived in WRIA 17 as of 2003, many of them in Port Townsend, the main population center of the watershed. The population is projected to increase significantly. Estimates developed from the 2000 Census show 2015 populations ranging from 29,935 in the low-growth scenario to 38,197 under the high-growth scenario. Much of this increase is expected to occur in the Quimper subbasin, which includes Port Townsend, and the Ludlow subbasin, which includes Port Ludlow. Growth is also expected in the Chimacum subbasin (Cascadia Consulting Group, 2003).

4.2.1 Jackson Cove (Hood Canal West Shore Upper)

4.2.1.1 Overview (Map 1a)

This shoreline stretches from the head of Right Smart Cove to Point Whitney and encompasses Jackson Cove, Wawa Point, and Pulali Point. Unlike most of Jefferson County's marine shoreline, this area is dominated by a rocky basaltic shoreline with pocket beaches. Three drift cells occur within this section of shoreline along with several areas of no net drift. Highway 101 veers inland away from the shoreline over Mount Walker. This basin is less developed than others in the WRIA, with scattered residential areas, a Boy Scout camp, and the State Shellfish Lab at Point Whitney. Jackson Cove was identified in the Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment as a priority conservation area for its high-quality nearshore and terrestrial habitat (Floberg et al., 2004).

4.2.1.2 Nearshore Reaches (Map 9)

Reach K: From the head of Right Smart Cove to Wawa Point.

Reach L: Wawa Point to Point Whitney, including Point Whitney Lagoon, adjacent to Point Whitney State Shellfish Lab.

4.2.1.3 Physical Environment (Map 12, 14, and 26)

Along the eastern shore of Right Smart Cove, drift cell JE-23 extends from 200 meters west of Wawa Point 300 meters to the northwest to converge with drift cell JE-24 at the head of Right Smart Cove. Glacial drift overlies basalt at the cell origin, where a thin, coarse gravel beach sits atop a wide, basalt wave-cut platform. Wawa Point is composed of basalt and there is no net drift in this area for 660 meters (Johannessen, 1992). The major substrates of this cove are sand and gravel (Correa, 2002).

Drift cell JE-22 is isolated between areas of no net drift. It stretches for 900 meters along the western shore of Jackson Cove to terminate at the southern edge of the Spencer Creek delta. There is little sediment transported in this drift cell due to a lack of overlying sediment on the basalt (Johannessen, 1992).

Jackson Cove from Spencer Creek delta around Pulali Point is also an area of no net drift, with pocket beaches between basaltic headlands and a large alluvial fan at the mouth of Spencer Creek. This area is similar in character to many areas of the San Juan Islands.

One-half mile north of Pulali Point, drift cell JE -21 extends northward for 1.5 miles to end at the 100-yard-wide beach just north of the Point Whitney State Shellfish Lab (Johannessen, 1992).

4.2.1.4 Biological Resources (Maps 18, 20, 24, and 26)

Pacific herring spawn in eelgrass along the entire length of Right Smart Cove. Sand lance spawn on the beaches on the east side of Right Smart Cove. Riparian vegetation overhangs about 25 percent of the shoreline in this reach (WDNR, 2001; Penttila, 2000).

A large salt marsh lagoon situated behind the barrier beach at the head of Right Smart Cove is part of the Wawa Point bald eagle territory (Todd et al., 2006). The marsh supports native high marsh vegetation such as pickleweed and sea arrow grass (Correa, 2002).

Eelgrass is continuous and herring use the Wawa Point reach for spawning substrate (Penttila, 2000). Riparian vegetation covers about half of the shoreline (WDNR, 2001).

Marple and Jackson Creeks and Spenser Creek are found at the head of Jackson Cove. Marple Creek supports spawning populations of coho and chum salmon (Correa, 2002). Eelgrass is continuous throughout western Jackson Cove.

Spencer Creek supports spawning habitat for coho and chum salmon, searun cutthroat trout, and winter steelhead. Sand lance spawn on the beach near the Boy Scout Camp, east of Spencer Creek (Penttila, 2000). Patchy eelgrass beds grow offshore between Spencer Creek and Pulali Point, and a geoduck tract is found in the subtidal areas along this reach (Penttila, 2000 as cited in Correa, 2002). Osprey and bald eagles nest in the vicinity of Pulali Point, while all of Jackson Cove is bald eagle territory.

Herring spawn on the eelgrass from Wawa Point north to the middle of Jackson Cove and beyond to Pulali Point (Penttila, 2000), and oysters are continuous along this shoreline (Correa, 2002). Although riparian vegetation increases to about 30 percent in the north, it is absent in front of the State Shellfish Lab. There is a small wetland located behind a barrier beach 900 yards south of Point Whitney. The accretionary beach at northern end of this reach encloses a lagoon that has been highly altered for use by the shellfish hatchery at the State Shellfish Lab at Point Whitney (Correa, 2002; Ecology, 2001; Johannessen, 1992). However, the lagoon and the surrounding tidelands offer clam and oyster shellfishing. Sand lance and surf smelt spawn on the beach in front and to the north of the State Shellfish Lab.

Within Reaches K and L, between 10 percent and 14 percent of the planning area is wetland. The primary wetland classification is estuarine – intertidal (unconsolidated shore, aquatic bed, open water, and emergent).

4.2.1.5 Land Use and Altered Conditions (Maps 12 and 22)

<u>Land Use and Zoning</u>

Land use along the Jackson Cove shoreline is dominated by residential development. Within Reach K, 86 percent of the planning area is zoned Rural Residential. Remaining Reach K zoning includes Water. Within Reach L, 76 percent of the planning area is zoned Rural Residential. Remaining Reach L zoning includes Parks, Preserves, and Recreation areas.

Transportation and Utilities

Within the planning area of Reaches K and L, Jefferson County and WDNR have mapped 0.75 mile and 1.1 miles of road, respectively. Highway 101 passes within the planning area in Reach K, and portions of intersecting roadways (e.g., Bee Mill Road) pass within both Jackson Cove reaches.

Shoreline Modifications

The terminus of drift cell JE-23 in Right Smart Cove is bulkheaded with cement high in the intertidal. This does not appear to have led to a coarsening of beach sediment based on aerial photos (Ecology, 2001). Just south of the mouth of Marple Creek there is bulkheading and fill. Approximately 20 percent of drift cell JE-22 is armored (Hirschi et al., 2003). The shoreline in front of Camp Parson in Jackson Cove is completely bulkheaded. Historically, a small lagoon and salt marsh occurred at Camp Parsons; it has been largely filled (Todd et al., 2006). The area between Camp Parsons and Point Whitney is largely free of modifications except for a few docks and short bulkheads. The area around Point Whitney State Shellfish Lab is highly altered with bulkheading in front of the parking lot and a dike built across the lagoon to serve a now inactive shellfish hatchery.

4.2.1.6 Public Access (Map 21)

The only public shoreline access by land to this area is at the State Shellfish Lab at Point Whitney, with a beach and a boat ramp. There are WDNR tidelands just southeast of Camp Parsons with no current public access by land. However, this may be a site where public access can be obtained either through Boy Scout land or other private lands off of Pulali Point Road.

4.2.1.7 Restoration Opportunities

The removal of the bulkhead in front of Camp Parsons would afford better access to the beach for the Boy Scouts and create more of a natural backshore. The bulkhead currently protects few if any structures. The fill near the mouth of Marple Creek could be removed to improve net shore-drift. Restoration of the area surrounding Point Whitney could involve relocating the parking lot to an upland location, removing fill and the dike across the lagoon, and returning the spit and lagoon to a more natural state.

4.2.2 Quilcene Bay (Hood Canal West Shore Upper, Big Quilcene River, and Little Quilcene River)

4.2.2.1 Overview (Map 1a)

Quilcene Bay contains three drift cells and a large area of no net drift. There are forested headlands along much of the backshore and large mudflats in the northern end of Quilcene Bay. The sizable Little and Big Quilcene Rivers flow into northern Quilcene Bay through the town of

Quilcene, creating an extensive estuary at the head of the bay. A marina and shellfish hatchery associated with the town of Quilcene are situated on the northwest shore of the bay.

Clam and oyster harvesting are major businesses in this part of Jefferson County and Quilcene Bay is an important shellfish resource. Residential development is concentrated in the northwest and northeast shores of the bay. Located farther north than Brinnon (and thus farther into the rain shadow of the Olympic Mountains), Quilcene receives about 50 inches of precipitation a year.

4.2.2.2 Nearshore Reaches (Map 8)

Reach M: Point Whitney to Quilcene Boat Haven (now Herb Beck Marina), encompassing drift cells JE-19, JE-19/JE-20, and JE-20.

Reach N: Quilcene marina to the southern edge of the Indian George estuary.

Reach O: From Indian George estuary to the terminus of drift cell JE-18.

Reach P: North edge of Fisherman's Point Salt Marsh to the start of drift cell JE-17.

4.2.2.3 Physical Environment (Maps 11, 14, and 26)

Between Point Whitney and the Herb Beck Marina, two drift cells diverge from an area 0.5 mile south of Frenchmen's Point. This divergence zone contains actively eroding feeder bluffs of glacial drift intermittently overlying areas of basalt. Drift cell JE-20 originates in this area of divergence. Northerly fetch from Quilcene Bay creates southward net shore-drift for 1 mile to the confluence with drift cell JE-21 just north of Point Whitney. North of this divergent feeder bluff area, southern fetch governs the net shore-drift of sediment in drift cell JE-19 north to its terminus at the marina (Johannessen, 1992). A stream draining Devil's Lake also contributes fluvial sediment to this drift cell (Correa, 2002).

From the marina to a point approximately 1.3 km south of East Quilcene there is no appreciable net shore-drift (Johannessen, 1992). The marina, which is at the terminus of the drift cell (JE-19), was built on an existing spit; it has filled parts of the former upper intertidal beach with rock armoring. The mouth of the marina is fairly stable and has not needed dredging for decades.

Drift cell JE-18 begins just south of Fisherman's Point in a broad area of divergent drift at the base of the Bolton Peninsula. Governed by southern fetch, net shore-drift is northward for 2.6 miles along the eastern shore of Quilcene Bay. Its origin is at a poorly vegetated, eroding bluff composed of glacial drift. Northwestward net shore-drift is indicated by a northwestward bluff vegetation increase, northeastward spit progradation enclosing a salt marsh north of Fisherman's Point, northerly sediment size decrease, nearshore bars oriented northwest-southeast, and sediment accumulations on the south side of a filled area in northern Quilcene Bay. The cell's terminus is located at the base of this filled area, as shallow depths prohibit waves from forming that are large enough to cause significant amounts of sediment transport. Northern Quilcene Bay is slowly shoaling with sediment transported from the Quilcene River and Donovan Creek. The Big and Little Quilcene delta fans were formed by alluvial deposition over about the last 12,000 years (Todd et al., 2006). The bluffs along this drift cell are generally considered unstable with many recent landslides. Except for the area immediately surrounding Fisherman's Point, which is composed of Tertiary Sandstone, these bluffs are made up of Double Bluff Drift and undifferentiated glacial stratified sediment predating the Vashon Glaciation (Johannessen, 1992; Ecology, 1978). Quilcene Bay shoreline consists largely of protected and semi-protected sand flat and sand beaches (Correa, 2002).

In general, water quality in Quilcene Bay is excellent with the exception of the upper bay, which experiences intermittent fecal coliform problems. The northern part of Quilcene Bay is listed as a Category 5 water for fecal coliform contamination according to Ecology's 2004 Water Quality Assessment and is periodically closed to shellfish harvest. The Washington State Department of Health has a harvest advisory in effect for public shellfish harvest and some areas were conditionally closed to harvest from May 1 to October 1, 2005, in accordance with the conditional management (WDH, 2006a). Problems with fecal coliform contamination have been attributed in past studies to natural seal populations, animal keeping practices, and onsite septic systems (Parametrix et al., 2000).

4.2.2.4 Biological Resources (Maps 18, 20, 24, and 27)

Reaches M and N are in an area of few homes and steep eroding bluffs. Riparian vegetation is nearly continuous throughout this stretch of shoreline (Ecology, 2001). Patchy to continuous eelgrass beds occur throughout. Oysters and clams are continuous and a geoduck tract extends from just north of the lagoon at Whitney Point to just south of Frenchman's Point (Correa, 2002). Bald eagles also use this area as habitat. Surf smelt spawn along segments of the beach from Whitney Point to Herb Beck Marina (Long et al., 2005). Sand lance spawn north of Whitney Point and just south of the marina and most of this shore is a designated herring spawning area (Penttila, 2000; Long et al., 2005). Just north of this is a residential area along Linger Longer Road. Eelgrass is continuous along this reach and hard-shelled clams, Pacific oyster, shrimp and Dungeness crab are abundant.

The marina and surrounding shoreline is within 0.25 miles of an active bald eagle nest and territory. This area is also within a northern spotted owl territory, but several miles from a nest (WDFW Priority and Habitats Map database).

The delta of the Big Quilcene River, the Little Quilcene River, and Donovan Creek (Reach O) is an area of winding tidal channels and salt marsh (Correa, 2002). Eelgrass is continuous throughout the northern end of Quilcene Bay and herring use it for spawning (Penttila, 2000). Quilcene Bay is famous for its clams and oysters; there are several commercial and recreational shellfish harvesting areas within the bay. For example, the allowable, sustainable harvest of manila clams for the WDFW property on Linger Longer Road was about 39,000 pounds in 2003 (Speck, personal communication, 2003). In the winter, large concentrations of waterfowl are found in northern Quilcene Bay including trumpeter swans, brant, and diving ducks.

May and Peterson (2003) identify the Quilcene Bay NSE as a Category A salmonid refugia. The NSE includes the estuaries of the Big Quilcene River, Indian George Creek, Devil's Lake Creek, numerous small streams, and the nearshore areas linking these habitats.

Surf smelt spawn throughout drift cell JE-18, and sand lance spawn in a small stretch near the center of this cell (Long et al., 2005). A 2-acre salt marsh is enclosed by a spit just north of Fisherman's Point (Fisherman's Point Salt Marsh) (Leon and Driscoll, 1975; Ecology, 2000). This salt marsh and lagoon have remained similar to its form in the late 1800s (Todd et al., 2006). North of Fisherman's Point, eelgrass beds are continuous throughout the reach and herring use it for spawning (Penttila, 2000). The east shore of Quilcene Bay is a year-round haulout site and seasonal pupping site for harbor seals. Riparian vegetation is heavy through the reach (WDNR, 2001).

Within Reaches M and N, 10 percent to 15 percent of the planning area is wetland. Within Reaches O and P, 40 percent to 70 percent of the planning area is wetland. The majority of wetlands in all Quilcene Bay reaches are estuarine – intertidal (aquatic bed/unconsolidated shore, emergent, and unconsolidated shore).

4.2.2.5 Land Use and Altered Conditions (Maps 12 and 22)

Land Use and Zoning

Land use along the Quilcene Bay shoreline is dominated by residential development and commercial timber and agriculture uses. Within Reaches M, N, and O, 47 percent to 64 percent of the planning area is zoned Rural Residential (100 percent Rural Residential in Reach P). Remaining reach areas are zoned Commercial Forest (Reaches M and N), Commercial Agriculture (Reach O), Parks, Preserves, and Recreation, and Rural Forest. In the vicinity of the Boat Haven (Herb Beck Marina) shoreline use consists of several homes and several commercial buildings related to shellfish/aquaculture. The marina has a sewage pump-out and the upland toilets are on septic.

Transportation and Utilities

Within the Quilcene Bay shoreline planning area, Jefferson County and WDNR have mapped 4 miles and 4.5 miles of road, respectively. Along the eastern shoreline of the bay, East Quilcene Road parallels the shorelines of Reaches O and P, and is within the planning area across the majority of the reaches. Roads associated with the town of Quilcene are within the planning areas of Reaches N and O.

Shoreline Modifications

Shoreline alterations are concentrated near the marina, in east Quilcene, and in the area of no net drift in northern Quilcene Bay. North of Point Whitney, shoreline modifications are absent from the West Quilcene Bay reach. At the terminus of JE-19 the marina and residential and business areas to the north are extensively bulkheaded (WDNR, 2001; Ecology, 2001; Hirschi et al., 2003b). Bulkheads to the north encroach into the nearshore, encroaching upon vital shallow water habitat for migrating juvenile salmonids (Correa, 2002).

Linger Longer Road and a landing strip north of the marina eliminated some of the upper marsh and tidal channels (Todd et al., 2006). Some restoration has taken place in the Indian George Creek estuary by removing dikes, fill associated with a parking lot at a WDFW shellfish harvesting site, and an abandoned barge.

In the Quilcene estuary, diking has eliminated large amounts of high salt marsh, intertidal channels, and riparian vegetation, based on differences between the 1880s coastal surveys and current aerial photos (Correa, 2002) (see Todd et al., 2006 for further details). A large area of fill extends into the intertidal zone in East Quilcene Bay at the terminus of drift cell JE-18. This fill eliminates shallow water habitat. Despite this feature, drift cell JE-18 has retained fluvial function with little shoreline alteration south of its terminus (Ecology, 2001).

4.2.2.6 Public Access (Map 21)

Public access to Quilcene Bay is available by land at Point Whitney State Shellfish Lab, on Port of Port Townsend land off Linger Longer Road, at the public shellfishing site by Linger Longer Road (owned by WDNR with upkeep by WDFW), on WDFW property in the Quilcene delta, and at East Quilcene County Park. WDNR also owns the shoreline south of the Quilcene Boat Haven.

4.2.2.7 Restoration Opportunities

Restoration opportunities in Quilcene Bay are centered in the deltas of the Big and Little Quilcene Rivers. In the lower Big Quilcene River potential actions include removing dikes, restoring salt marsh habitat, and reconnecting the main river channel with tidal channels. Plans for this are currently being developed by the Hood Canal Salmon Enhancement Group and other partners. Between the Quilcene Boat Haven and Indian George Creek, the shoreline could be further restored using soft armoring techniques. Removing dikes on both banks could restore the estuary of the Little Quilcene River. East Quilcene Road interferes with natural backshore sediment processes and constricts Donovan Creek; this area could be enhanced if the road were reconfigured to allow for these processes. Acquiring and removing fill at the terminus of drift cell JE-18 would allow for natural deposition of sediment into northern Quilcene Bay and increase shallow water habitat.

Additionally, best management practices could be implemented to control stormwater and agricultural runoff, and to protect water quality from septic systems and marina and boating activity, to help maintain the shellfish industry.

4.2.3 Rice Lake (Hood Canal West Shore Upper)

Rice Lake is the only SMA-designated lake which drains directly to Quilcene Bay (Reach O).

4.2.3.1 Freshwater Reaches (Map 8)

Rice Lake: Approximately 1.5 miles north of the City of Quilcene, approximately 0.5 miles east of Highway 101.

4.2.3.2 Description

Rice Lake has a surface area of approximately 21 acres. Rice Lake drains to Quilcene Bay via Donovan Creek, which does not meet SMA criteria. Downstream of Rice Lake, Donovan Creek has high temperatures according to Ecology’s 2004 Water Quality Assessment. Rice Lake is not listed as impaired for temperature or other monitored parameters according to Ecology. The majority of the lake, and the entire perimeter of the lake, is mapped as lacustrine wetland by Jefferson County and NWI wetlands mapping. Rice Lake is presumed habitat for coho salmon, steelhead, and cutthroat trout.

Rice Lake is bordered by a relatively high number of residential lots. Current land uses are a mix of rural residential (Rural Residential 1:5 and Rural Residential 1:20 zoning) and managed forest (Rural Forest and Commercial Forest zoning). There is no public access to Rice Lake. Within the Rice Lake planning area, the only public road appears to be Rice Lake Road, which extends towards the lake from Highway 101 to the west. In addition, a significant utility corridor passes to the east of the lake, however is located approximately 800 feet away from the shoreline and is likely outside of the lake planning area.

4.2.4 Big Quilcene River (Big Quilcene River)

4.2.4.1 Overview (Map 1a)

The Big Quilcene River flows out of the Olympic Mountains, south of the town of Quilcene and into Quilcene Bay. The watershed is 69.5 square miles with a mainstem length of 19 miles and tributary length of 80 miles, with elevations up to 7,800 feet. The watershed experiences a relatively mild marine climate with an average annual precipitation of 61 inches (51 inches in Quilcene and at the river mouth; 76 inches in the upper watershed). Upper portions of the Big Quilcene watershed are protected by the ONP and USFS wilderness areas (Correa, 2002).

The City of Port Townsend maintains a 30 cfs water right to the Big Quilcene River. This water is diverted out of the basin at RM 9.4. The effect this diversion has on the overall hydrology and fish habitat quality is unknown (Correa, 2002).

4.2.4.2 Freshwater Reaches (Map 9)

Big Quilcene River 1: From the upper edge of the estuary to the fish hatchery at the confluence with Penny Creek (RM 2.8).

Big Quilcene River 2: From the fish hatchery to the National Forest boundary.

4.2.4.3 Physical Environment (Map 15, 22, and 27)

As the river leaves its bedrock channel at about RM 4, the streambed is composed of large boulders and cobbles that grade into gravel and sand as it approaches the mouth at Quilcene Bay (Simonds et al., 2003). Reaches on the Big Quilcene River appear to alternate between relatively straight, narrow reaches with little LWD and few secondary channels, and sinuous wide reaches with greater amounts of LWD and multiple channels (Klawon, 2004). The groundwater flow system is dominated by the presence of volcanic bedrock in the upper reaches of the subbasin with some alluvial or glacial deposits present along major streams. In the lower portions of the subbasin, glacial deposits and alluvium are extensive. At the mouth of the Big Quilcene River, these deposits compose the principal aquifer for many of the domestic wells in this area (Parametrix et al., 2000; Simonds et al., 2003).

Downstream of Highway 101, small conifers are scattered throughout a largely deciduous riparian zone at the pole/sapling stage. From Highway 101 upstream to Hiddendale, the riparian condition is degraded by rural development (Correa, 2002).

Within the planning area of Reach 1, land cover includes herbaceous rangeland/grassland (53 percent of total area), evergreen forest (21 percent), and mixed forest (12 percent). Within the planning area of Reach 2, land cover includes evergreen forest (63 percent) and mixed forest (21 percent).

Surrounding the Big Quilcene River, 22 percent to 30 percent of the planning area is wetland. Palustrine forested (53 percent) and palustrine scrub/shrub (42 percent) are the primary classifications of Reach 1 wetlands. Palustrine forested (75 percent) and palustrine scrub/shrub (25 percent) are also the primary classifications of Reach 2 wetlands.

Within Reach 2, from RM 2.8 to the residential development of Hiddendale at RM 3.2, the river channel migrates south to north with signs of beaver activity on the east valley wall. Some armoring and diking have occurred in this area.

The entire mainstem below Hiddendale (RM 3.2), with the exception of the section between Rogers Street Bridge and Highway 101, is lacking LWD due to removal for bank protection or firewood. Between RM 1.1 and the Highway 101 Bridge, LWD is accumulating, although overall levels are low. This section has good instream structure and side channel development. The riparian zone is also recovering (Correa, 2002) and the frequency of pools increases upstream to the National Forest boundary. Large boulders between Hiddendale and the falls at RM 7.8 provide some fish habitat. There is one small logjam within the canyon but no other significant LWD (Labbe, personal communication, 2002 as cited in Correa, 2002).

Two stretches of the lower Big Quilcene River in Reach 1 are impaired according to Ecology's 2004 Water Quality Assessment. The lower reach is a Category 5 water for temperature, and a Category 4c water for fish habitat. Contamination by fecal coliform bacteria has also been an issue in the lower reaches of the river. Ecology lists the downstream reach as a Category 2 water of concern for fecal coliform.

4.2.4.4 Biological Resources (Map 18)

The Big Quilcene is a Category C nodal corridor for salmonids (May and Peterson, 2003). The stretch from the mouth to about RM 1.1 supports spawning by fall chum, summer chum, Chinook and pink salmon and steelhead despite significant impacts from levee construction, water withdrawal (upstream), dredging, and other stream and shoreline modifications (May and Peterson 2003). The upper reaches are important rearing habitat for coho and steelhead.

4.2.4.5 Land Use and Altered Conditions (Maps 22 and 25)

<u>Land Use and Zoning</u>

Thirty-one percent of the watershed (the headwaters of the Big Quilcene River) is protected in the USFS Buckhorn Wilderness and the ONP. Downstream of this, most of the watershed is managed as commercial timberland. Jefferson County zoning indicates 93 percent of the watershed is Forestry (including public and private working timberland), 4 percent is Rural Residential, 0.2 percent is Agricultural, and 0.1 percent is Commercial (Correa, 2002). Within the planning area, Reach 1 is zoned 53 percent Rural Residential and 43 percent Local Agriculture, while Reach 2 is zoned 92 percent Rural Residential.

Transportation and Utilities

Within the planning area of the Big Quilcene River, Jefferson County and WDNR have each mapped 1.5 miles of road. Highway 101 is aligned within and around the Big Quilcene River planning area within both reaches. Additional intersecting roads associated with the town of Quilcene and vicinity are also located within the planning area. Roads are located within the floodplain from Rogers Street to Linger Longer Bridge (Todd, personal communication, 2006).

Shoreline Modifications

There are no natural barriers to anadromous fish below the National Forest boundary at about RM 4.0. However, the Quilcene National Fish Hatchery operates an electronic weir at RM 2.8. When this weir is in operation between September and December, it is a total barrier to upstream passage of fish. It is also a barrier during low river flows. In addition, the fish hatchery diverts water from the Big Quilcene River and also from Penny Creek, a tributary. This water intake structure permanently blocks fish access to Penny Creek, a potentially excellent refugium (Correa, 2002; May and Peterson, 2003).

Boundaries to the channel migration zone for the Big Quilcene River were identified as the USFWS hatchery; Highway 101 near the bridge; and along the south side of river in Quilcene, from the second dike west of Rogers Street to the east side of the BPA lines (Perkins and Klawon, 2004). From the mouth to RM 1.1, extensive diking and armoring isolate the river from its floodplain. This has also led to channel aggradation, which increased channel streambed elevation and extended the river mouth 1,700 feet into the estuary between 1971 and 1993. In sum, these modifications have led to a near complete loss of floodplain habitat (Correa, 2002), although the left bank dike at the river mouth was removed in 2005.

The reach of the river that flows by and through the National Fish Hatchery has been modified by riprap, water diversion, and an electronic fish weir (Correa, 2002). Upstream to the National Forest boundary the river flows past the Hiddendale residential development where there is some diking, riprap, and development in the floodplain. However, in general, the channel is allowed to migrate in this section.

Livestock access coupled with malfunctioning onsite septic systems have been considered to be the fecal coliform loading sources for the lower river reach (Parametrix et al., 2000).

4.2.4.6 Public Access (Map 21)

None identified.

4.2.4.7 Restoration Opportunities

Opportunities include restoring fish passage into Penny Creek around the fish hatchery water intake. Below RM 1.1, there may be opportunities to remove some of the extensive diking and channel-constricting fill. This would increase estuary function and salt marsh habitat, which are important for summer chum survival.

4.2.5 Lake Leland and Lords Lake (Little Quilcene River)

Two SMA-designated lakes are located in this area: Lake Leland and Lords Lake, which drain into the Little Quilcene River.

4.2.5.1 Freshwater Reaches (Map 9)

Lake Leland: Approximately 4.5 miles north of the City of Quilcene, immediately west of Highway 101.

Lords Lake: 0.6 mile north of Little Quilcene River 2.

4.2.5.2 Description

Lake Leland has a surface area of 108 acres. Leland Creek downstream of Lake Leland has high temperatures, although the lake is not listed as impaired for temperature according to Ecology's 2004 Water Quality Assessment. Sixty-four percent of the lake's shoreline planning area is mapped as wetland, with the primary wetland classification being lacustrine – limnetic (open water).

Lake Leland is presumed habitat for coho salmon, steelhead, and cutthroat trout, as well as bald eagle foraging territory. Growth of invasive weeds such as reed canarygrass and Brazilian elodea have contributed to habitat degradation and extremely low dissolved oxygen conditions in the summer (Correa, 2002). Lake Leland is a Category 4c water for invasive aquatic species according to Ecology's 2004 Water Quality Assessment.

Lake Leland is surrounded by moderately dense rural residential development (Rural Residential 1:5). There is public access to Lake Leland via a County boat launch and a County park that includes camping. Within the Lake Leland planning area, Jefferson County and WDNR have mapped 1.2 and 1.5 miles of road, respectively.

Lords Lake is a reservoir in the water supply system for the City of Port Townsend. Created by damming Howe Creek, the lake receives water from the Little Quilcene River. The City has a 9.6 cfs water right to the Little Quilcene River to fill Lords Lake. Water from the lake is used during times when water cannot be diverted from the Big Quilcene River for municipal use due to low flows or excessive suspended sediment. "Moderate" and "slight" landslide potential areas are mapped in 31.5 percent of the planning area. Approximately 47 percent of the Lords Lake planning area is mapped as wetland (primarily lacustrine – limnetic open water).

Lords Lake was created by the construction of a dam at the north end of the lake. The facility includes a lake inflow (from Little Quilcene River diversion) and an outflow (Port Townsend water supply) as well as a spillway. Forest and Rural Residential zoning surround the lake, and Jefferson County and WDNR have mapped 0.45 mile of road within the Lords Lake planning area. There is no mapped public access to Lords Lake.

4.2.6 Little Quilcene River (Little Quilcene River)

4.2.6.1 Overview (Map 1a)

The Little Quilcene River's headwaters are on the northern side of Mount Townsend in the northeast Olympic Mountains. The river flows generally southeast to empty into northern Quilcene Bay just north of the town of Quilcene. In contrast to other rivers flowing out of the northeast Olympic Mountains, only a small portion of the Little Quilcene's headwaters are protected in the National Park or National Forest designated wilderness. County jurisdiction begins at RM 6 at the ONF boundary. Downstream from there, the river flows through commercial timberland for roughly 2 miles and then through rural residential land, finally crossing about 0.5 mile of agricultural land just upstream from the mouth.

4.2.6.2 Freshwater Reaches (Map 9)

Little Quilcene River 1: River mouth to approximately RM 3.0.

Little Quilcene River 2: RM 3.0 to the ONF boundary.

4.2.6.3 Physical Environment (Maps 15, 22, and 27)

The Little Quilcene River flows over bedrock until about RM 3 where the streambed is composed of boulders and cobbles that grade into gravel and sand near the mouth at Quilcene Bay (Simonds et al., 2003). A moderate rate of groundwater recharge in the basin is largely controlled by the presence of bedrock and till, which cover approximately 62 percent and 27 percent of the basin, respectively. In the lower portions of the Little Quilcene River subbasin, recessional outwash and alluvium are extensive near the mouth of the Little Quilcene River, Leland, Donovan, and Jakeway Creeks. Similar to the Big Quilcene subbasin, these deposits may compose the principal aquifer for many of the domestic wells in this area (Parametrix et al., 2000, Simonds et al., 2003).

From the mouth to RM 1.3, the gradient is less than 1 percent and the channel is unconfined. The lower 0.2 mile is tidally influenced, and the channel is wide relative to the upstream segments due to the presence of beaver ponds. The channel is highly unstable and confined by dikes in this segment, and contains very few pieces of LWD. The substrate is predominantly sand and gravel. From RM 1.3 to 3.3, the channel is moderately confined and the gradient between 1 and 2 percent. The upper reaches hold more LWD, but pools are still infrequent. Channel substrate is predominantly gravel (Parametrix et al., 2002). Below RM 3.0, the riparian zone is dominated by young deciduous or mixed-species forest with numerous exotic species such as ivy, holly, blackberry, and reed canarygrass (Parametrix et al., 2000; Correa, 2002), so LWD recruitment potential is low. Between RM 2.7 and 5.2, percent pool habitat is poor at 23 to 25 percent. LWD is generally lacking; however, it appears that there is a potential for recruitment if the riparian zone can be preserved. The riparian zone is rather narrow but appears to have a high percentage of conifers (Correa, 2002).

Within the planning area of the Little Quilcene River, land cover includes evergreen forest (55 percent of total area) and mixed forest (27 percent). Shrub and brush rangeland, deciduous forest, herbaceous rangeland/grassland, recent clearcut, and pasture/hay represent the remaining land cover. Surrounding the Little Quilcene River, less than 1 percent of the planning area is wetland (palustrine open water).

There are no barriers to fish migration in the lower 6 miles of the river (Correa, 2002). LWD has been removed from the reach between the mouth and RM 2.7 (Reach 1). The riparian zone lacks conifer trees and has limited future LWD recruitment (Labbe, personal communication, 2002 as cited in Correa, 2002). There is less than one piece of wood per channel width throughout this segment. The lower 0.2 mile has good pool habitat but this habitat feature diminishes upstream (Correa, 2002).

In past years residential development and agriculture have been suspected as a source for the low-level fecal coliform measured in the Little Quilcene River (Gately, 1992 as cited in Parametrix et al., 2000).

4.2.6.4 Biological Resources (Maps 17 and 18)

Summer chum, fall chum, and coho salmon and winter steelhead trout spawn in the Little Quilcene River. This summer chum salmon run is part of the Hood Canal summer chum ESU. Both the fall and summer runs of chum have been extremely low in recent years, and both runs contain strays from the Big Quilcene hatchery (Correa, 2002). The coho run on the Little Quilcene is a distinct stock from that on the Big Quilcene with a significantly later run timing. Winter steelhead status and origin are unknown on the Little Quilcene (Correa, 2002).

The lower Little Quilcene was divided into three Nodal Riparian Corridors, all classified as Category B, by May and Peterson (2003). The first extends from the mouth to RM 0.8. This reach of stream has been heavily impacted by channelization, loss of floodplain habitat, levee construction, upstream water withdrawal, loss of LWD, forest conversion to agriculture and pastureland, gravel dredging, and residential land uses. The lower Nodal Riparian Corridor remains important spawning habitat for summer and fall chum salmon (May and Peterson, 2003). The Nodal Riparian Corridor from RM 0.8 to RM 3.0 also serves as spawning habitat for summer chum and other salmonids.

4.2.6.5 Land Use and Altered Conditions (Map 22 and 25)

Land Use and Zoning

Conversion of floodplain habitat to agriculture and pastureland has impacted the Nodal Riparian Corridor from RM 0.8 to RM 3.0. It is estimated that about 50 percent of the floodplain of the lower Little Quilcene has been developed (May and Peterson, 2003). Within the lower river reach (Little Quilcene River 1) planning area, 60 percent of land cover is rural residential and 24 percent is commercial forest. Within the upper river reach (Little Quilcene River 2) planning area, commercial forest (77 percent) and rural forest (13 percent) are the predominant land cover.

A total of 52 percent of the watershed is zoned Forestry, 17 percent Rural Residential, and 0.8 percent Agriculture (Correa, 2002)

Transportation and Utilities

The lower reach of the Little Quilcene mainstem between the mouth and RM 2.7 has 5.2 miles of road per square mile of watershed. Road density from RM 2.7 to RM 6.8 is 3.3 miles of road per square mile of watershed (Correa, 2002).

Within the river's planning area, Jefferson County has mapped 0.8 mile of road, and WDNR mapped 0.9 mile of road. Major roadways include Highway 101 to RM 2 and Lords Lake Loop Road above RM 2.

Shoreline Modifications

Between 6 cfs and 9.6 cfs of water are diverted from the Little Quilcene River for the City of Port Townsend's water supply into Lords Lake. This diversion is within the National Forest at RM 7.1; however it affects the downstream water flow within the County's jurisdiction. There is also an unscreened irrigation canal on the Little Quilcene River which is operated haphazardly, allowing coho, cutthroat, and steelhead juveniles access to the canal. These juvenile fish are then stranded upon closing of the intake or pumped through the irrigation systems and spread on agricultural fields (Davis, personal communication). Boundaries to the channel migration zone for the Little Quilcene River were identified as Highway 101, East Quilcene Road, Center Road, Brush Plant Loop, and the Avulsion Hazard Zone on both sides of Frank Beck Road (Perkins and Klawon, 2004).

4.2.6.6 Public Access (Map 22)

None identified.

4.2.6.7 Restoration Opportunities

In the middle reach of the Little Quilcene River, riparian plantings would provide shade and improve habitat where there is currently a lack of riparian cover. Floodplain acquisition and restoration could be completed to provide off-channel rearing opportunities for salmonids. In the lower reach, riparian planting would lead to increasing future LWD recruitment potential. In the delta and estuary, removing or pulling back dikes and levees would create channel sinuosity and connectivity. This action would also increase salt marsh habitat.

4.2.7 Dabob Bay (Hood Canal West Shore Upper)

4.2.7.1 Overview (Map 1a)

Dabob Bay is a long bay with relatively little development along its shores. Around the bay are steep, eroding feeder bluffs interspersed with low, forested bluffs. About 400 acres are protected as state-owned Natural Area Preserves, including the lower mile of Tarboo Creek and the coastal spits and adjoining upland forest (Bahls, 2004). Tarboo-Dabob Bay is at the center of The Nature Conservancy's priority conservation area in eastern Jefferson County (Bahls, personal communication, 2006). This area also appears to support the largest high quality salt marsh complex remaining in the Hood Canal and Straits region (Todd et al., 2006).

There are several spit and salt marsh complexes, including the estuary of Tarboo Creek at Dabob Bay's northern tip, Broad Spit, Tarboo Bay, the mouth of Camp Discovery Creek, and at Zelatched Point. These marshes are important stops for migrating juvenile summer chum salmon. Summer chum inhabit Tarboo-Dabob Bay for over three months, from late January through early May (Bahls, 2004). Tarboo Creek flows into Tarboo Bay and it supports runs of coho and fall chum salmon, as well as a small number of Chinook salmon.

Dabob Bay has some residential and vacation homes along its shores, primarily concentrated at Lindsay Beach, Camp Discovery, and Camp Harmony. The U.S. Navy uses Dabob Bay as a torpedo and submarine testing area, and a small base at Zelatched Point supports these operations. Overall this region maintains a rural natural character. As in Quilcene Bay, Dabob Bay is a major shellfish producing area.

4.2.7.2 Nearshore Reaches (Map 8)

Reach Q: From the center of the divergence zone between drift cells JE-17 and JE-18 to the terminus of drift cell JE-17 at Tarboo Bay barrier spits.

Reach R: Tarboo Bay north of the barrier spits and Long Spit.

Reach S: From the center of the JE-15/JE-16 divergence zone north along the west shore of Toandos Peninsula to the terminus of drift cell JE-16.

4.2.7.3 Physical Environment (Maps 11, 14, and 26)

As part of the Dabob-Thorndyke subbasin, this shoreline area receives a relatively high rate of predicted groundwater recharge, which is influenced by relatively high precipitation (averaging 39 inches per year) and extensive outwash deposits (Parametrix et al., 2000).

Dabob Bay is bounded by long drift cells on each side: JE-17 (5.9 miles) to the west, and JE-16 (13 miles) to the east. JE-17 originates on the southern Bolton Peninsula and has a general northward net shore-drift along the western shore of Dabob Bay to terminate at Tarboo Bay. It originates from a broad zone of drift divergence west of Red Bluff. This feeder bluff consists of red coarse-grained sandstone and conglomerate that is overlain by sandy glacial drift fronted by a poorly sorted beach. This steep bluff is poorly vegetated and has experienced recent slope failure. Evidence of northeast followed by northern drift includes the presence of red sand on the beach northeast of the red sandstone outcrop at the cell origin, northward sediment size decrease, northward progradation of Broad Spit, and the northeastward progradation of nearshore bars at the head of the bay.

Protected within the bars at the head of Dabob Bay is Tarboo Bay, composed primarily of mudflat and salt marsh lagoons and slowly filling with sediment supplied by Tarboo Creek (Johannessen, 1992; Bahls, 2004). Outside of the spits, Dabob Bay plunges to a depth of more than 500 feet (Bahls, 2004). The shoreline along the west side of Dabob Bay is generally considered unstable, except for low areas around Lindsay Beach and Broad Spit. The bluffs here are, in general, composed of a shallow layer of Vashon till overlying thicker layers of undifferentiated stratified sediments and a base of Double Bluff Drift. This bluff area is prone to failure and contributes abundant sediment to the nearshore (Ecology, 1978; Correa, 2002).

Reach S includes the longest drift cell in eastern Jefferson County, JE-16, with net shore-drift running northward for 13 miles from just north of Oak Head to Long Spit. The drift cell originates within the broad zone of divergence between Tskutsko Point and Oak Head. Northward net shore-drift is indicated by northward and northeastward stream mouth offset throughout the drift cell, northward spit progradation north of Camp Harmony, sediment accumulation on the south side of rock groins north of Camp Harmony, the erosional nature of the bluff at the southwest shore 1.3 miles north of Camp Discovery, the northward bluff vegetation increase north of this location, and the northward progradation of the mile-long spit (Long Spit) at the drift cell's terminus (Johannessen, 1992). Along this shoreline there are numerous areas of recent sliding and, except for some areas of low marsh and Long Spit, this area is classified as unstable. In general, the bluffs here are composed of a relatively thin layer of Vashon till, overlying Vashon advance outwash, and a large layer (several hundred feet) of undifferentiated stratified sediments on a base layer of Double Bluff Drift. Numerous slides mark the shoreline, including a spectacular slide between Long Spit and Camp Discovery that is roughly 120 yards high, 160 yards wide, and extends about 100 yards into the intertidal (Ecology shoreline photo #010522-111636). Just south of this slide are several homes perched on top of similar, steep, high bluffs (Ecology, 2001, 1978).

Within Dabob Bay Reaches Q and S, between 13 percent and 16 percent of the planning area is wetland. Within Reach R, 78 percent of the planning area is wetland. Estuarine – intertidal (aquatic bed/unconsolidated shore) is the primary wetland classification within all shoreline reaches.

4.2.7.4 Biological Resources (Maps 17, 20, 24, and 26)

Dabob Bay contains some of the most valuable and pristine nearshore habitat in Hood Canal and should be a top conservation priority for Jefferson County (May and Peterson 2003). Eelgrass beds are patchy or continuous throughout drift cell JE-17. However, they are absent from Tarboo Bay. Broad Spit has both commercial and recreational shellfish harvesting (Correa, 2002). There is also a bald eagle nest at Broad Spit. Broad Spit contains a salt marsh of about 2 acres. Sand lance spawn on the north side of the spit, and juvenile summer chum were found in the salt marsh and along the shore (Leon and Driscoll, 1976; Penttila, 2000; Bahls, 2004; Long et al., 2005). Habitat includes relatively small patches of salt marsh and drift logs around the mouth of the stream, and narrow fringes of marsh along the margins of the bay (Todd et al., 2006). Sand lance spawning has been documented at several sites north of Broad Spit in Reaches Q and R on the west side of Tarboo Bay (Long et al., 2005). Riparian vegetation appears to be healthy in these reaches along western Dabob Bay, except in areas where it is absent because of bluff erosion and isolated development (Ecology, 2001).

Eelgrass beds are patchy at the origin of drift cell JE-16, but with few exceptions are continuous along East Dabob Bay. Dabob Bay is a major breeding habitat for bald eagles with several recent nest sites documented in Reach S. Other priority species located in this reach include nesting great blue herons and nesting ospreys.

Camp Discovery Creek lagoon was found to harbor juvenile Chinook, coho, and chum salmon (Hirschi et al., 2003a). This watershed also supports coho and chum salmon spawning (Correa, 2002). May and Peterson (2003) identify all of Dabob Bay as a NSE salmonid refugia. Both the east and west bay are classified as Category A refugia. The NSE includes the full bay, plus many small coastal streams and Camp Discovery Creek.

Dabob Bay is one of the top oyster seed growing areas in the world (May and Peterson 2003). Forage fish spawn in numerous locations along this drift cell, including areas along Long Spit, south of Camp Discovery, and north of Tabook Point (Long et al., 2005).

A salt marsh lagoon at the mouth of a presumed salmon stream occurs just north of Zelatched Point (Correa, 2002). This habitat complex consists of a barrier spit that partially envelops two tidally connected lagoons and associated marsh. Small freshwater streams enter both lagoons, and a sizable deltaic fan occurs where a channel enters Dabob Bay (Todd et al., 2006).

The barrier spit at the head of Tarboo Bay and Long Spit are home to rare plant communities of native salt marsh and berm plants. It is identified as one of the best spit habitats with native vegetation in Washington State and is currently protected by the WDNR's Natural Heritage Program. The spit is jointly owned by the WDNR and The Nature Conservancy. The adjoining lagoons were seined for fish use by Peter Bahls of the Northwest Watershed Institute in 2003, and were found to harbor significant numbers of juvenile Chinook, summer and fall chum, coho, and cutthroat trout (Bahls, 2004).

Tarboo Creek runs into the head of the bay and supports coho, Chinook, and chum salmon spawning, as well as searun and resident cutthroat trout and steelhead (Bahls, personal communication, 2006). A small number of Chinook adults were observed spawning in the lower mile of Tarboo Creek between 1994 and 2003. The population may have originated from a release of hatchery smolts in the early 1990s, but is believed to be naturally reproducing at this point (Bahls, 2004). The lower mile of the stream has an intact riparian corridor with conifer and deciduous mixed forest throughout the floodplain, and is owned by WDFW (Correa, 2002). For this reason the Tarboo Bay estuary, spit, and lagoon complex should also be afforded County protection as a natural shoreline.

Low summer flow has been identified as a factor that limits coho salmon production in Tarboo Creek, but if estimates are correct, it is unlikely that consumptive use of groundwater has materially influenced streamflow. There are consumptive use rights for surface water totaling 2.31 cfs, and claims of 2.96 cfs. If actual use approaches the claimed volume, it could significantly influence summer low flow (Parametrix et al., 2000).

4.2.7.5 Land Use and Altered Conditions (Maps 11 and 21)

<u>Land Use and Zoning</u>

Land use along the Dabob Bay shoreline is zoned primarily for Rural Residential development. Within all reaches, 75 percent to 88 percent of the planning area is zoned Rural Residential (this varies by reach). Remaining reach areas are zoned Commercial Forest, Local Agriculture, Parks, Preserves, and Recreation, and Military Reservation.

Transportation and Utilities

Within the Dabob Bay marine planning area, Jefferson County and WDNR have mapped 1.8 miles and 2.3 miles of road, respectively. Roads providing access to rural residential areas and the marine shoreline are intermittent within the planning areas of all reaches.

Shoreline Modifications

Lindsay Beach on the west shore and several areas north of Tabook Point on the east shore are relatively heavily armored (60 percent at Lindsay Beach). These are pockets between pristine and relatively untouched shoreline. There are several houses perched on top of eroding bluffs, and there may be pressures to protect the toe of the bluff from erosion (e.g., the residence in Ecology photo #010522-110544). In general, however, fluvial processes appear to be healthy in western Dabob Bay, with shoreline armoring concentrated in areas without bluffs and that are not likely contributing much sediment to the nearshore. Areas without bluffs were about 11 percent armored (out of a total of 13 km). Only approximately 2 percent of the high or low bluff areas were armored (out of a total of 23 km) (Hirschi et al., 2003b).

Along the eastern shore of the bay, drift cell JE-16 is 6 percent armored out of 19 km of total length (Hirschi et al., 2003b). Some of these structures may interfere with the longshore transport of sediment, particularly a set of groins south of Camp Discovery. About 11 percent of the historical marsh at Zelatched Point Lagoon has been lost, mostly in the far west side near the origin of the spit as a result of filling for a parking area and helicopter pad (Todd et al., 2006).

4.2.7.6 Public Access (Map 21)

At the head of Tarboo Bay there is public WDFW land. There is boat access to Broad Spit, with WDNR tideland containing extensive shellfish beds, and County-owned uplands. There are WDFW public tidelands on the east shore of the bay north of and adjacent to Camp Discovery, and another north of Tabook Point. Between the Navy property at Zelatched Point and Fisherman’s Harbor, South Toandos State Park includes the beaches along this shoreline, but no upland access.

4.2.7.7 Restoration Opportunities

Restoration opportunities are somewhat limited. There are existing shoreline structures that interfere with longshore transport of sediment and may alter migration pathways used by juvenile salmon. These structures could be replaced with soft bank armoring. The protection of high-quality habitat, including forage fish spawning beaches and the bluffs that supply these beaches, should be a high priority.

4.2.8 Tarboo Lake, Sandy Shore Lake, and Wahl Lake (Hood Canal West Shore Upper)

4.2.8.1 Freshwater Reaches (Map 9)

Tarboo Lake: 5.5 miles to the north of Tarboo Bay’s northern boundary, adjacent to the headwaters of Tarboo Creek.

Sandy Shore Lake: Approximately 1.5 miles to the west of the intersection of Highway 104 and State Route 19, at 47°53’26”N and 122°46’00”W.

Wahl Lake: Approximately 2.2 miles to the west of northwest extent of Squamish Harbor, at 47°51’50”N and 122°44’22”W

4.2.8.2 Description

Generally, there is limited information on lakes in this area. Tarboo Lake is located between Highway 104 and Lake Leland within commercial forestland. It has no outlet and a surface area of 20.3 acres. Land use in the Tarboo Lake planning area is dominated by commercial forest activities. Ninety percent of the planning area is zoned Commercial Forest. Agricultural practices in the Tarboo Bay basin are a primary source of fecal coliform in Dabob Bay (Parametrix et al., 2000).There has been no recent timber cutting adjacent to the lake. Public access is provided by a WDFW-owned boat ramp at the end of Tarboo Lake Road. It is a popular trout fishing lake.

No significant geologically hazardous areas or aquifer recharge areas are mapped within the Tarboo Lake planning area. The lake is mapped with lacustrine – limnetic (open water) wetland over 66 percent of the planning area.

Tarboo Lake is mapped with less than 200 feet of road by both Jefferson County and WDNR. Mapping indicates the lake access point at the end of Tarboo Lake Road.

The area surrounding Sandy Shore Lake is commercial timberland. South of the lake there is a recent timber cut as determined from aerial photography. The planning area of the lake is zoned Commercial Forest. Sandy Shore Lake is presumed coho, cutthroat, and steelhead habitat (Correa, 2002). Pope Resources owns the property surrounding Sandy Shore Lake, and allows conditional recreation use of their land at both locations. Less than 200 feet of road are mapped by WDNR at Sandy Shore Lake, and Sandy Shore Lake Road ends on the west shore of the lake within the planning area.

Wahl Lake is south of Highway 104 near Shine. Its surface area is 21.6 acres. Surrounding the lake, 54 percent of the planning area is mapped as wetland, with palustrine scrub/shrub and open water the primary wetland classifications. Wahl Lake is home to several rare wetland plants and plant assemblages. It is one of several isolated lakes in the Thorndyke Creek/Shine area.

Wahl Lake is located on commercial timberland owned by Pope Resources, and the surrounding area has experienced recent logging. Pope Resources allows conditional recreation use of their land at this location. The planning area of the lake is zoned Commercial Forest with a Mineral Resource Lands Overlay. Fred Hill Materials gravel mine operates adjacent to Wahl Lake. This gravel mine, permitted in 2005, allows the proposed 137-acre extraction area to be mined sequentially, in segments ranging in size from 12 to 15 acres (JCDCD, 2005). Less than 200 feet of road are mapped by WDNR at Wahl Lake.

4.2.9 Southern Toandos Peninsula, Thorndyke Bay, and Squamish Harbor (Hood Canal West Shore Upper)

4.2.9.1 Overview (Map 1a)

This Hood Canal shoreline faces Kitsap County. The uplands are relatively low glacial deposits. There are long stretches of pristine shoreline south of the Thorndyke Creek estuary, which is one of the finest examples of an unaltered estuary in Jefferson County. The Nature Conservancy has identified this area as a priority conservation area. There are three drift cells along this shoreline.

The southwestern shore of Squamish Harbor has little development and is generally in pristine condition. Shine Creek enters the harbor at its head after flowing through a large estuarine wetland. Near the head of the harbor and along its northern shore (Shine) there is moderately dense residential development. East of Shine there is an area of massive erosion that threatens several structures on the top of the bluffs.

4.2.9.2 Nearshore Reaches (Map 9)

Reach T: From center of divergence between drift cell JE-15 and JE-16 to terminus of drift cell JE-15 at Hazel Point.

Reach U: Drift cell JE-14, Hazel Point to center of divergence zone JE-13/JE-14.

Reach V: Toandos Peninsula along Hood Canal, from the center of divergence zone JE-13/JE-14, including drift cells JE-13 and JE-12, to the terminus of drift cell JE-12 at Squamish Harbor.

Reach W: Drift cell JE-11, including areas inside the spit at the head of Squamish Harbor that are part of the extensive estuary of Shine Creek.

4.2.9.3 Physical Environment (Maps 11, 12, 14, 15, 26, and 27)

The Dabob-Thorndyke subbasin receives a relatively high rate of precipitation (averaging 39 inches per year), and is characterized by high levels of groundwater recharge. Principal aquifer materials in the Shine area are composed of pre-Vashon stratified glacial drift and interglacial deposits. In addition, Vashon advance outwash materials may be saturated in places. Exposures of principal aquifer materials are present along the incised channels. Recessional outwash and alluvial materials have subsequently filled in portions of the channels (Parametrix et al., 2000).

Reach T begins in a zone of divergence that encompasses sediment sources for drift cells JE-16 and JE-15. The first drift cell in this reach, JE-15, has its origin at the broad zone of divergence between Tskutsko Point and Oak Head. Sediment is derived from bluffs cut into sandy glacial drift of the Double Bluff formation, pre-Vashon Stade sediments, and Vashon till. Net shore-drift is to the southeast past Oak Head and northeast to Hazel Point where the drift cell terminates at the end of a cuspate spit. Net shore-drift is indicated by northeastward progradation of the bay mouth spit across the mouth of Fisherman’s Harbor, and progradation of the cuspate spit at Hazel Point. It is thought that much of the sediment is lost to deep water (70 to 90 yards deep) immediately off of the point (Johannessen, 1992). This shoreline is generally considered unstable with numerous recent landslides (Ecology, 1978).

Reach U encompasses drift cell JE-14, which begins 2.25 miles northwest of Hazel Point. Drift cell JE-14 has a net shore-drift to the southeast to terminate at Hazel Point. Drift here is governed by a northerly fetch of up to 17 miles causing southward and southeastward net shore-drift. Evidence of southward drift includes the buildup of sediment on the north side of boat ramps, southward stream mouth offset, and the progradation of Hazel Point (Johannessen, 1992). Bluffs in this drift cell and in the zone of divergence to the north are considered unstable with several recent landslides. These bluffs are of similar composition to others on the Toandos Peninsula: Vashon till overlying thicker layers of Possession Drift, older, undifferentiated stratified sediments, and Double Bluff Drift (Ecology, 1978).

Reach V originates from the same zone of divergence as JE-14, located 3.6 km north of Hazel Point, and encompasses drift cells JE-13 and JE-12, terminating at the head of Squamish Harbor. Within drift cell JE-13, net shore-drift is generally northeastward for 17 km to terminate at the northern tip of the South Point Spit. Drift cell sediment is initially derived from exposed bluffs cut into sandy glacial drift and streams that are found intermittently along the cell. Northward and northeastward net shore-drift to Thorndyke Bay is indicated by northward offset of two small deltas located 1 and 2 miles south of Brown Point, nearshore bars oriented northeast-southwest that are moving northward in the southern portion of the cell, progradation of two looped bars (that bear a superficial resemblance to a cuspate spit but are much more blunt) from uplands, which project seaward slightly, and the northward stream mouth offset on these features (Johannessen, 1992).

Within marine Reaches T, U, and V, 7 percent to 17 percent of the planning area is wetland, with estuarine – intertidal the primary wetland classification.

Just north of the Thorndyke estuary, several homes sit on top of eroding bluffs (Ecology, 2001). This is an area of frequent slides that contribute abundant sediment to this long drift cell. The shoreline is characterized by areas of heavy riparian vegetation between the eroding bluffs (Ecology, 2001; WDNR, 2001). Water quality in Thorndyke Bay is generally considered good (Parametrix et al., 2000).

The long and narrow South Point Spit was formed by sediment transport from an extensive drift cell from the south. The habitat complex historically supported fringing tidal marsh and lagoon habitat protected behind the spit (Todd et al., 2006). Historically, net shore-drift continued north of here to terminate at the head of Squamish Harbor (where JE-12 now terminates). However, dredging the entrance of the marina at Bridgehaven and the jetty to the north of this entrance have interrupted continued net shore-drift to the north (Hirschi et al., 2003b; Johannessen, 1992).

Immediately to the north of the jetty at the entrance to Bridgehaven Marina begins drift cell JE-12. This drift cell continues north for about 2 miles terminating at the head of Squamish Harbor, near the mouth of Shine Creek. The spit at the origin of the cell used to be prograding to the north, but this seems to have ceased and the spit has now become detached from the mainland due to the reduction of sediment reaching it, possibly resulting from the shoreline alterations at Bridgehaven (Johannessen, 1992) and the jetty that marks the entrance to the marina. Northward net shore-drift in this part of Squamish Harbor is indicated by northward beach increase (north of the spit), sediment accumulations on the south side of several large trees lying across the beach, and the northward progradation of the small spit 300 yards south of the terminus of the cell (Johanessen, 1992).

The northern shore of Squamish Harbor (Reach W) is bounded by drift cell JE-11 which encompasses net shore-drift for 2 miles from the large glacial drift bluff 0.5 mile southwest of the Hood Canal Bridge to the head of the harbor, converging with drift cell JE-12. Abundant sediment is derived from a high bluff west of Termination Point composed of various layers of glacial sediment. A house is perched precariously on the top. This shoreline is classified as unstable recent landslide (Ecology, 1978). Net shore-drift to the west is indicated by sediment accumulations on the east side of obstacles and the westward prograding spit at the mouth of Shine Creek.

Within marine Reach W, 27 percent of the planning area is wetland, with estuarine – intertidal (53 percent) and palustrine forested/emergent/scrub-shrub (46 percent) the primary wetland classifications. Sandy Shore Lake is in the upper Thorndyke Creek watershed. Its surface area is 34.9 acres. Surrounding the lake, 66 percent of the planning area is mapped as wetland, with lacustrine – limnetic (open water) the primary classification.

4.2.9.4 Biological Resources (Maps 17, 18, 20, 26, and 27)

Major habitat features along drift cell JE-15 include a brackish marsh just northwest of Oak Head, Fisherman’s Harbor estuary and mudflats, and a salt marsh enclosed by Hazel Point. Two small drainages into Fisherman’s Harbor support chum and coho spawning (Correa, 2002). Bald eagle territory includes the area between Tskutsko Point and Oak Head and the area between Fisherman’s Harbor and Hazel Point. Several bald eagle nests are located in this vicinity. Riparian vegetation covers 60 to 80 percent of this shoreline; eelgrass beds are patchy to continuous throughout (WDNR, 2001).

Salt marshes occur at Hazel Point and behind a longshore spit 1.7 km to the north (Southeast Toandos Lagoon) (Todd et al., 2006). A surface channel connection is evident between the lagoon and adjacent nearshore waters. It appears that the lagoon receives freshwater inputs from a ditch draining a large lawn area located immediately upslope, and possibly through a narrow forested ravine to the northwest. The native vegetation surrounding the complex to the south has apparently been removed but native conifers occur to the west and north (Todd et al., 2006). This marsh may have been encroached upon from the north by the development of a road and boat ramp. Sand lance spawn just south of this salt marsh; surf smelt also spawn farther north in the zone of divergence between JE-14 and JE-13 (Long et al., 2005). Riparian vegetation is abundant throughout this drift cell except in a few areas of development and bluff face sliding (Ecology, 2001). Eelgrass is patchy in the northern section of this drift cell and largely absent toward the south. There is a bald eagle nest located north of Hazel Point.

Eelgrass beds are patchy throughout the length of drift cell JE-13. In general the East Toandos shoreline reach retains function, with undisturbed feeder bluffs interspersed by lower banks covered in healthy riparian vegetation. There is little shoreline alteration to interrupt alongshore drift. Numerous barrier spit salt marshes, often associated with small stream mouths, occur primarily on Navy property, between the origin of the cell and Thorndyke Bay (Ecology, 2001). There are several bald eagle nests in the vicinity of Brown Point. Sand lance spawn in several locations north and south of Brown Point including on the alongshore spit formations mentioned above (Penttila, 2000; Long et al., 2005).

The Thorndyke Bay shoreline is one of the least developed areas on Hood Canal and as result is considered one of the top priorities for estuarine conservation in the Puget Sound region (May and Peterson, 2003). Thorndyke Creek estuary is an example of an intact estuary of a mid-sized stream, which is relatively rare in the Puget Sound basin. It is unique for several reasons, including a lack of road crossings, little residential development, and beaver dams in the lower reaches of the stream down to the high-tide line (Correa, 2002; Hirschi, personal communication, 2001). It has a large (32-acre) marsh and mudflat complex enclosed by a barrier beach (Leon and Driscoll, 1975). Spartina, an invasive cordgrass, had established and spread over large areas of the mudflats by early 2000, but persistent eradication efforts by the Washington State Department of Agriculture have been successful (WSDA 2007). Bald eagles and osprey nest in this area. May and Peterson (2003) identify the Thorndyke Creek estuary as a Category A NSE refugia for salmonids. Thorndyke Bay is also a regionally significant overwintering site for waterfowl.

Low summer flow, which may be related to consumptive use of groundwater, has been identified as a factor that limits coho salmon production in Thorndyke Creek. There are consumptive use rights for surface water totaling 2.31 cfs, and claims of 2.96 cfs. If actual use approaches the claimed volume, it could significantly influence summer low flow (Parametrix et al., 2000). Despite a history of logging activity in the watershed and apparent log storage in the estuary, the general extent and configuration of major habitat features are similar to historical conditions. The overall connectivity of the Thorndyke Creek estuary appears relatively unimpaired (Todd et al., 2006).

Sand lance spawn just north of the Thorndyke estuary (Penttila, 2000; Long et al., 2005). Nordstrom Creek runs into Hood Canal just south of South Point; its mouth is marked by a small salt marsh of the type favored by juvenile salmonids, and coho and steelhead spawn upstream (Hirschi, personal communication, 2004; Correa, 2002). There are few houses in this area, which appears to be a well functioning ecosystem.

Despite shoreline alteration in the South Point area, sand lance spawn both south of South Point and north along the outside of the spit. Surf smelt spawn on the shore just north of the spit (Penttila, 2000; Long et al., 2005).

Behind Bridgehaven in a slough dredged for a marina, juvenile salmonids were not found, whereas they were found immediately to the north in the relatively unaltered backshore of the spit at the origin of drift cell JE-12. The southern part of drift cell JE-12, from the origin to the small point about 1.25 miles to the north, has healthy riparian vegetation (100 percent) often with large trees growing over the intertidal zone. This may be because this area is somewhat protected from southern fetch (Correa, 2002; WDNR, 2001). In the nearshore, eelgrass beds are continuous along the outside and the inside of the South Point Spit and patchier farther north to the point mentioned above. The characteristics of this reach are unique. A small stream enters Squamish Harbor near the middle of this drift cell and is presumed cutthroat trout habitat (Correa, 2002).

Development increases in the northern end of the drift cell to the head of the harbor, and riparian vegetation decreases to cover about 20 percent of the shoreline (WDNR, 2001). Eelgrass beds are patchy throughout with barnacles and *Ulva*. There is also a bald eagle nest in this area.

At the terminus of this drift cell is the Shine Creek estuary, with an extensive salt marsh totaling 85 acres with about 5 acres of intertidal habitat. Shine Creek supports chum and coho salmon and cutthroat and steelhead trout spawning. The wetlands are also important rearing habitat for natal and non-natal juvenile pink, chum, coho, and Chinook salmon (Hirschi et al., 2003a).

May and Peterson (2003) identify Squamish Harbor and the Shine Creek estuary as a Category A NSE salmonid refugia. The intertidal marsh, mud flat, sand pit and other features of the harbor and estuary provide habitat diversity that increases their ecological value. The NSE refuge provides highly productive rearing habitat for salmon and other species.

With the exception of the area in front of the feeder bluff, eelgrass is continuous in the eastern half of drift cell JE-11 and patchy in the western end. Riparian vegetation is sparse along this reach, never covering more than 10 percent of the shoreline. This is primarily due to clearing for views in front of the many houses along this stretch of shoreline (Ecology, 2001). Sand lance spawn along the western end of this reach (Reach W) and herring spawn in the eelgrass beds offshore (Penttila, 2000; Long et al., 2005).

4.2.9.5 Land Use and Altered Conditions (Maps 11, 12, 21, and 22)

Land Use and Zoning

The dominant land use in this area is commercial timberland. Areas of shoreline residential use are concentrated at the southern end of the Toandos Peninsula, south of the Thorndyke estuary, South Point, and Bridgehaven. Within all marine reaches, between 50 percent and 100 percent of the planning area is zoned Rural Residential. Other significant planning area zoning includes Military Reservation and Commercial Forest.

Transportation and Utilities

Throughout the marine planning area, Jefferson County and WDNR have mapped 14 miles and 28 miles of road, respectively. Mapped roads are focused around areas of higher population density, including Fisherman's Harbor at the south end of Toandos Peninsula, Thorndyke Bay, South Pt/Bridgehaven Marina, and Squamish Harbor near Shine. Planning areas of Reach U and the majority of Reach V are largely without roadways.

Shoreline Modifications

There is no shoreline armoring of note along drift cell JE-15. However, there are several docks and overwater structures in Fisherman's Harbor, some in disrepair (Ecology, 2001).

Just north of Hazel Point a residential bulkhead extends into the upper intertidal zone, possibly interfering with longshore transport of sediment to the point. This house is also set on the very seaward edge of the bulkhead. Otherwise drift cell JE-14 is minimally altered. The feeder bluffs in the zone of divergence between JE-14 and JE-13 are not armored. JE-13 is subject to only minor bulkheading until the broad point 1,600 meters south of the Thorndyke Creek estuary. There are several extensive bulkheads and a private gazebo or deck structure on the backshore.

The forested uplands surrounding the Thorndyke Creek estuary have been logged at least once, and apparently the lagoon itself was used to store and transport logs. Fencing occurs in parts of the estuary, suggesting the area was once used for pasture (Todd et al., 2006). Between the Thorndyke estuary and South Point there are no bulkheads or shoreline alterations of note. Just south of the old South Point ferry dock, several bulkheads extend into the upper intertidal.

From South Point ferry dock (now abandoned) northward through the Bridgehaven development the shoreline is severely altered. The entire outer shoreline of the spit has been armored with riprap or concrete bulkheads, while the complete interior side of the spit has a wooden seawall with backfill. In addition, the former salt marsh has been dredged to provide space for the marina. The access road to Bridgehaven constricts tidal exchange to the little salt marsh that remains. There is a riprap jetty north of the entrance to the marina that stops longshore transport of sediment. Developments on the spit complex at the terminus of drift cell JE-13 have severely altered the deposition zone of this drift cell. The former ferry terminal at South Point also interrupts longshore transport of sediment (Correa, 2002).

Due to the armoring of the South Point reach shoreline, a coarsening and eroding of the beach has occurred along the southern half of Bridgehaven. This has likely decreased the fine sediments needed by forage fish for spawning (Hirschi et al., 2003b).

Shoreline armoring is absent from the southern end of drift cell JE-12, while roughly 30 percent of the northern portion of the drift cell is armored (Hirschi et al., 2003b). This armoring may interfere with longshore transport of sediment and beach substrate composition. Fill and several culverts under Shine Road that modify and restrict flow were replaced with a full-span bridge in 2005 (Davis, personal communication, 2006) with the intent of increasing tidal exchange to the upper estuary.

Shoreline armoring is prevalent along the north shore of Squamish Harbor, with about 26 percent of this reach armored (Hirschi et al., 2003b). Two boat ramps, one at a County park, extend into the intertidal, with parking lots located on fill. A considerable portion of the lower Shine Creek estuary salt marsh has been filled for residential development, probably beginning in the 1960s (Todd, personal communication, 2006). There are several large riprap bulkheads covering the bluff in front of residences. At the terminus of drift cell JE-11 in the depositional zone, there are several cement bulkheads that may have limited usefulness since erosion is not a major issue at this location. Sediment for this drift cell primarily comes from the large feeder bluff west of Termination Point. Erosion and landsliding are inherent features of this area (Ecology, 2001).

4.2.9.6 Public Access (Maps 21 and 22)

South Toandos State Park provides boat access at Oak Head. Brown Points WDNR tidelands are accessible by boat. The possibility of upland access to this area through Pope Resources land or Navy property should be explored.

Case Shoal offshore in the southern part of Squamish Harbor, only exposed at low tide, is owned by the WDNR and is open to recreational shellfishing. The WDNR timberland north of the spit on the west side of the bay is open to public access; however there are no facilities or improvements. Hicks County Park on the north shore of Squamish Harbor has a boat ramp and there are public WDNR tidelands to the east of the park.

4.2.9.7 Restoration Opportunities

Unused docks and pilings could be pulled from Fisherman's Harbor. The South Point/ Bridgehaven area could benefit from actions that improve sediment function and provide salt marsh habitat for juvenile salmonids. This area is heavily developed and immediate restoration actions are not clear. Potential opportunities include improving/replacing the culvert at the remnant South Point salt marsh to provide fish access.

The reach between South Point Spit and Shine Creek is in pristine condition and should be protected; part of it is already WDNR timberlands (Correa, 2002). Removing or reconfiguring the boat ramps on the north side of the bay would allow for longshore transportation of sediment and increase shallow water habitat. In the North Squamish and Shine reaches, alternatives to bulkheads and restoration of nearshore riparian habitat would improve longshore transport of sediment and enhance shallow water/nearshore habitat.

4.2.10 Hood Canal Bridge to Tala Point (Admiralty Inlet)

4.2.10.1 Overview (Map 1a)

This shoreline is situated between the Hood Canal Bridge and Port Ludlow. Some pristine areas are located in Bywater Bay and around Hood Head. Residential development is concentrated in Reach AA; however, scattered homes are found throughout this section of shoreline. Hood Head is an island connected to the mainland by a tombolo (or spit) and is predominantly undisturbed by development. Development pressures in this area are concentrated south of Tala Point, White Rock Cove, and Bywater Bay.

4.2.10.2 Nearshore Reaches

Reach X: Drift cell JE-10, including Termination Point, the western shore of Bywater Bay, and Wolfe Property State Park.

Reach Y: Drift cell JE-9 on the western side of Hood Head.

Reach Z: Drift cell JE-8 on the east side of Hood Head.

Reach AA: From Point Hannon to Tala Point, including north Hood Head, White Rock Cove, and Paradise Bay.

4.2.10.3 Physical Environment (Maps 12, 15, and 27)

A large basalt bedrock body occurs south of Ludlow Bay. It underlies the principal aquifer between Ludlow Bay and Squamish Harbor at elevations ranging from land surface to several hundred feet below sea level (Parametrix et al., 2000).

Drift cell JE-10 originates at the depositional bluffs at Termination Point and continues north to the head of Bywater Bay. At the base of the Hood Canal Bridge, significant progradation seaward (to the southwest) occurred, allowing sediment to continue to travel northward (Johannessen, 1992). Eroding bluffs dominate the shoreline of Bywater Bay, and are unstable from just north of the parking lot at Termination Point to the mouth of a small stream 500 yards south of the end of Seven Sisters Road. Beach width and riparian vegetation increase northward to where the drift cell terminates in a 500-yard-long, broad sand and pea gravel spit at the head of Bywater Bay in Wolfe Property State Park (Johannessen, 1992).

Drift cell JE-9 originates at the erosional headland at the southern tip of Hood Head, and net shore-drift is to the north 1 mile to terminate at the head of Bywater Bay (Johannessen, 1992).

The next drift cell, JE-8, extends from the feeder bluffs on south Hood Head 1 mile to the northeast to terminate at Point Hannon on Whiskey Spit. South Hood Head is a steep headland of glacial drift that supplies abundant sand and gravel to the intertidal (Johannessen, 1992). This bluff is composed of Vashon lodgement till over a layer of undifferentiated stratified sediments overlying a layer of Possession Drift. Although Vashon lodgement till is considered relatively stable, the underlying sediments are considered unstable on slopes greater than the angle of repose (generally slopes greater than 30 to 39 degrees). Several recent landslides mark this area and, as with all the bluffs on the east side of Hood Head, landslide hazard is considered high (Ecology, 1978).

Drift cell JE-7 extends for 4.9 miles from the erosional feeder bluffs at Tala Point in the north to Point Hannon in the south. The sediment source in this drift cell comes from eroding bluffs composed of sandy glacial drift found in the northern and central parts of the cell. Beach characteristics and sediment composition vary as the level of beach exposure varies. Sandy drift material is abundant in the bluffs close to Tala Point but relatively scarce farther south where the bluffs are composed of silt and clay-rich glacial till, with little sand or gravel to replenish the beach (Johannessen, 1992). The remaining shoreline from Paradise Bay to Tala Point is semi-protected, with the majority of the abundant sediment coming from backshore sources.

Net shore-drift in cell JE-7 creates the tombolo to North Hood Head, a narrow, low berm that is overtopped at high storm tides. The drift cell terminates at Point Hannon, a cuspate spit that extends more than 300 yards from the uplands and is a zone of drift convergence in common with drift cell JE-8 (Johannessen, 1992).

Within marine Reaches X and Y, 22 percent to 27 percent of the planning area is wetland. Within marine Reaches Z and AA, 6 percent to 8 percent of the planning area is wetland. Estuarine – intertidal (unconsolidated shoreline and emergent) is the primary wetland classification within all shoreline reaches.

4.2.10.4 Biological Resources (Maps 18, 20, 24, and 27)

A freshwater marsh lies on the landward side of Shine Tidelands State Park. It is cut off from salt water by riprap fronting a parking lot (Correa, 2002). An osprey pair nests on the peninsula jutting into the tidal lagoon formed by the spit. As of 1999 there was a great blue heron colony of three nests near the end of Seven Sisters Road. Sand lance and surf smelt spawn along the Wolfe

Property State Park from near the end of Seven Sisters Road northward to the beginning of the spit (Penttila, 2000). Brown kelp and eelgrass are continuous to patchy in Bywater Bay, with several dense beds of eelgrass about 200 meters north of the Hood Canal Bridge (Woodruff et al., 2002). Chum salmon are found in the large tidal lagoon in Wolfe Property State Park created by the spit at the head of Bywater Bay. In addition, the small stream draining into the tidal lagoon presumably provides cutthroat trout habitat (Correa, 2002).

Water quality in this entire shore segment is generally good and most areas are approved for shellfish harvest (WDH, 2006). The area at the head of Bywater Bay and the area immediately adjacent to the spit and lagoon are private tidelands belonging to Shellfish Farm, LLC. (Adams, personal communication, 2006). Other tidelands in the area are also privately owned.

The end of drift cell JE-9 encloses a salt marsh along the northeastern shore of Hood Head. Riparian vegetation along this segment is generally dense with the exception of the erosional headlands on the southern end. Eelgrass is patchy in this area of Bywater Bay.

Riparian vegetation is healthy in the northern half of drift cell JE-8, whereas in the southern half much of the riparian vegetation has slid into the nearshore. Sand lance spawning is documented along the south side of Whiskey Spit at Point Hannon (Penttila, 2000). Patches of eelgrass and *Ulva* are found along the southern and eastern sides of Hood Head.

An open water lagoon, with no outlet to the nearshore and surrounded by marsh, occurs at the base of Whiskey Spit. Juvenile Chinook salmon have been observed along Point Hannon Spit feeding on sand lance. Sand lance spawning has been documented on the north side of this spit (Long et al., 2005). The remainder of the spit is covered in dune grass, the only disturbance being a small abandoned cabin and navigational light. This area has been identified as an example of a healthy cuspate spit habitat type (Correa, 2002).

Near Tala Point, tall bluff-top trees harbor a bald eagle nest and an osprey nest. The sandy gravel beaches south of Tala Point provide sand lance and surf smelt spawning habitat. There are several additional surf smelt spawning beaches in this reach (Penttila, 2000; Long et al., 2005). The riparian vegetation along this reach is nearly continuous. A brackish marsh is situated south of the unnamed broad point south of Tala Point. Clearing of riparian vegetation for views has occurred, particularly north of Paradise Bay and in White Rock Cove (Ecology, 2001). Patches of *Fucus*, barnacles, *Ulva*, and soft brown kelp, with continuous eelgrass beds, are present in White Rock Cove. Patches of barnacles, eelgrass, and *Ulva*, with some soft brown kelp, are found in the nearshore reaches from Paradise Bay to Tala Point (Correa, 2002).

Patches of *Ulva* and continuous eelgrass occur along drift cell JE-7. A bald eagle nest is located on the northern bluffs of Hood Head.

4.2.10.5 Land Use and Altered Conditions (Maps 12 and 22)

Land Use and Zoning

Land use along the marine shoreline is dominated by residential development. Within all reaches, 100 percent of the planning area is zoned Rural Residential.

Transportation and Utilities

Throughout the marine planning area, Jefferson County and WDNR have mapped 14 miles and 28 miles of road, respectively. Mapped roads are focused around areas of higher population density. However, there are roads along the majority of the shoreline throughout the marine planning area.

Shoreline Modifications

Shoreline modifications in this segment include less than 2 miles of bulkhead. The footing of the Hood Canal Bridge interferes with the longshore transport of sediment (Johannessen, 1992). Just to the north of the Hood Canal Bridge, a long riprap bulkhead protects the road and parking lot at Shine Tidelands State Park. Considerable changes have taken place to the marsh/lagoon at Shine Tidelands State Park. There is question as to whether a tidal inlet ever occurred at this site, but the marsh/lagoon was probably dredged at one time (perhaps for log storage) and the current fill and riprap surrounding the marsh/lagoon prevents any regular tidal connection (Todd, personal communication, 2006).

Besides some shoreline armoring above the intertidal zone along the west side of Hood Head, Bywater Bay is largely free of bulkheads. No shoreline armoring exists on the north or east sides of Hood Head (Hirschi et al., 2003). White Rock Cove is 20 percent armored with riprap (WDNR, 2001). To the north of Paradise Bay a private access road with a bulkheaded landing extends into the intertidal and interrupts net shore-drift (Correa, 2002). Just north of this, a large riprap bulkhead was installed to protect a large stairway structure and a house situated close to the edge of a slumping bluff (Ecology, 2001). The high bluff at the origin of the drift cell at Tala Point is armored at the toe, which interrupts sediment source for drift cells JE-6 and JE-7 (Correa, 2002).

4.2.10.6 Public Access (Map 22)

Just north of the Hood Canal Bridge, Shine Tidelands State Park provides access to the shoreline north to Hood Head. In addition, there is another parking area at the end of Seven Sisters Road for beach access north to Wolfe Property State Park. Properties on the north shore of Hood Head are owned by WDNR. Some parcels between the state park and DNR tidelands are in private ownership. Point Hannon is owned by Washington State Parks. North of the Paradise Bay development is WDNR-owned public access shoreline that ends just south of the broad point south of Tala Point. A water access primitive campground is planned for State Park land on Point Hannon.

4.2.10.7 Restoration Opportunities

Moving the parking lot to the south and removing the bulkhead at Shine Tidelands State Park would open up the marsh to the nearshore, providing potential rearing habitat for migrating chum and pink salmon (Correa, 2002). Several bulkheads extending into the nearshore in the Tala Shores area could be removed to allow for improved longshore transport of sediment. Removal of riprap at the base of the bluff at Tala Point would recover the natural rate of sediment input into the nearshore.

4.2.11 Port Ludlow (Admiralty Inlet)

4.2.11.1 Overview (Map 1a)

Port Ludlow, which is designated a Master Planned Resort, is an area of relatively intense residential development. Future development in this area could include expansion of the marina and associated condominium development. Port Ludlow retains some valuable natural habitat including at least one salmon spawning creek (Ludlow Creek), several salt marsh areas, and numerous forage fish spawning beaches. Two drift cells occur in this area as well as extensive back bay areas of no net shore-drift. The geology of this area is mainly glacial drift derived bluffs; however, there are several basaltic outcroppings in southwest Ludlow Bay and farther north at Basalt Point.

4.2.11.2 Nearshore Reaches (Map 9)

Reach BB: Drift cell JE-6 from the origin at Tala Point to the salt marsh at the terminus of drift cell JE-6.

Reach CC: Ludlow Bay from the terminus of drift cell JE-6 to Ludlow Spit, including the Twins, the two basaltic islands in the southern bay.

Reach DD: Drift cell JE-5, the Mats Mats shoreline from Ludlow Spit north to the south jetty at the barge harbor near Basalt Point.

4.2.11.3 Physical Environment (Maps 12, 15, and 27)

Principal aquifer materials in the Port Ludlow area include pre-Vashon stratified glacial drift and interglacial deposits. In addition, Vashon advance outwash materials may be saturated in places. Exposure of principal aquifer materials is noted along the incised channels. Recessional outwash and alluvial materials have subsequently filled in portions of the channels. A large bedrock body occurs south of Ludlow Bay, and underlies the principal aquifer between Ludlow Bay and Squamish Harbor at elevations ranging from land surface to several hundred feet below sea level. The bedrock is composed of basalt (Parametrix et al., 2000).

The tall eroding feeder bluffs on Tala Point provide much of the sediment for the south shore of Ludlow Bay. Tala Point is a classic feeder bluff with little vegetation due to near constant erosion. Drift cell JE-6 begins at this feeder bluff, and net shore-drift continues southeast for about 2 miles into Ludlow Bay. Farther west, contributing bluffs, often forested with patches of even-aged trees indicating past bluff failures, add more sediment to this drift cell. There is abundant evidence of recent landslides along this shoreline including large boulders in the intertidal. Net shore-drift continues to the west to form an accretionary beach in front of a salt marsh. Several groins placed to capture sediment and a turn-of-the-century shipwreck interfere with net shore-drift (Johannessen, 1992; Correa, 2002).

There is no appreciable net shore-drift occurring within Ludlow Bay (Reach CC), the southern shore of which is composed of basalt. Although sandy beach occurs over parts of the harbor, low wave energy and substantial human modification preclude net shore-drift from occurring (Shipman, 1991).

Drift cell JE-5, originating just south of Basalt Point, has net shore-drift to the south for 2.6 miles to the marina at Port Ludlow. Sediment for this drift cell is supplied by several sources, including a contributing bluff composed of compact glacial till, sometimes overlying basalt at the beginning of the cell; a feeder bluff south of this, supplying sediment rich in gravel; and another contributing bluff south of the village of Mats Mats. A large housing development is located on top of this southernmost contributing bluff, near the southern end of Reach DD. Poor drainage management appears to have aggravated and accelerated bluff erosion. This development corresponds to the area listed as unstable recent slides in the Coastal Zone Atlas (Johannessen, 1999; Ecology, 1982). The drift cell terminates at the depositional beach in front of the Port Ludlow resort and restaurant. This is a modified spit complex that still maintains a wide beach with minimal shoreline armoring.

Along the marine shoreline, less than 13 percent of the planning area is wetland in all reaches (less than 0.5 percent in Reach DD). The primary wetland classification is estuarine – intertidal (unconsolidated shoreline and rocky shore. Reach land cover within the planning area is predominantly evergreen forest, bare rock/sand/clay, and acreages/rural residential. Additional areas of commercial/industrial/transportation, deciduous forest, low intensity residential, urban/recreational grasses, transitional, woody wetlands, and mixed forest land cover are mapped.

4.2.11.4 Biological Resources (Maps 18, 20, and 27)

Eelgrass beds are continuous and riparian vegetation is heavy in Reach BB. Eelgrass beds are patchy to continuous within the southern portion of this reach, with riparian vegetation decreasing to the west due to clearing of trees for development and views. Two marshes, the East Ludlow Marsh and Ludlow Lagoon, are found in this reach. East Ludlow Marsh is a small fringing salt marsh that is supported by limited tidal connection and at least one small freshwater stream (Todd et al., 2006). Ludlow Lagoon is important habitat for juvenile salmonids, though some diking and filling of the salt marsh and lagoon has occurred since the 1800s (Todd, personal communication, 2006). The stream flowing into the marsh supports cutthroat trout (Correa, 2002). The Tala Point bald eagle territory includes Tala Point and West Tala Point (Reaches AA and BB). Surf smelt spawn in the middle of the reach, while both surf smelt and sand lance spawn on the barrier beach at the western end of Reach BB (Penttila, 2000; Long et al., 2005).

The back bay area of West Port Ludlow contains the small estuary of Ludlow Creek, which supports coho, chum, cutthroat, and steelhead. The estuary is truncated by fill and culverts associated with the Paradise Bay Road crossing. Juvenile cutthroat and coho use the tidal channels cut into the road fill. In North Port Ludlow, there is an area of fill and scattered residential development with sparse riparian vegetation. Surf smelt and sand lance spawn just west of the marina (Long et al., 2005). The small stream entering Ludlow Bay between Ludlow Creek and the marina supports cutthroat trout and possibly chum salmon, although available habitat is limited due to a blocking culvert at the Oak Bay Road crossing (Hirschi, 1999). Patchy eelgrass beds occur throughout the northern portion of Reach CC.

Forage fish spawning along Reach DD is extensive, with sand lance spawning sites along Ludlow Spit and south of the Mats Mats quarry, and extensive surf smelt spawning along the middle of the drift cell (Long et al., 2005). Nine winter surf smelt sites were found by North Olympic Salmon Coalition studies in the past few years. Two summer surf smelt spawning sites were also found, a rarity in east Jefferson County (Long et al., 2003). These findings reconfirm and expand the spawning sites documented by Dan Penttila of WDFW in the 1990s (Penttila, 2000).

Riparian vegetation is sparse along the northern part of this shoreline, although in the middle it covers roughly 60 percent of the backshore. Clearing has contributed to the spottiness of backshore riparian vegetation. The preservation of existing vegetation might alleviate some of the erosion of the bluffs in the North Port Ludlow development (Johannessen, 1999; Ecology, 2001). Eelgrass beds are continuous in the central portion of this reach, and patchy at the north end and along Ludlow Spit. Offshore, the Colvos Rocks are documented as a seal pupping and haulout area.

The enclosed bay of Port Ludlow provides significant nearshore habitat for salmonids (May and Peterson, 2003). The estuary area at mouth of two small season streams at the east edge of the bay is classified as a Category A NSE salmonid refugia. The remainder of the Ludlow Bay NSE is a Category C refugia (May and Peterson, 2003).

4.2.11.5 Land Use and Altered Conditions (Maps 12, 22, and 25)

Land Use and Zoning

Land use along the Port Ludlow shoreline is dominated by residential development and resort communities. Within Reaches BB and DD, 65 percent and 48 percent (respectively) of the planning area is zoned Rural Residential. Within all reaches, 32 percent to 57 percent of the planning area is zoned Master Plan Resort – Single Family. Other Master Plan Resort zoning (Resort Complex/Community Facilities and Multiple Family) exists within Reaches CC and DD.

Transportation and Utilities

Within the Port Ludlow shoreline planning area, Jefferson County and WDNR have mapped 1.4 miles and 0.7 mile of road, respectively. Shoreline roads include Ludlow Bay Road, South Bay Lane, Skiff Lane, Camber Lane, and Paradise Bay Road along the south shoreline of Port Ludlow, and Oak Bay Road, North Bay Lane, and Gull Drive along the north shoreline of the port. Continuing north along Reach DD, Montgomery Lane and Olympus Boulevard parallel the shoreline.

Shoreline Modifications

Development has encroached into the salt marsh at the terminus of drift cell JE-6. There are several docks in the vicinity of The Twins in the southwest part of the harbor. Six dock-pier structures are mapped in Reach BB, and nine dock-pier structures are mapped in Reach CC. Additionally, a rail launch is mapped within Reach BB. Along the shoreline to the northeast of Ludlow Creek, a log storage yard and loading area was active for many decades. The site today appears abandoned and future plans for restoration of the site are unknown (Todd et al., 2006). In Reach CC there is major shoreline alteration associated with the marina and resort (Ecology, 2001). The back of the 2,000-square-foot marina is completely armored. Construction of the mill in the 1800s resulted in substantial filling of shallow tide flats (Todd et al., 2006). Concrete and rock bulkheading have been identified and mapped along the shoreline as follows: 0.3 mile within Reach BB, 100 feet within Reach CC, and 0.5 mile within Reach DD. Between the barge harbor at Mats Mats and Port Ludlow, drift cell JE-4 is about 9 percent armored with a majority of this armoring in the sediment transport zone.

The few groins and bulkheads along the southern shore of Ludlow Bay do not appear to significantly impact the overall transport of sediment to the accretion beach at the terminus of drift cell JE-6. A greater threat to this drift cell would be armoring of the contributing or feeder bluffs near Tala Point. The Paradise Road crossing at Ludlow Creek, although not a barrier to fish, does interfere with the natural aggradation of the salt marsh into the bay. The marina on the north side of the bay could be impacting the growth of eelgrass. Private docks are also abundant throughout Ludlow Bay, which can have an adverse effect on the growth of eelgrass. Despite the high level of development at Port Ludlow, natural shore forms have largely been maintained, except near the old mill and current marina/resort.

Groundwater contamination has been diagnosed from a leaking underground storage tank at the Port Ludlow Golf Course. Cleanup has been initiated at the site, and the site is not listed as containing groundwater contamination that affects drinking water (Ecology and WDOH, 1999 as cited in Parametrix et al., 2000).

4.2.11.6 Public Access (Map 22)

The beaches of Port Ludlow are private.

4.2.11.7 Restoration Opportunities

Fluvial flow under the Paradise Bay Road crossing could be improved. As the docks are replaced in Port Ludlow, opportunities to reduce overwater coverage could be explored. There is currently an experiment at the NW Maritime center dock in Port Townsend examining “eelgrass friendly” docks, and the results of this study may be applicable in this and other areas. Restoring a more natural lagoon with flow into the bay and a vegetated shoreline on the current site of the tidal pond behind the marina has the potential to increase juvenile migratory salmonid habitat. The need for some of the bulkheads north of Port Ludlow should be explored and alternatives to bulkheads should be assessed. The restoration of native vegetation on the bluffs north of Port Ludlow may help stabilize the bluffs.

4.2.12 Mats Mats Bay (Admiralty Inlet)

4.2.12.1 Overview (Map 1a)

This shoreline extends from the Mats Mats quarry south of Basalt Point to Olele Point, and includes Mats Mats Bay. Three streams enter the west side of Mats Mats Bay, including Piddling Creek.

4.2.12.2 Nearshore Reaches (Map 9)

Reach EE: Olele Point to Basalt Point, including the entire Mats Mats Bay shoreline.

4.2.12.3 Physical Environment (Maps 12, 15, and 27)

The bedrock along the coast at Mats Mats Bay is composed of basalt (Parametrix et al., 2000). A zone of no net shore-drift exists between the barge harbor located south of Basalt Point, north to Olele Point and includes Mats Mats Bay. The only sediment present is on small isolated pocket beaches between basalt outcroppings. Within Mats Mats Bay there is not enough wave action to create net shore-drift (Johanessen, 1992). The mouth of Piddling Creek and a small drainage to the south once formed a wetland complex, but the extent of the original habitat is unknown (Todd et al., 2006).

Six percent of the planning area is mapped as wetland, with 85 percent of the wetland area classified as estuarine – intertidal (aquatic bed/unconsolidated shoreline) and 15 percent classified as palustrine emergent/forested.

Within the shoreline planning area of Mats Mats Bay, reach land cover is predominantly evergreen forest. Areas of bare rock/sand/clay, quarries/strip mines/gravel pits, and low intensity residential land cover are also mapped.

Water quality, specifically fecal coliform contamination, is a problem in Mats Mats Bay, which is considered a Category 5 water for fecal coliform according to Ecology's 2004 Water Quality Assessment. Dissolved oxygen in Mats Mats Bay is depressed in the autumn because of upwelling from Admiralty Inlet (Parametrix et al., 2000).

4.2.12.4 Biological Resources (Maps 18, 20, 24, and 27)

Riparian vegetation has been cleared around the Mats Mats quarry barge harbor. North of this, in the southern entrance to Mats Mats Bay, the riparian buffer is intact.

The North Mats Mats marsh is a tiny fringing salt marsh located on a point in Mats Mats Bay. Though a defined channel is not evident at this marsh, it is of such a low elevation that it probably becomes inundated frequently. There are no known freshwater inputs at the site. Within the Piddling Creek estuary, it is possible that former marsh was filled for residential lawns. An extremely limited amount of tidal marsh is available near the mouth of at least one of the streams near Piddling Creek. A narrow fringing salt marsh at the south end of Mats Mats Bay has been filled for the development of houses, and access to a pier. Much of the shoreline at the south end of the bay appears bulkheaded (Todd et al., 2006).

Mats Mats Bay was newly classified as a seasonal conditionally approved shellfish harvest area in 2005. The marine waters of Mats Mats Bay are impaired by fecal coliform due to elevated levels of bacteria. A management plan requires the seasonal conditionally approved area to be closed to harvest from June through September (WDH, 2006a).

Piddling Creek supports chum salmon and cutthroat trout and once supported coho. However, past land use practices (clearcutting the upper watershed) and an impassable culvert at Oak Bay Road have extirpated the coho. Efforts are underway by Trout Unlimited to reintroduce coho and fix the culvert (Hirschi, 1999). Riparian vegetation is largely intact along the Olele Point reach; this area also supports at least one pair of nesting bald eagles (Correa, 2002). Patchy eelgrass beds line the entrance of Mats Mats Bay.

4.2.12.5 Land Use and Altered Conditions (Maps 12, 22, and 25)

Land Use and Zoning

Land use is predominantly rural residential, reflecting the zoning within Mats Mats Bay and in the areas between Basalt Point and Olele Point. Mats Mats quarry and the associated barge facility dominate the shoreline land use to the south of Basalt Point. The quarry is used for mineral extraction.

Transportation and Utilities

Within the Mats Mats Bay marine planning area, Jefferson County and WDNR have both mapped 0.5 mile of road. Roads within the planning area are part of a network of roads serving the Mats Mats Bay community and the Mats Mats quarry.

Shoreline Modifications

Several rock jetties extend from the Mats Mats quarry barge harbor located to the south of Basalt Point. Twenty-two docks and one boat launch ramp are documented within Mats Mats Bay. Most of the bay has a developed and cleared shoreline, with the exception of the area around the mouth of Piddling Creek, though it appears some filling of former wetland has occurred here and native vegetation has been replaced by lawns and drainage ditches near Piddling Creek (Todd, personal communication, 2006). Within the reach there is 0.37 mile of bulkhead (predominantly rock).

4.2.12.6 Public Access (Map 22)

There is public access to Mats Mats Bay at the public boat ramp on the south side of the bay.

4.2.12.7 Restoration Opportunities

If the basalt quarry ceases operations and is available, it could be an excellent park and restoration site. Riparian vegetation could be planted throughout the shore of Mats Mats Bay where it is lacking.

4.2.13 Oak Bay (Admiralty Inlet)

4.2.13.1 Overview (Map 1a)

This shoreline stretches from Olele Point to the Port Townsend Ship Canal. Development along this shoreline is nearly continuous but less intense compared to the larger scale housing developments in Port Ludlow. Much of this shoreline has sandstone outcroppings at the base of the bluff, so the amount of sediment transported is moderate. Four drift cells extend from Olele Point to the Ship Canal.

4.2.13.2 Nearshore Reaches (Map 9)

Reach FF: Drift cells JE-3 and JE-4.

Reach GG: Drift cell JE-2.

Reach HH: Divergent zone JE-1/JE-2, and drift cell JE-1 to Washington Street, south of Oak Bay County Park.

Reach II: Origin of drift cell JE-1 through Oak Bay County Park, as well as the west shore of the Portage Canal.

4.2.13.3 Physical Environment (Map 12, 15, and 27)

Principal aquifer material along the coast at Oak Bay is composed of sedimentary bedrock (Parametrix et al., 2000). The southernmost reach in this segment of shoreline is Reach FF, encompassing drift cells JE-3 and JE-4. In drift cell JE-4 net shore-drift is to the west from glacial drift deposits immediately to the west of the basaltic headland of Olele Point. The depositional area for this cell is the beach (spit) in front of a salt marsh 780 yards west of Olele Point. Likely there is some continuity of drift with drift cell JE-3, the next drift cell to the west. This is a reinterpretation of the original drift cell study published in 1992 by Johannessen (Johannessen, 1999). Drift cell JE-3 continues to the west 330 yards to a broad 120-yard-long beach that serves as a shared depositional shore form with drift cell JE-2.

Drift cell JE-2 (Reach GG) extends from a zone of divergence about 1.5 miles northwest of Olele Point to the shared zone of deposition with JE-3 located 1 mile west of Olele Point. Net shore-drift is to the south, a local reversal due to the sheltering of this shoreline from fetch by Olele Point. Sediment is derived from Vashon till overlying Quimper sandstone. Advance outwash sand and gravel underlies the till along much of the reach. This layer supplies the greatest amount of sediment to the beach. Mass wasting is not extensive due to the relatively erosion-resistant sandstone toe of the bluff; thus the landslide hazards are low. Erosion in this area is generally triggered by surface water flow and ground saturation (Johannessen, 1999).

Reach HH encompasses much of drift cell JE-1 from its origin to the southern end of Oak Bay County Park. Drift cell JE-1 originates at the same zone of divergence as drift cell JE-2 and has a northward net shore-drift for 5 km to Oak Bay County Park. A small amount of sediment is transported in this drift cell, with geology similar to that of JE-2. Northward net shore-drift is indicated by sediment size decrease, northward bluff vegetation increase, and beach width increase.

Drift cell JE-1 within Reach II terminates at the riprap jetty on the western side of the Portage Canal (Johannessen, 1999). A small stream enters Oak Bay here, where the original spit likely started (Johannessen, 1999). The mouth of Little Goose Creek once entered the extensive salt marsh now trapped behind the riprap associated with the park and dredged canal. The western side of the Portage Canal is an area of no net drift.

Within Reach FF, 8 percent of the planning area is wetland, with estuarine – intertidal, unconsolidated shore (79 percent) and palustrine emergent (21 percent) wetland classifications.

Within Reaches GG and HH, 12 percent of the planning area is wetland classified as estuarine – intertidal (aquatic bed/unconsolidated shore). Within Reach II, 33 percent of the planning area is wetland, with estuarine – subtidal (31 percent) and estuarine – intertidal (69 percent) the wetland classifications.

4.2.13.4 Biological Resources (Maps 18, 20, 24, and 27)

Riparian habitat is fragmented along Reach FF, with only about 20 percent remaining uncleared (WDNR, 2001; Ecology, 2000). Eelgrass is nearly continuous along drift cell JE-4 and patchy eelgrass beds occur in front of drift cell JE-3. A salt marsh occurs behind the depositional spit at the terminus of drift cell JE-4. It is located along a pocket beach bounded to the west and east between outcrops of Crescent basalts; the beach has been incrementally filled for development and is truncated by a driveway (Hirschi, 1999; Ecology, 2000; Todd et al., 2006). Sand lance spawn along the beach fronting the marsh and at the shared terminus of cells JE-3 and JE-2 (Penttila, 2000; Long et al., 2005).

Eelgrass beds are patchy throughout Reach GG. Riparian vegetation ranges from 20 percent to 50 percent with patches of trees separated by areas cleared for views. There is a bald eagle nest in the northern part of this reach.

Eelgrass beds are continuous in the northern part of Reach HH and patchy in the south, providing a migratory corridor for juvenile salmonids. Riparian vegetation is patchy, being cleared in front of many houses to provide views; locally, there are several large intact regions of vegetation. Surf smelt spawn on a pocket beach in the southern part of the reach (Long et al., 2005).

Reach II includes the accretionary zone of drift cell JE-1, about 1 km of shore in the minor embayment in the northwest corner of Oak Bay that has developed into a spit and barrier beach system. The north side is a broad depositional beach and spit that has been bulkheaded to stabilize it for a campground and parking lot associated with the Oak Bay County Park. This spit and the jetty on the west side of the Portage Canal keep the salt marsh isolated from the bay, although in recent years, the spit has eroded and riprap is failing, allowing for a regular tidal connection with the saltmarsh/lagoon behind the spit (Todd, personal communication, 2006)

Sand lance spawn on the Oak Bay Spit beach (Penttila, 2000; Long et al., 2005). Although previous reports (Hirschi 1999) suggested that coho no longer inhabited Little Goose Creek, local residents have observed coho and resident cutthroat salmon in Little Goose Creek on several occasions during recent years (Davis, personal communication, 2006, Clogston and Hopkins, Personal communication 2007).

4.2.13.5 Land Use and Altered Conditions (Maps 12, 22, and 25)

Land Use and Zoning

Land use along the Oak Bay watershed is dominated by residential development and commercial forestry. Within all reaches except for Reach II, 100 percent of the planning area is zoned Rural Residential (69 percent in Reach II). Remaining Reach II areas are zoned Parks, Preserves, and Recreation, and Water.

Transportation and Utilities

Within the Oak Bay planning area, Jefferson County and WDNR have mapped 0.8 mile and 0.6 mile of road, respectively. Roadways within the planning area provide access to residential properties along and near the shoreline.

Shoreline Modifications

Residential development has encroached on the salt marsh on the north side of Olele Point. There are relatively few bulkheads along this stretch of shoreline. However, at the terminus of drift cell JE-2 at the spit in front of the salt marsh at Oak Bay County Park there is major shoreline alteration. The front of the spit is armored with riprap for park access and the campground. Combined with the jetty along the Ship Canal, this cuts off the salt marsh from the nearshore under most conditions. Due to major erosion during winter 2005/2006, there is now tidal access to the marsh/lagoon. Dredging of the Ship Canal resulted in major loss of tidal flat by conversion to deep water and upland fill of the salt marsh (Todd, personal communication, 2006). In addition, at Little Goose Creek, a small coho stream, was rerouted out of the marsh and through a culvert to the southwest of the Oak Bay Lagoon.

Bulkhead and stairways are mapped along the Oak Bay shoreline as follows: Reach FF, 280 feet of rock and wood bulkhead and 3 stairways; Reach GG, 130 feet of wood bulkhead and 12 stairways; Reach HH, 0.3 mile of concrete, rock, and wood bulkhead and 8 stairways; Reach II, 0.2 mile of rock bulkhead and 1 stairway. A landfill is mapped within Reach II.

4.2.13.6 Public Access (Map 22)

There are WDNR tidelands south of Oak Bay County Park accessible by boat. Oak Bay County Park has beach and salt marsh access, shellfish beds, and camping.

4.2.13.7 Restoration Opportunities

Enhancing and/or preserving bluff-top vegetation in this reach could reduce surface runoff which is a primary cause of bluff erosion in this area. The salt marsh at Olele Point could be partially restored.

4.2.14 South Indian Island and Marrowstone Island (Admiralty Inlet)

4.2.14.1 Overview (Map 1a)

Indian and Marrowstone Islands are situated between Port Townsend Bay and Admiralty Inlet. Except for the County park on the southern shore, Indian Island is owned by Naval Magazine Indian Island, a federal naval munitions base for forces stationed in Puget Sound; hence, it is not within County shoreline jurisdiction. However, management of Indian Island shoreline reaches may affect shoreline processes along adjacent shorelines within the County's jurisdiction. Habitat on Indian Island is regionally significant as it is an important nesting area for bald eagles (eight pairs) and its beaches are host to numerous spawning sites for surf smelt and sand lance (Kalina, personal communication, 2000; Penttila, 2000; Long et al., 2005).

Historically connected across a spit/salt marsh, Marrowstone Island is currently connected to Indian Island by a causeway built on fill. Marrowstone Island is primarily rural residential with state parks at both the northern end (Fort Flagler) and the southern end (Kinney Point, accessible only by boat). Growth on Marrowstone Island has been slowed by the general lack of fresh water, although this may change with the construction of a public water system. Between the two islands are Kilisut Harbor and Scow Bay with rich shellfish beds, herring spawning grounds, and large concentrations of overwintering waterfowl.

4.2.14.2 Nearshore Reaches (Map 9)

Reach JJ: Western shore of Indian Island along Portage Canal.

Reach KK: Drift cell JEF-2, from Portage Canal east to the divergence zone JEF-2/JEF-3 between Kinney Point and Lilip Point.

Reach LL: Divergence zone JEF-2/JEF-3 and drift cell JEF-3 to Marrowstone Point.

Reach MM: Drift cell JEF-4 and eastern part of divergence zone JEF-4/JEF-5.

Reach NN: Feeder bluffs in zone of divergence JEF-4/JEF-5 and drift cell JEF-5, including the end of the spit by the Flagler Campground.

Reach OO: Area of divergence JEF-6/JEF-7, drift cell JEF-6 north to the Flagler Campground.

Reach PP: Area of divergence JEF-6/JEF-7, and drift cell JEF-7.

Reach QQ: Mystery Bay and eastern end of divergence zone JEF-8.

Reach RR: Drift cell JEF-9, from the eastern edge of Mystery Bay State Park to the terminus in Scow Bay.

Reach SS: Scow Bay Marsh, the area of undefined drift at the head of Scow Bay.

4.2.14.3 Physical Environment (Maps 12, 15, and 27)

The Indian-Marrowstone Island subbasin is characterized by extensive areas covered with dense basal till overlying glacial sediments and bedrock of volcanic and sedimentary origin. Bedrock is exposed on the southern end of Indian Island and along various coastal locations on Marrowstone Island such as south of Mystery Bay. On Marrowstone Island, the till overlies Vashon advance outwash sediments in most locations. However, in a few locations the till immediately overlies bedrock. On the southern end of Marrowstone Island, outwash deposits reach thicknesses as great as 100 feet but are thin or absent in places. On the northern end of the island, glacial deposits reach thicknesses as great as 1,400 feet (Parametrix et al., 2000).

The east side of the Portage Canal is an area of no net drift, and in the northern half it contains bluffs composed of hard shale and mudstone (Ecology, 1978). Drift cell JEF-2 extends from a zone of divergence between Kinney and Lip Lip Points on Marrowstone Island northwestward to the riprap jetty on the east side of the Portage Canal. Sediment is supplied to this drift cell by erosion in the zone of divergence and contributing bluffs on southeastern Marrowstone Island. Major depositional areas occur in Reach KK, on the barrier spit fronting a lagoon between the islands, and on the barrier beaches protecting salt marshes in the last kilometer of the drift cell.

Reach LL begins at the zone of divergence with JEF-2 and net shore-drift is generally northward along the entire eastern side of Marrowstone Island. The drift cell terminates at the cuspate spit at Marrowstone Point (Keuler, 1988). An interesting rocky intertidal zone occurs at Nodule Point where there is an outcropping of tertiary sandstone. In general, the uplands are stable; however the immediate bluff faces along most of this segment are unstable and marked by many small slides (Ecology, 1978). North of Sound View Cemetery, for example, there are a number of houses now very close to the bluff edge (several meters) where the bluff has shown a steady retreat due to many rather small block slides coming off a steep bluff of compacted fine, silty, Vashon advance outwash. Each slide has removed a couple of meters of bluff top, creating a serious threat to property. Lack of bluff-top vegetation, ground and surface water erosion, and bluff toe erosion all appear to have contributed to this problem.

Drift cells JEF-4 and JEF-5, in Reaches MM and NN respectively, occur completely within Fort Flagler State Park and govern net shore-drift on the northern shore of Marrowstone Island. Both drift cells begin at a large feeder bluff 0.5 mile west of Marrowstone Point. Sediment is derived from 100-foot-tall bluffs composed of Vashon till overlying advance outwash sediments. Net shore-drift in Reach MM is to the east from this feeder bluff and terminates at the cuspate spit at Marrowstone Point. Net shore-drift in JEF-5 extends from the same feeder bluff as JEF-4 for 2 miles to the southwest tip of Rat Island (Keuler, 1988). Rat Island was originally a spit but was breached in the middle of the last century (Correa, 2002). It is now grouped into Reach VV, and is not addressed due to its proximity to Indian Island.

Drift cell JEF-6 originates at a zone of divergence 1 mile north of Mystery Bay, and net shore-drift extends about 2 miles to the north to terminate inside the spit at Fort Flagler. This drift cell is within relatively sheltered Kilisut Harbor with limited southern fetch (Keuler, 1988). Sediment is derived from eroding bluffs near the origin of the cell and alongshore (WDNR, 2001). Depositional beaches occur in the middle of the cell and at the terminus (Keuler, 1988).

Drift cell JEF-7 originates in the same zone of divergence as JEF-6. Net shore-drift is to the south for 1 mile into Mystery Bay, terminating in the vicinity of Mystery Bay State Park (Keuler, 1988). Sediments are derived from Vashon till and advance outwash deposits (Ecology, 1978).

An area of divergence occurs from the relatively tall bluffs cut into shale and mudstone on the northern side of Griffiths Point. Keuler (1988) shows some net drift occurring to the east into Mystery Bay; however, the current Ecology Coastal Zone Atlas shows this as an area of divergence but no significant drift to the east (Keuler, 1988). To the west and then south from this zone of divergence, drift cell JEF-9 encompasses net shore-drift for 1.7 miles into southern Scow Bay. Sediment is derived from mixed shale/mudstone and glacial till feeder bluffs in southern Kilisut Harbor (Keuler, 1988).

The Scow Bay habitat complex forms the low-lying connection between Indian and Marrowstone Islands. A broad spit defines the southern margin of the marsh. Sediments forming this spit are derived primarily from the south shoreline of Marrowstone Island. The overall connectivity has been severely impaired by the road causeway through the middle of the marsh, eliminating a southern tidal connection with adjacent open waters (Todd et al., 2006).

Within Reaches JJ, KK, LL, MM, NN, PP, and RR, 8 percent to 16 percent of the planning area is wetland. Within Reaches OO, QQ, and SS, 29 percent to 54 percent of the planning area is wetland. The majority of these wetland areas are estuarine – intertidal (aquatic bed/unconsolidated shore is the most common classification, with additional areas of emergent/unconsolidated shore).

Land cover within the shoreline planning area is primarily evergreen forest (20 percent to 60 percent, varies reach to reach) and bare rock/sand/clay (33 percent to 53 percent in all reaches except KK and SS). The remaining land cover includes acreages/rural residential (significant in reaches NN and QQ), low intensity residential (significant in Reaches KK and SS), mixed forest (18 percent in Reach SS), pasture/hay, deciduous forest, transitional, woody wetland, and urban/recreational grasses.

4.2.14.4 Biological Resources (Maps 18, 20, 24, and 27)

Sand lance spawn along the southeast shore of the Portage Canal and at two pocket beaches between the north end of the Portage Canal and the Navy property boundary (Penttila, 2000; Long et al., 2005). A salt marsh is protected by an extensive barrier beach along the southern part of the Portage Canal (Ecology, 2001; Todd et al., 2006). The South Indian Island Lagoon, located just east of the Portage Canal, has formed where a westward-pointed spit partially encloses a tidally connected lagoon and fringing marsh. In recent years, it appears that subspits or bars have formed immediately offshore, possibly a result of deflection of sediment from extension of the jetty (Todd et al., 2006).

Patchy eelgrass beds occur throughout drift cell JEF-2. There is a bald eagle nest on Kinney Point. This part of Oak Bay serves as an overwintering area for waterfowl including brant. Juvenile salmonids are found in South Indian Island Marsh (Hirschi et al., 2003a). In the County park on South Indian Island, riparian vegetation has been preserved and there are extensive salt marshes. South Indian Island is a popular area for recreational clam digging (Speck, personal communication, 2003). Sand lance spawn on the barrier beach connecting the islands and along the central portion of Indian Island's southern coast (Penttila, 2000; Long et al., 2005).

Eelgrass beds are patchy to continuous along East Marrowstone Island. Riparian vegetation is fragmented due to clearing for views in the southern portion (south of East Beach County Park) but is mostly intact in the northern portion (Correa, 2002). Sand lance spawn north of East Beach Park as well as on the depositional beach along Marrowstone Point (Penttila, 2003; Long et al., 2005). Three bald eagle nest sites have been documented within this reach.

Eelgrass is absent along drift cells JEF-4 and JEF-5, except for patchy beds around Rat Island. Sand lance spawn on the north side of the spit near Flagler Campground (Long et al., 2005). Bald eagles nest in Reach NN. Riparian vegetation is largely absent from the high bluff areas; however, it is present in the lower bluff areas along this shoreline. Also, LWD is recruited off of the tops of the high bluffs as they erode. Rat Island is a haulout and pupping site for harbor seals and a nesting area for gulls. A brackish marsh at Marrowstone Point apparently has never had an outlet to Admiralty Inlet (Correa, 2002). Marrowstone Point is home to prairie plants including menzies larkspur (*Delphinium menziesii*) and chocolate lily (*Frittilaria lanceolata*).

Eelgrass occurs in patchy beds throughout drift cell JEF-6. Herring spawn on eelgrass throughout Kilisut Harbor. Surf smelt and sand lance spawn along most of drift cell JEF-7 (Long et al., 2005). There is little riparian vegetation in Reaches PP and QQ (WDNR, 2001). The depositional beach in Reach PP encloses a salt marsh. This part of Kilisut Harbor is also an important overwintering area for brant and other waterfowl.

A depositional spit at the northern tip of Mystery Bay encloses a salt marsh lagoon (Ecology, 1978). Another salt marsh is protected behind a barrier beach within Mystery Bay State Park. Native riparian vegetation has been mostly cleared between the west and east lagoons (Todd et al., 2006). Within Mystery Bay there is no net shore-drift. A small salt marsh is isolated by driveway fill at the southern tip of the bay (Correa, 2002). Eelgrass is nearly continuous north of, and within, Mystery Bay except for patchy beds at the head of the bay. Sand lance spawn on the beaches just north of Mystery Bay and just south of and in the state park (Penttila, 2000; Long et al., 2005). The Mystery Bay shellfish harvest area is listed as an area of concern due to the number of boats, some of which are live-aboards, moored in Mystery Bay (WDH, 2006a). Kilisut Harbor and Mystery Bay are regionally significant overwintering areas for diving ducks.

Development around Nordland has eliminated riparian vegetation on the eastern shore of the bay; in contrast, about 65 percent of riparian vegetation remains on the western shore (WDNR, 2001). Historically, a small salt marsh occurred near the Nordland Store and main road. It has been completely filled (Todd, personal communication, 2006).

Riparian vegetation along the northern side of Griffiths Point is fragmented (Ecology, 2001). Eelgrass is continuous along Reach RR. Surf smelt and sand lance use this shoreline for spawning (Penttila, 2000; Long et al., 2005). This is an important overwintering area for waterfowl and spawning grounds for herring (herring roe is important food for diving ducks). There is commercial aquaculture in Scow Bay. Reach SS has extensive salt marshes.

4.2.14.5 Land Use and Altered Conditions (Maps 12, 22, and 25)

Land Use and Zoning

Land use on Marrowstone Island is primarily rural residential along with farming and forestland. North of Fort Gate Road the entirety of Marrowstone Island is Fort Flagler State Park. Land use on Indian Island is related to the U.S. Navy operations. Zoning in the shoreline planning areas of all reaches reflects current land use.

Transportation and Utilities

Within the South Indian and Marrowstone Island planning area, Jefferson County and WDNR have mapped 4.2 miles and 3.8 miles of road, respectively. Along the south shoreline of Indian Island and continuing north along the southwest shoreline of Marrowstone Island, State Route 116 is within the shoreline planning area. Bridges pass over Portage Canal (between mainland and Indian Island) and the south end of Scow Bay (linking Indian Island and Marrowstone Island). Additionally, stretches of East Marrowstone Road, Griffith Point Road, Flagler

Campground Road, Beach Drive, and other park and residence access roads pass within the shoreline planning area of all reaches.

Shoreline Modifications

The Naval Magazine Indian Island (formerly Port Hadlock Detachment-Indian Island) Superfund site was used by the Navy for munitions storage and handling from 1939 to 1984. Disposal activities at several locations resulted in soil, groundwater, sediment, and shellfish contamination from ordnance compounds, heavy metals, polychlorinated biphenyls (PCBs), and pesticides. The site was added to the National Priorities List (NPL) (Superfund) in June 1994. Following extensive remedial activities, the site was removed from the NPL in June 2005. Additionally, Ecology indicates a Hazardous Waste Generator within the planning area of Reach JJ and a State Cleanup Site within the planning area of Reach NN.

Within Reach KK, the parking lot for the South Indian Island County Park is constructed on fill placed behind a riprap bulkhead on the beach. Within Reaches KK and LL, the marine shoreline is intact, with feeder bluffs and extensive salt marshes. A small area of shoreline modification exists along the southwest face of Marrowstone, which includes a paved boat ramp, and bulkhead section in front of a resort. A total of 0.65 mile of bulkhead and 17 stairways are mapped within Reaches KK and LL.

In Reaches MM and NN, the parking lot and campground at Fort Flagler State Park are constructed on fill placed on top of approximately 22 acres of historic salt marsh (Correa, 2002). A riprap bulkhead protecting the Coast Guard facility interferes with sediment transport along the north side of Marrowstone Point in Reach MM. The terminus of drift cell JEF-5 in front of the campground at Fort Flagler is altered. Historically, Rat Island was a spit extending from the point. This spit enclosed what was historically an approximately 22-acre salt marsh where the campground now sits (Correa, 2002). In the 1940s the spit was breached by dragging boats over it during military exercises (Hirschi et al., 2003a). Since that time a combination of currents and the interruption of sediment transport have kept Rat Island separated from Marrowstone Island except during low tides. Longshore sediment transport has been interrupted by the little-used boat ramp on the north side of the point (one of two boat ramps existing in Reach NN) (Hirschi et al., 2003a).

Little or no armoring occurs on East Marrowstone except for the bulkhead protecting the parking lot at East Beach County Park. An abandoned pier at Fort Flagler State Park disrupts longshore transport of sediment. On the inside of Kilisut Harbor (Reach OO) there is a boat ramp and dock at Fort Flagler with some nearby associated bulkheading. However, this drift cell, JEF-6, is not highly altered and there is very little armoring of its contributing and feeder bluffs. To the south there is extensive bulkheading in front of the feeder and contributing bluffs in drift cell JEF-7 (Reach PP) amounting to 32.5 percent of the total length of the drift cell (Hirschi et al., 2003b).

Within Mystery Bay State Park, at the north end of the Reach QQ shoreline, there is a dock and boat ramp. There are three docks associated with the town of Nordland and several buildings and filled areas intruding into the nearshore. Just south and north of the Nordland Store, Highway 116 is bulkheaded, possibly eliminating shallow water habitat for juvenile salmonids. At the head of Mystery Bay a driveway truncates a salt marsh. In Scow Bay (Reaches RR and SS) residential bulkheading amounts to 16.1 percent of the total length of drift cell JEF-9, a small house is built on stilts over the intertidal, and there are 11 staircases. Additional modifications include three dock/pier structures and one rail launch. At the head of Scow Bay, along the border of Reaches SS and KK, the causeway that connects Marrowstone Island to Indian Island interrupts tidal flow.

Extensive bulkheading in front of the feeder and contributing bluffs in drift cell JEF-7, amounting to 32.5 percent of the total length of the drift cell, could lead or have already contributed to erosion of the alongshore and depositional spits just north of Mystery Bay State Park.

4.2.14.6 Public Access (Map 22)

At the southern tip of Marrowstone, Kinney Point is owned by Washington State Parks and the tidelands are owned by WDNR. Although currently only accessible by boat, this state park property abuts the end of Baldwin Road, so upland access could be possible with parking and road improvements. On the east side of Marrowstone Island there is beach access at East Beach County Park. Fort Flagler at the north end of the island provides access to miles of shoreline along with a campground, shellfish beds, and a boat ramp. Mystery Bay State Park in Nordland has about 700 feet of public access shoreline, a boat ramp, and a dock. In Scow Bay there is WDNR shoreline accessible by boat. There is a street easement extending to the water at Strawberry Lane to the west of Flagler Road where public access from land might be possible, but parking may be a problem due to lack of space between the bluff and the road. The entire south shore of Indian Island is public access and there are several parking areas at South Indian Island County Park off of Highway 116.

4.2.14.7 Restoration Opportunities

There are numerous restoration opportunities in Oak Bay and Marrowstone Island. Juvenile salmonid migratory habitat could be improved by replacing undersized culverts under the road between Marrowstone and Indian Islands to allow for the passage of juvenile salmonids (Correa, 2002). A larger culvert or culverts could be placed under the causeway between Marrowstone and Indian Islands to improve tidal exchange between Scow Bay and Oak Bay and improve water quality in Kilisut Harbor, especially near the Scow Bay aquaculture operations.

Moving the parking lot at East Beach County Park to an upland site would increase shallow water habitat for migratory salmonids (pink and chum salmon). Removal of an abandoned pier at Fort Flagler along with random creosote pilings in this area would improve transport of sediment north to the terminus of drift cell JEF-3 at Marrowstone Point and decrease creosote input to the water. Removing the bulkhead and restoring the salt marsh at Marrowstone Point would improve beach habitat and increase migratory salmonid habitat. This may entail the removal or relocation of the USGS laboratory at Marrowstone Point and/or the automated Coast Guard light (Correa, 2002). If the little-used boat ramp on the north side of the spit (by the campground at Fort Flagler) were removed, it would improve sediment transport to the terminus of the drift cell on Rat Island (Hirschi et al., 2003b). Restoring at least part of the historic salt marsh at the campground at Fort Flagler could improve habitat for juvenile salmonids and other salt marsh dependent species.

Removing the bulkheads within drift cell JEF-7 would improve sediment recruitment and could help sustain beaches north of Mystery Bay. Removal of fill within a salt marsh in Reach PP would increase salt marsh habitat (Correa, 2002). A driveway truncating the salt marsh at the head of Mystery Bay could be removed to provide access to salmonids and other wildlife. A neighboring driveway can be used for access (as is evident from the Ecology shoreline photos). Unused creosoted pilings could be removed from Mystery Bay State Park to improve water quality (Correa, 2002).

4.2.15 Port Townsend Bay (Admiralty Inlet)

4.2.15.1 Overview (Map 1a)

This area contains the most intense development within the County's jurisdiction at Port Hadlock and near the Port Townsend Paper Mill. This area also includes the relatively undeveloped areas south of Hadlock and between Chimacum Creek and Glen Cove. This shoreline is within the watershed of the Tri-area Urban Growth Area around Port Hadlock and Irondale. There are five drift cells and a portion of another cell within this area. This area is drier than areas farther south in the County, with approximately 28 inches of annual rainfall in the Chimacum area, and 18 inches a year in Port Townsend.

The City of Port Townsend has shoreline jurisdiction along the eastern portion of Reach CCC and the eastern portion of Reach EEE.

4.2.15.2 Nearshore Reaches (Map 9)

Reach YY: From the origin to the terminus of drift cell JEF-16.

Reach ZZ: Hadlock Lagoon, drift cell JEF-17, and the southern end of divergence zone JEF-18.

Reach AAA: The northern end of divergence zone JEF-18 and the Chimacum Creek estuary.

Reach BBB: Kala Point, including drift cells JEF-19, JEF-20, JEF-21, and the divergence zone JEF-21/JEF-22.

Reach CCC: Drift cell JEF-22, including the shoreline from the north edge of Old Fort Townsend State Park to the City of Port Townsend boundary.

4.2.15.3 Physical Environment (Maps 12, 15, and 27)

Drift cell JEF-16 begins at the northwest edge of the broad point to the north of the Portage Canal and continues about 1 km to terminate at a depositional beach just to the west of the Inn at Port Hadlock. The average rate of erosion near the origin of the drift cell is 4 cm a year based on a greater than 20-year record (Keuler, 1988). Sediment is derived from contributing bluffs of till overlying sandstone at the origin of the cell and just east of the Inn at Port Hadlock (Johannessen, 1999).

The depositional beach just west of the Inn at Port Hadlock encloses a small salt marsh, which is part of Reach ZZ (Ecology, 2001). Skunk Island is a basaltic outcropping covered in vegetation just south of Port Hadlock. It remains in a relatively undisturbed state.

Drift cell JEF-17 originates north of Port Hadlock, and net shore-drift is south to terminate at the spit south of lower Port Hadlock. Sediment is derived from the steep feeder bluffs south of Irondale. The bluff is composed of sandy recessional outwash, over till, over advance glacial outwash which, in sum, provides abundant sediment to the nearshore. This bluff (Hadlock Bluffs) has not experienced any large failures recently; however, it remains the only long-term sediment source for drift cells JEF-17 and JEF-18 (Johannessen, 1999). This shoreline is classified as unstable with recent landslides (Ecology, 1978). A wide depositional beach is present along the Port Hadlock waterfront and continues to form a long (780-yard) depositional spit enclosing a large tidal lagoon south of lower Port Hadlock (Hadlock Lagoon). This spit still appears to be prograding to the southeast (Johannessen, 1999).

Drift cell JEF-18 originates from the same feeder bluffs as JEF-17. Net shore-drift is northward to the mouth of Chimacum Creek in Reach AAA. A small accretionary beach forms at the end of the extensive bulkheading and fill from the iron and paper mills (Keuler, 1988). This fill was removed in spring 2006 (Todd, personal communication, 2006).

Two drift cells (JEF-19 and JEF-20) occur between the mouth of Chimacum Creek and Kala Point, diverging from a shared feeder bluff. This feeder bluff, composed of advance outwash overlain by glacial till, contributes high-quality sediment to the nearshore (Johannessen, 1999) and marks the boundary between Reaches AAA and BBB. This 330-yard-wide bluff just north of Chimacum Creek feeds the short drift cell JEF-19 with sediment for net shore-drift to the south to terminate at the mouth of Chimacum Creek. It also feeds sediment into drift cell JEF-20, which has northeastern net shore-drift, to terminate at the mouth of the lagoon on Kala Point, a cuspate spit. This lagoon with its associated tidal channels is encircled by the spit and maintains a vigorous tidal exchange with Port Townsend Bay. These reaches are not subject to any shoreline modification and exhibit relatively natural function (Johannessen, 1999).

The subestuary at the mouth of Chimacum Creek is in good condition. There are no roads, jetties, or dikes encroaching on the small, 5.2-acre delta. Several acres of the tidal marsh were filled in the late 1800s; a road crosses this filled area. A small area of the delta has been used for log storage (Parametrix et al., 2000). WDFW purchased the old log dump area south of the mouth of Chimacum Creek in 2003 and removed the fill from approximately 6 acres to restore the beach and shoreline in 2006; riparian vegetation is also being restored (Todd, personal communication, 2006; Davis, personal communication, 2006).

The geology of the Quimper Peninsula (including Reaches BBB and CCC) is characterized by extensive areas covered with dense basal till, by broad channels eroded through the till into underlying principal aquifer materials, and by the presence of loose ablation till overlying portions of the basal till. Principal aquifer materials are predominantly composed of Vashon advance outwash, pre-Vashon stratified glacial drift, and interglacial deposits (Parametrix et al., 2000).

Drift cell JEF-21 (Reach BBB) originates from a zone of divergence in the southern shore of Old Fort Townsend and exhibits net shore-drift to the south to the lagoon entrance on the southern side of Kala Point (Keuler, 1988; Johannessen, 1999). The bluffs forming divergence zone JEF-21/JEF-22 are composed of glacial till overlying Vashon advance outwash sediments and are classified as unstable with many recent slides (Ecology, 1978). A rarity in the Puget Sound region, small sand dunes occur along the north side of the spit at Kala Point (Todd et al., 2006).

Reach CCC includes the next drift cell and the last in this segment, JEF-22, as well as the northern portion of the feeder bluffs in divergence zone JEF-21/JEF-22 in Old Fort Townsend State Park. Net shore-drift is to the northeast and then northwest to Point Wilson, being interrupted along the modified portions of shoreline by the Port Townsend Paper Mill and City of Port Townsend. The paper mill, at the northeast end of a major depositional beach, has filled over a portion of a backshore marsh/lagoon at Glen Cove; the complex encloses a glacial depression that supports marsh and lagoon habitat features (Keuler, 1988; Ecology, 2001; Todd et al., 2006). The City of Port Townsend municipal boundary is just north of the paper mill. For more information about the shorelines within the City of Port Townsend, refer to the *Shoreline Inventory Summary Report* (Nightingale, 2002) and *Final Report Characterization of Functions & Ecosystem-wide Processes* (GeoEngineers, 2004).

Water quality in Port Townsend Bay is generally considered good, although residential and urban areas have been identified as the primary non-point sources of pollutants, as well as the relatively high abundance of farms and livestock rearing activities (Parametrix et al., 2000). The Washington State Department of Health (2006) has classified the nearshore area of Reach YY as a prohibited shellfish harvest area and the bay is identified as a Biotoxin Closure zone.

With variation from reach to reach, between 6 percent and 20 percent of the shoreline planning area is wetland, with estuarine – intertidal (aquatic bed/unconsolidated shore) the most common wetland classification. Significant areas of palustrine open water wetlands are mapped in Reach CCC.

Land cover within the shoreline planning area is primarily evergreen forest (27 percent to 48 percent, varies reach to reach) and bare rock/sand/clay (29 percent to 39 percent in Reaches YY and BBB). The remaining land cover includes commercial/industrial/transportation (significant in Reach CCC), residential (significant in Reaches ZZ and AAA), urban/recreational grasses (significant in Reaches ZZ and AAA), woody wetland (16.5 percent in Reach ZZZ), mixed forest, low intensity residential, and acreages/rural residential.

4.2.15.4 Biological Resources (Maps 18, 20, 24, and 27)

Riparian vegetation is fragmented along the drift cell JEF-16 shoreline (WDNR, 2001, 2005; Ecology, 2001). Eelgrass is continuous and sand lance spawn along much of this drift cell (Penttila, 2000; Long et al., 2005).

Riparian vegetation in the Hadlock Bluffs area is largely intact, but it is largely absent from the Hadlock Waterfront area of Reach ZZ (Ecology, 2001). Sand lance spawn along the length of these beaches. Surf smelt spawn just north of the waterfront (Penttila, 2000; Long et al., 2005). Eelgrass is continuous along Hadlock Bluffs and patchy beds occur in front of the waterfront, spit, and lagoon. The small salt marsh and lagoon has exchange with the bay, and contains shallow water foraging habitat for juvenile salmonids (Hirschi, 1999). Low and high salt marsh lines the perimeter of this lagoon (Leon and Driscoll, 1976). A small unnamed stream flows into the lagoon and at one time possibly provided salmonid spawning habitat; however, recent salmonid use was not found (Hirschi, 1999). This lagoon is also an important area for overwintering waterfowl.

Riparian vegetation is present along the moderately high feeder bluffs at the southern part of Reach AAA. However, it is absent throughout the modified part of this reach (Ecology, 2001). Clam digging is locally popular at the mouth of Chimacum Creek. The estuary of Chimacum Creek contains salt and brackish marsh (Todd et al., 2006).

Collectively, the beaches, intertidal areas, and nearshore areas from Pulali Point to just south of Chimacum Creek are considered to be a Category A NSE salmonid refugia (May and Peterson, 2003). The estuary provides quality rearing habitat for juvenile coho, searun cutthroat trout, and summer and fall chum salmon. The summer chum salmon run has been restored to Chimacum Creek after being extirpated in the early 1990s, and the estuary and nearshore are important nursery habitat for this species (May and Peterson, 2003).

The riparian zone is intact along the lower section of Chimacum Creek (May and Peterson, 2003). Eelgrass beds offshore provide more habitat. Sand lance spawn along the beaches south of the Chimacum Creek estuary (Long et al., 2005). The mouth of Chimacum Creek is also important habitat for waterfowl.

Eelgrass beds are patchy to continuous south of Kala Point in Reach BBB, providing a migratory corridor for juvenile salmonids and spawning substrate for herring. The lagoon at Kala Point and its associated 8.5-acre salt marsh are likely intimately associated with the success of outmigrating salmonids from Chimacum Creek (Hirschi, 1999; Leon and Driscoll, 1976). Sand lance spawn just south of the outlet to the lagoon and on the north side of the point (Penttila, 2000; Long et al., 2005). This shoreline supports a bald eagle territory and significant waterfowl concentrations. Riparian vegetation is largely intact, but some bluff-top clearing has occurred for new home sites (Ecology, 2001). The bluff immediately to the north of Chimacum Creek was recently purchased with State Salmon Recovery Funding Board (SSRFB) funds.

North of Kala Point, eelgrass meadows are continuous and the Port Townsend Bay herring stock uses them for spawning substrate (Penttila, 2000). Sand lance and surf smelt spawn at the north end of Reach BBB into Reach CCC (Long et al., 2005). This shoreline is also one of the few in Jefferson County where summer surf smelt spawn.

Historically, there have been bald eagle nests along this shoreline and it is a bald eagle territory. Riparian vegetation is generally healthy in this segment. While some bluff-top clearing has occurred, there has historically been an effort in the Kala Point Development to preserve riparian vegetation (Ecology, 2001). This has maintained relatively stable bluffs and preserved shoreline ecology.

Drift cell JEF-22 south of the paper mill is rather pristine and is contained in Reach CCC. Eelgrass is continuous along this segment, becoming patchy in front of the barrier beach just south of the paper mill, and again serves as spawning substrate for herring (Penttila, 2000). Surf smelt and sand lance spawn on the beaches in Old Fort Townsend State Park, in the southern portion of this drift cell, and on the beach in the center of Glen Cove (Penttila, 2000; Long et al., 2005). The pond and marsh at Glen Cove harbors significant waterfowl concentrations. Riparian vegetation from the origin of this drift cell north to Glen Cove is intact (Ecology, 2001).

4.2.15.5 Land Use and Altered Conditions (Map 12 and 22)

Land Use and Zoning

Land use along the Port Townsend Bay drainage is dominated by residential development. Except for small areas of Parks, Preserves, and Recreation (11 percent in Reach BBB) and Rural Village Center (11 percent in Reach ZZ), zoning throughout the planning is reflects rural residential land use.

The Inn at Port Hadlock, Port Hadlock, Irondale, and Port Townsend Paper are within commercial and industrial zoning. Irondale is registered as a state historic district and had extensive charcoal kilns and concrete tanks on the waterfront, along with deepwater piers. The ironworks also mined all the iron and charcoal deposits from “Chimacum Bog”. There are plans for concentrating commercial development along the shoreline at the Inn at Port Hadlock and at Port Hadlock, which include increased boat and water access (and dock expansion). These plans could affect future shoreline use and habitat functions.

Transportation and Utilities

Within the Port Townsend Bay planning area, Jefferson County and WDNR have mapped 1.7 miles and 1.9 miles of road, respectively. Road densities are higher to the south and north of Old Fort Townsend State Park, with roads in proximity to the shoreline providing access to residences.

Shoreline Modifications

A large marina with about 100 small slips is located in front of the Inn at Port Hadlock in Reach YY. However based on an examination of Ecology shore photos, it does not appear to significantly affect net shore-drift. Approximately 177 meters of drift cell JEF-16 are armored, representing about 17 percent of its total shoreline. Modifications appear concentrated along the low bank area near the origin of the cell (Hirschi et al., 2003; Ecology, 2001). Three wooden bulkheads along the contributing bluff area of this drift cell may limit sediment recruitment into the nearshore (Johannessen, 1999).

Numerous docks, bulkheads, a boat ramp, and other structures are present along Reach ZZ. Extensive bulkheading has occurred just north of the waterfront in front of low-bank residential property. On the spit south of Hadlock there has been some bulkheading and a dock associated with a house (Johannessen, 1999; Ecology, 2001). Overall, shoreline armoring impacts 335 yards of drift cell JEF-17, or 31 percent of its length (Hirschi et al., 2003b). However, it appears that net shore-drift is not completely impaired as the spit southeast of the waterfront continues to prograde.

Reach AAA is extensively modified with 513 yards of bulkhead fronting fill in its depositional zone along the former iron mill and log dump sites (Johannessen, 1999). Most likely a salt marsh spit complex prior to fill activity, this site has been publicly acquired for a park, and the rock bulkhead and fill have been removed to restore shallow water habitat for juvenile salmonids and beach habitat for forage fish spawning (Hirschi et al., 2003b; Todd, personal communication, 2006). The restoration project has been funded by the State Salmon Recovery Funding Board to remove the fill and restore the depositional beach (Correa, 2002). Two facilities are monitored by Ecology within Reach AAA, including one State Cleanup Site and one Underground Storage Tank.

A dock and boat ramp on the north side of Kala Point, within Reach BBB, do not appear to impede significant amounts net shore-drift (Ecology, 2001). A bulkhead extends into the intertidal zone in Old Fort Townsend State Park.

Within Reach CCC, the salt marsh at Glen Cove is extensively filled and modified for settling ponds and other structures associated with the Port Townsend Paper Mill. The paper mill is built over the water and is the site of extensive bulkheading and shoreline armoring. There are also several large docks and barge unloading facilities at this location. Several facilities are monitored by Ecology within Reach CCC, including five Hazardous Waste Generators, six Underground Storage Tanks, one Leaking Underground Storage Tank Facility, one Voluntary Cleanup Site, and two Enforcement Final Locations (Ecology, 2006). The shoreline north of the mill to the City of Port Townsend boundary is bulkheaded, fronting a converted railroad grade (which is now a public path) and isolating the bluff from the nearshore (Ecology, 2001; Correa, 2002).

4.2.15.6 Public Access (Map 22)

A public boat ramp is located on the lower Hadlock waterfront. In Irondale the shoreline from the old iron mill site to Chimacum Creek is a combination County park and WDFW lands. A major restoration occurred in 2006 with the removal of fill associated with the log dump and the reestablishment of a beach. There is waterfront access at Old Fort Townsend State Park south of Port Townsend. Between the Port Townsend Paper Mill and the Port of Port Townsend there is a public waterfront trail (the Larry Scott Trail).

4.2.15.7 Restoration Opportunities

The lower Hadlock waterfront should be examined for opportunities to remove alterations that interfere with longshore transport of sediment. The restoration of the beach at the old log dump is a major project completed in 2006. This should improve estuarine and forage fish spawning habitat. The removal of the filled bulkheaded area at Old Fort Townsend would improve the longshore transport of sediment and increase shallow water nearshore habitat. The opening of an outlet that would allow fish passage to the lagoon south of the paper mill would increase salt marsh habitat for summer chum and pink salmon. Studies and possible modification of the paper mill to allow for less disruption to salmon migration could be explored. Alterations to the mill could happen as part of normal maintenance and refurbishment. The removal or modification of the Larry Scott Trail north of the paper mill would allow for the recruitment of sediment into the nearshore.

4.2.16 Chimacum Creek (Admiralty Inlet)

4.2.16.1 Overview (Map 1a)

Chimacum Creek has a watershed of about 33 square miles, with headwaters in the coastal hills south of the town of Chimacum. The stream flows north through the Chimacum, Port Hadlock, and Irondale communities into Port Townsend Bay. The shoreline of the state begins at the mouth and stretches to the fork at about RM 2.9 to create the east and west forks. There are four lakes and the mill settling pond in this watershed that are subject to the County's SMP.

4.2.16.2 Freshwater Reaches (Map 9)

Chimacum Creek 1: From the end of tidal influence to just downstream of where east and west forks diverge.

Chimacum Creek 2: From downstream of where east and west forks diverge to approximately RM 3.3.

Chimacum Creek 3: From approximately RM 3.3 to near the crossing of State Route (SR) 19.

Chimacum Creek 4: From near SR 19 to near the crossing of Highway 104 and Center Road.

4.2.16.3 Physical Environment (Maps 15, 22, and 25)

The upland geology of the Chimacum Creek basin consists of quaternary glacial deposits as much as 900 feet thick overlying shale, sandstone, and lava, while the lowland valleys are characterized by deep muck and peat soil. Principal aquifer materials are composed of pre-Vashon stratified glacial drift, interglacial deposits, and Vashon advance outwash. Exposures of principal aquifer materials are noted along the incised valleys. Bedrock exposures are present along the western edge of the subbasin near Anderson Lake, Gibbs Lake, southeast of Peterson Lake, and along the east fork of Chimacum Creek (Parametrix et al., 2000; Simonds et al., 2003).

From the mouth to RM 1.3 the stream flows through a tightly constricted ravine with good riparian cover and fair pool habitat (May and Peterson, 2003). For the lower 0.2 mile, Chimacum Creek is tidally influenced, with salt marsh and lagoon habitat, and relatively unaltered by development. Between RM 1.3 and 2.9 the riparian area is generally in good condition with medium to high quality spawning and reading habitat and floodplain wetlands; however, adjacent commercial and residential development are increasing (May and Peterson, 2003).

Above RM 3.0, Chimacum Creek has been channelized via maintenance dredging associated with reed canarygrass removal. Historic beaver ponds/wetlands have been converted to agriculture and rural residential use and are now predominantly ditches without structure, complexity, or well vegetated riparian zones. LWD is lacking in this segment and future recruitment potential is limited due to lack of a forested riparian zone (Correa, 2002). A number of channelized reaches have had meanders reincorporated, and native riparian plantings have been installed in recent years (Todd, personal communication, 2006).

Chimacum Creek in Reach 4 is listed as a Category 5 water for temperature according to the 2004 Ecology Water Quality Assessment.

Within Chimacum Creek Reaches 1, 2, and 3, approximately 25 percent to 40 percent of the planning area is wetland. Within Reach 4, 93 percent of the planning area is wetland. The majority of wetlands are classified palustrine emergent and scrub/shrub in Reaches 1, 2, and 3 and palustrine forested in Reach 3. A small area of estuarine – intertidal wetland is mapped at the mouth of the stream.

4.2.16.4 Biological Resources (Map 18)

Coho, summer chum, fall chum, steelhead, and cutthroat use this watershed for spawning. Coho salmon spawn from the lower reaches of Chimacum Creek up to the headwaters, and are considered a healthy stock with spawning surveys indicating an increasing trend (Parametrix, 2000). Summer chum were extirpated from Chimacum Creek in the early 1990s and have since been reintroduced. Summer chum spawned in the lower mile of stream, below the Irondale Road crossing. The population, already critical, was unable to spawn after a culvert failure at Irondale Road sent tons of fine sediments into the stream in the winter of 1985-1986. This cemented the spawning gravels together, reducing reproductive success and causing eventual extirpation (Lowrie, personal communication, 2005). This population has since been reintroduced with stock from Salmon Creek in a volunteer broodstock hatchery program. The first returning spawning adults were counted in 1999, and in 2001 the estimated return based on spawning surveys was about 900 adults (Correa, 2002). Recent returns have been even higher, estimated at over 1,300 in 2004-2006 (Latham, personal communication, 2006). In 2004-2006 summer chum spawned up to Ness's Corner Road, a mile farther than previously observed. This may have been a reestablishment of historical spawning habitat (Long, personal communication, 2004).

4.2.16.5 Land Use and Altered Conditions (Maps 22 and 25)

<u>Land Use and Zoning</u>

Land use in the upper Chimacum watershed is characterized by public and private forestry, while the middle section is characterized by agriculture, rural residences, commercial enterprise, industry, and parks. At the reach scale, zoning along Reach 1 is mainly Rural Residential with some Light Industrial (Commercial). The middle reaches are zoned Rural residential with some Park land (Reach 2 and 3). Reach 4 is mostly zoned for Agriculture.

<u>Transportation and Utilities</u>

Within the planning area of Chimacum Creek Reaches 1 through 4, Jefferson County and WDNR have mapped 0.5 mile and 1.5 miles of road, respectively. Roadways within the planning area never parallel the stream, with the exception of a short stretch of West Valley Road within Reach 4. A total of 14 road crossings occur within the four stream reaches, the majority of which involve culverts.

Jefferson County and WDNR have mapped 0.44 mile and 0.34 mile of road, respectively, within the planning area of Gibbs Lake. Gibbs Lake Road parallels the eastern shore of the lake.

Shoreline Modifications

Historically this area, and the broad agriculturally dominated valley upstream, was a complex of beaver ponds and cedar/spruce swamp. This type of habitat provided excellent coho rearing habitat. Subsequently, much of this area was drained and channelized, altering flow and destroying 90 percent of juvenile salmonid rearing habitat in the watershed (Correa, 2002). Agriculture such as livestock production in the Chimacum Creek valley has been identified as one of the main sources of pollutants in this subbasin. Voluntary implementation of agricultural best management practices by landowners in recent years has improved salmon habitat and reduced the impacts of farming operations on water quality. Residential development in the towns of Chimacum, Port Hadlock, and Irondale is also a potential non-point source.

West of Chimacum Creek in an area of Vashon advance outwash, Jefferson County Public Utility District #1 withdraws groundwater at a rate of approximately 555 gallons per minute from a highly transmissive zone known as the Sparling Aquifer to supply the communities of Chimacum, Irondale, and Port Hadlock (Simonds et al., 2003). Groundwater contamination from a leaking underground storage tank is reported at the Chimacum School District; however, reviewed references provide no evidence that this leak has compromised drinking water for other groundwater users (Parametrix et al., 2000).

4.2.16.6 Public Access (Map 22)

The area surrounding Chimacum Creek is privately owned throughout all reaches except at road right-of-way crossings of the stream.

4.2.16.7 Restoration Opportunities

Most of the restoration opportunities on Chimacum Creek occur upstream on the East and West Forks where there are opportunities to restore the channelized stream to a more natural system. In the lower section, protecting existing riparian vegetation and maintaining water quality are essential.

Water quality problems, which include high temperature, low dissolved oxygen, and elevated fecal coliform levels, could be alleviated with significant recovery of the riparian zone (Parametrix et al., 2000). In addition, restoration of lost/degraded wetlands and floodplain reconnection would improve ecological function in this area.

4.2.17 Gibbs, Beausite, Anderson, Peterson, Ludlow, and Teal Lakes and Mill Pond (Admiralty Inlet)

4.2.17.1 Freshwater Reaches (Map 9)

Gibbs Lake: Approximately 0.9 mile northwest of the intersection of Gibbs Lake Road and West Valley Road.

Beausite Lake: Approximately 0.5 miles east of Gibbs Lake and 0.4 miles west of the intersection of Beausite Lake Road and West Valley Road.

Anderson Lake: Approximately 1.2 miles west of Chimacum Creek 2 and Chimacum Creek 3 reaches.

Peterson Lake: Near the intersection of Highway 104 and Highway 101.

Ludlow Lake: Approximately 3.3 miles west of Port Ludlow and 0.4 miles northeast of the intersection of Highway 104 and North Sandy Shore Road.

Teal Lake: Approximately 1.4 miles south of Port Ludlow and immediately to the west of the intersection of Teal Lake Road and Andy Cooper Road.

Mill Settling Pond: Located directly east of the Port Townsend Paper Mill facility, near Glenn Cove.

4.2.17.2 Description

Gibbs Lake is located southwest of Chimacum in the Naylor's Creek watershed, which flows into Chimacum Creek. The lake has a surface area of 35.5 acres. Around the shoreline of Gibbs Lake, 75 percent of the area is wetland (primarily lacustrine – limnetic open water). Primary land cover is evergreen forest within the lake planning area, with additional areas of bare rock/sand/clay, deciduous forest, and mixed forest.

In high-flow years, coho salmon spawn just downstream from Gibbs Lake in Naylor's Creek, and upstream of the lake to spawn in two small tributaries (Correa, 2002). There is evidence that coho use Gibbs Lake for rearing and may be trapped in the lake during dry years (Soehl, personal communication, 2001).

The shorelands and uplands surrounding Gibbs Lake are a County park, providing both passive and active recreational public access. There is public access to the lake from Gibbs Lake Road.

Beausite Lake is also located southwest of Chimacum, approximately 0.5 miles east of Gibbs Lake, and drains to Chimacum Creek via a left bank tributary stream. The lake has a surface area of approximately 20 acres. Immediately along the shoreline of Beausite Lake, the majority of the area is mapped as wetland (primarily lacustrine – limnetic open water). Primary land cover is evergreen forest within the lake planning area, with additional areas of deciduous forest and mixed forest. There is no documented anadromous salmonid use of Beasite Lake.

The shorelands and uplands surrounding Beausite Lake are predominantly County park lands, which is leased to the Northwest Kiwanis. The leased land, encompassing a total of approximately 50 acres, is used as the Northwest Kiwanis Camp and as a event rental facility during non-summer months. The leased parks property is accessed via Beausite Lake Road to the south of the lake. It is along the southern lake shoreline where all existing development is located, including several structures and a dock. Limited public access is available through the Northwest Kiwanis rental and camp programs.

Anderson Lake is located west of Chimacum in the Chimacum watershed. The surface area of the lake is 57.3 acres. Its outflow is to Chimacum Creek via Putaansuu Creek through a wetland with no definitive channel. Seventy-five percent of the Anderson Lake planning area is mapped as wetland, with lacustrine – limnetic (open water) the primary wetland classification (NWI, 2005). Primary land cover is evergreen forest within the lake planning area, with additional areas of bare rock/sand/clay, woody wetlands, shrub and brush rangeland, and mixed forest.

Surrounded by 410 acres of forest and wetland within Anderson Lake State Park, Anderson Lake provides high-value habitat to trout, eagles, herons, waterfowl, and many other wildlife species (WSP, 2006). Surrounding forested areas include cedar, fir, and alder-dominated communities.

Anderson Lake is surrounded by state park land and, except for park facilities, is quite pristine. It is a popular seasonal fishing spot and provides additional passive and active public recreational opportunities, including swimming and hiking. Walking, running, and biking trails skirt the lakeshore.

Within the planning area of Anderson Lake, WDNR has mapped 300 feet of road. From Anderson Lake Road, a small roadway approaches the lake and state park facilities from the southwest.

In June 2006, the Department of Ecology warned areas residents of blue-green algal blooms on Anderson lake. The algae, or cyanobacteria, typically occur in nutrient-rich lakes, with excessive phosphorus. The blooms accumulate near shore as a thin bright green surface scum. Some blue-green algae blooms cause health problems, especially for pets but also for humans.

Peterson Lake is located south of Discovery Bay in the Chimacum Creek watershed (Map 16). The surface area of the lake is 22.6 acres. Seventy-one percent of the Peterson Lake planning area is mapped as wetland (primarily lacustrine – limnetic open water) (NWI, 2005). Land cover is primarily evergreen forest and mixed forest within the lake planning area, with Commercial Forest zoning. The area has seen recent (1999) clearcutting, although a buffer was left around the lake. Peterson Lake is a bald eagle territory. It is also presumed habitat for anadromous steelhead and cutthroat trout (Correa, 2002).

Within the planning area of Peterson Lake, WDNR has mapped 132 feet of road. From Peterson Road, a small, unpaved roadway approaches the lake from the east. There is no public access to Peterson Lake.

Ludlow Lake is located to the west of Port Ludlow in the headwaters of the Port Ludlow drainage basin. The lake has a surface area of approximately 20 acres. The lake is documented as a high value habitat: it is within WDNR's NHP for Low Elevation Bog and few flower sedge (*Carex pauciflora*). Ludlow Lake was also identified by Tomassi et al. (2004) as part of a habitat corridor and lying within a Type 1 Core Habitat (most intact habitat type in the County). This habitat corridor extends further into the headwater areas of the drainage basin, primarily to the north and southeast of the lake, and downstream of the lake along the Ludlow Creek riparian corridor. According to the Jefferson County wetland inventory, the majority of the lake is mapped as wetland and areas of lacustrine wetland are mapped to the south and north along the lakes shoreline.

The Ludlow Lake area has seen relatively recent clearcutting to the east and northeast of the lake. Adjacent zoning to Ludlow Lake is Commercial Forest and most of the lake is surrounded by forested buffers. A short roadway extends into and dead-ends within the east side of the lake's shoreline planning area. There is no existing public access to Ludlow Lake. Ludlow Lake is not on Ecology's 303d list for any water quality parameters, and no other documented water quality concerns are known.

Teal Lake is located to the south of Port Ludlow along Teal Lake Road. The lake drains to Port Ludlow via an non-SMA jurisdictional stream. Teal Lake is within WDNR's current NHP for Low Elevation Sphagnum Bog and Labrador Tea (*Ledum groenlandicum*)/Alpine Laurel (*Kalmia microphylla*)/Sphagnum Species Shrubland. The majority of the lake is mapped as lacustrine wetland according to the Jefferson County inventory, with additional wetland mapped to the north of the lake along the outlet stream.

Teal Lake is surrounded by forested land and zoned Rural Residential 1:20. There is very limited existing development within the lake's shoreline area. The intersection of Teal Lake Road and Anderson Cooper Road is located directly west of the lake, within the lake's shoreline area.

The Mill Settling Pond is a highly altered water body that serves industrial purposes, located just east of the Port Townsend Paper Mill. The total surface area of the pond is 30.5 acres. Around the shoreline of the Mill Settling Pond, 57 percent of the area is palustrine open water wetland (NWI, 2005). The primary land cover around the pond is commercial/industrial/transportation, with areas of evergreen forest and low intensity residential.

The Mill Settling Pond has little apparent habitat value. Historically this pond was part of a larger salt marsh in Glen Cove that included some of the filled area where the mill now sits and the 15-acre salt marsh adjacent to the south.

The Mill Settling Pond is currently designated an urban shoreline due to its industrial use. Zoning is 98 percent Heavy Industrial within the planning area.

Jefferson County and WDNR have mapped 0.6 mile and 1.5 miles of road, respectively, within the planning area of Mill Settling Pond. Mill Road, South 8th Street, and several other roads surround the settling pond. There is no public access to the Mill Settling Pond.

4.2.18 Strait of Juan de Fuca and Discovery Bay

4.2.18.1 Overview (Map 1a)

This shoreline stretches from the boundary of the City of Port Townsend in the east to the boundary of Clallam County in the west. The shoreline along the Strait of Juan de Fuca is subject to the greatest wave action in eastern Jefferson County and is characterized by tall, steep, eroding bluffs. Discovery Bay is a protected embayment with some development in the areas around Cape George, Beckett Point, and Adelma Beach. It was here Captain Vancouver first anchored while exploring Puget Sound in 1792. Early in the development of Puget Sound it was the location of a lumber mill and port at Mill Point. Salmon and Snow Creeks drain into Discovery Bay and support populations of chum, coho, cutthroat, and steelhead. The Washington State Department of Health has listed Discovery Bay as a threatened shellfish growing area, with portions of the area closed due to biotoxin from September 16 to October 6, 2005 (WDH, 2006a).

Unarmored shorelines within and near Discovery Bay support a number of depositional features at the terminal ends of their drift cells, and point bar features formed at the convergence of neighboring drift cells. These features are often associated with a wide intertidal and shallow subtidal shelf, creating an extensive area within the photic zone. This is important because the waters of outer Discovery Bay and the Eastern Strait are otherwise quite deep (PSAT, 2005). A brief discussion of Protection Island National Wildlife Refuge is included in this section.

4.2.18.2 Nearshore Reaches (Map 9)

Reach EEE: East end of divergence zone JEF-23/JEF-24 and drift cell JEF-23 to the City of Port Townsend boundary.

Reach FFF: West end of divergence zone JEF-23/JEF-24 and drift cell JEF-24 to the northern edge of Beckett Point.

Reach GGG: Segment of undefined drift around Beckett Point.

Reach HHH: Northern half of divergence zone JEF-25/JEF-26 and drift cell JEF-25.

Reach III: Southeast Discovery Bay, from the south edge of divergence zone JEF-25/JEF-26 south through the Salmon/Snow Creek delta.

Reach JJJ: Drift cell JEF-27 including Mill Point, and the southern half of divergence zone JEF-27/JEF-28.

Reach KKK: Northern half of divergence zone JEF-27/JEF-28 and drift cell JEF-28 to south of Contractor’s Point.

Reach LLL: The shoreline from the terminus of drift cell JEF-29 to the Jefferson/Clallam County boundary.

4.2.18.3 Physical Environment (Maps 15, 22, and 25)

Reach EEE originates at a zone of net shore-drift divergence between McCurdy Point and Cape George to the City of Port Townsend boundary. These tall feeder bluffs (50 to 70 meters high) are composed of Vashon till overlying weaker layers of advance outwash, unidentified glacial sediment, and a base layer of Double Bluff Formation (Ecology, 1978; Keuler, 1988). In general, there is a wave-cut cliff under a steep vegetated slope, topped with another tall cliff of glacial sediments (Ecology, 2001). Net shore-drift is east to Point Wilson in the City of Port Townsend. The bluffs in this reach are considered unstable. In addition, east of McCurdy Point there are many recent and old landslides (Ecology, 1978). The estimated annual rate of bluff retreat at the end of Elmira Street near the City/County boundary is 6 cm a year (Keuler, 1988).

Reach FFF, encompassing drift cell JEF-24, originates from the same feeder bluffs as drift cell JEF-23 and net shore-drift is to the southwest to terminate at Beckett Point (Keuler, 1988).

Accretionary zones occur at the Cape George marina (historically a salt marsh and lagoon) and at the terminus at Beckett Point (Reach GGG), a cuspate spit with salt marsh and lagoon. Erosion is severe just north of Cape George and has endangered homes (Gerstel et al., 1997). With the exception of accretionary shoreforms, this shoreline is considered unstable with frequent landslides (Ecology, 1978). An enclosed brackish lagoon is located within Beckett Point with no open water outlet to the bay (Correa, 2002). Historically, this lagoon/marsh complex was considerably larger and had more regular tidal connection through an inlet to the south. Roads and residential development have filled former wetlands and eliminated tidal connection (Todd, personal communication, 2006).

The next drift cell (JEF-25) originates at a zone of divergence south of Adelma Beach. Net shore-drift is to the northwest for approximately 4.4 miles to terminate at the cuspate spit at Beckett Point (Keuler, 1988). Sediment is derived from Vashon till, undifferentiated Pleistocene sediments, and Vashon advance outwash. This shoreline is generally considered unstable (Ecology, 1978). Salt marshes occur behind deposition beaches in this drift cell, two in the vicinity of Tukey Spit and Chevy Chase and one at Beckett Point (Leon and Driscoll, 1975).

South Discovery Bay (Reach III) encompasses an area of net shore-drift divergence and drift cell JEF-26 south of Adelma Beach to the Snow Creek delta. Drift cell JEF-26 originates from this zone of divergence, and net shore-drift is to the south to terminate at the delta of Snow Creek (Keuler, 1988; Correa, 2002). Sediment is derived from Vashon till; along the shore there is an area of tertiary basalt between Woodman and Fairmont. There is a brackish marsh at Woodman that has no open water connection to the bay (Ecology, 1978). A salt marsh at Fairmont is isolated from the bay by an abandoned railroad bed (Correa, 2002; Ecology, 2001).

A drift cell analysis is not available for Discovery Bay south of the 48th parallel (roughly from Woodman south). Sediment is deposited at the head of the bay at the estuary formed by the deltas of Salmon and Snow Creeks (Correa, 2002). Water quality sampling in Discovery Bay during 2006 showed that all stations met water quality standards for approved classification, except Station #48 (near the boundary with drift cell JEF-27) continues to be listed as threatened because the 90th percentile for the station is near the upper range of the water quality standard. At this point, however, the threatened listing for Station #48 is based on sample results obtained in 2002 and 2003.

The geology of the Quimper Peninsula (including Reaches EEE, FFF, GGG, HHH, and III) is characterized by extensive areas covered with dense basal till, by broad channels eroded through the till into underlying principal aquifer materials, and by the presence of loose ablation till overlying portions of the basal till. Principal aquifer materials are predominantly composed of Vashon advance outwash, pre-Vashon stratified glacial drift, and interglacial deposits (Parametrix et al., 2000).

Reach JJJ, encompassing drift cell JEF-27, originates from a zone of divergence north of Mill Point. Net shore-drift is south to the delta of Salmon and Snow Creeks. A narrow spit occurs perpendicular to shore at Mill Point. Sediments are derived from Vashon recessional outwash, and the bluffs are generally considered unstable with the exception of Mill Point and the depositional beaches and flats at the terminus of the cell (Ecology, 1978; Keuler, 1988).

Drift cell JEF-28 (Reach KKK) originates from the same zone of divergence as drift cell JEF-27. Net shore-drift is north 1.5 km to terminate on the cuspate spit at Contractor's Point. Sediments are derived from the same parent material as JEF-27. Depositional areas are at Kalset Point and Contractor's Point (Keuler, 1988).

Reach LLL encompasses drift cell JEF-29 and Contractor's Point spit. Drift cell JEF-29 originates at the Clallam County boundary. Net shore-drift is southeast toward Contractor's Point, with areas of deposition in front of the Gardiner salt marsh and Contractor's Point (Keuler, 1988).

The geology of Reaches JJJ, KKK, and LLL is characterized by extensive areas covered with till and narrow exposures of alluvium, recessional outwash, and advance outwash along the coast. Bedrock is present in Reach JJJ. The principal aquifer system beneath the till is relatively stratified. The shallow aquifer is primarily composed of Vashon glacial sediments, while both the middle and deep aquifers (where present) are composed of pre-Vashon materials (Parametrix et al., 2000).

4.2.18.4 Biological Resources (Maps 18, 20, 24, and 27)

There is little riparian vegetation in Reach EEE; however, there is significant bluff-top and bluff-side vegetation along this shoreline. Some clearing for views has occurred which may accelerate the inevitable erosion of the shoreline in this reach (Ecology, 2001). One bald eagle nest and patchy kelp have been documented within this reach.

Two bald eagle nests have been documented in Reach FFF. Patchy beds of bull kelp (*Nereocystis luetkeana*) are found north of Cape George. Eelgrass beds are patchy in front of Cape George and Beckett Point and continuous in between. Riparian vegetation is largely intact between the Cape George development and Beckett Point, but some clearing for views has occurred (Ecology, 2001).

Historically, the cuspate spit at Beckett Point enclosed a backshore lagoon and fringing marsh connected to the open water via a surface channel along the south shore of the spit. The spit has been entirely developed, though a remnant of the historical lagoon and fringing salt marsh remains; the tidal connection has been eliminated (Todd et al., 2006).

Within Reach HHH, South and North Tukey Marshes near Chevy Chase have no direct connection to the salt water and are contained by alongshore spits. South Tukey Marsh appears to hold little or no open water, whereas North Tukey Marsh contains a lagoon (Ecology, 2001). This northern marsh also has a small stand of garry oak (*Quercus garryanna*) and other native and uncommon prairie plants along its shores (Admiralty Audubon Society, 1990). There is a bald eagle nest within this reach as well. Sand lance spawn on the north side of both of these spits (Penttila, 2000; Long et al., 2005). Eelgrass beds are patchy in front of Beckett Point and near Adelma Beach; otherwise eelgrass grows continuously along this shoreline and the Discovery Bay herring stock uses it for spawning (Penttila, 2000). Sand lance spawning habitat is continuous along Adelma Beach, and surf smelt spawn at the southern end of this reach (Penttila, 2000; Long et al., 2005).

The steep, unstable bluffs south of Beckett Point harbor uncommon prairie species, including prickly pear cactus (*Optunia fragilis*), threadleaf phacelia (*Phacelia linearis*), menzies larkspur (*Delphinium menziessi*), chocolate lily (*Fritilaria lanceolata*), and harvest brodiaea (*Brodiaea coronaria ssp. coronaria)* (Gorsline, personal communication, 2004). This is the only site in Jefferson County where prickly pear cactus and thread-leaf phacelia are found, and it is a rare example of the dry, post-glaciation vegetation on the northeast Olympic Peninsula. In addition, this area harbors the only significant old-growth Douglas fir forest on the Quimper Peninsula. Most likely, it was passed over for cutting due to the trees being severely pruned and topped by strong winds out of the Strait of Juan de Fuca, and the very steep nature of the bluffs. It is a rare example of a Douglas fir, madrona, and snowberry dominated ecosystem.

Riparian vegetation is spotty throughout drift cell JEF-25 due to clearing in the Adelma Beach reach and erosive bluffs in the reaches north. A house is perched on top of an active feeder bluff (essentially a landslide) in the South Beckett Point Bluffs area (Ecology, 2001). In general, the area between Tukey and Beckett Point is a quite pristine area of erosive bluffs and forested slopes with intermittent meadows that support uncommon prairie plants (WDNR, 2001; Ecology, 2001).

Eelgrass is continuous in the northern part of Reach III and patchy near the head of the bay; herring use it for spawning (Penttila, 2000). Two bald eagles have been documented within this reach. Surf smelt and sand lance spawn near the origin of drift cell JEF-26 as well as in front of the old mill pond; sand lance spawn in front of Fairmont (Penttila, 2000; Long et al., 2005). Riparian vegetation is generally sparse and absent from the southern part of drift cell JEF-26 due to the abandoned railroad grade (WDNR, 2001). Some salt marsh vegetation is present in Fairmont Marsh and Discovery Junction Marsh. It is likely that a shift has occurred from salt marsh domination to a mixture of fresh and salt marsh vegetation in Fairmont Marsh. A limited saltwater connection occurs today through a pipe, and a small delta is present on the beach (Todd et al., 2006).

The estuaries of Salmon and Snow Creeks provide salt marsh and shallow water habitat for juvenile salmonids. Salmon Creek supports spawning by summer chum and coho (Correa, 2002). Maynard Lagoon, located just north of the Salmon Creek estuary, was historically an open tidal flat, with at least two streams entering the nearshore at this site. This area has received fill for a mill and Highway 101. The Chicago, Milwaukee, and St. Paul railroad grade has enclosed the lagoon, resulting in filling with sediment due to a reduction in tidal exchange (Todd et al., 2006).

In Reach JJJ, eelgrass is patchy toward the end of drift cell JEF-27 and in front of Mill Point. Otherwise, eelgrass grows continuously along this drift cell. Herring use this eelgrass for spawning. Sand lance spawn on the north side of Mill Point, just north of Trend West Condominiums and continuously for the last kilometer of the cell (Penttila, 2000; Long et al., 2005). Riparian vegetation covers about 20 percent of the shoreline south of Trend West and is heavy north of Mill Point. However, for the most part it is lacking over the remainder of this shoreline (WDNR, 2001). A bald eagle nest occurs within this reach as well.

Eelgrass is continuous along Reach KKK with patches of brown kelp and *Ulva*. There is a salt marsh at Kalset Point. Oysters are found south of Contractor’s Point and an aquaculture facility is located at Kalset Point (Correa, 2002). Sand lance spawn at the origin of the cell and on Kalset

Point, while herring spawn offshore (Penttila, 2000; Long et al., 2005). The shoreline between Kalset Point and Contractor's Point spit is pristine with abundant riparian vegetation, as is the area south of Kalset Point (Ecology, 2001; Correa, 2002). The area surrounding Contractors Point spit has been cleared and fragmented by numerous private roads and drives (WDNR 1994, 2000 aerials). The lower half-mile of Contractor's Creek was routed through a series of culverts and the adjacent riparian zone filled for private development. A blocked culvert at the Old Gardiner Highway temporarily dammed Contractors Creek, which then undercut the highway and washed the highway and large volumes of highway fill into a new floodway on the north side of the spit. After the flood, the property owner rerouted the creek back into the culverts and the Jefferson County Public Works Department replaced the highway and re-routed the creek channel into a deep ditch. Upstream of Old Gardiner Highway, the Contractors Creek crossing at State Route 101 has been identified as a Chronic Environmental Deficiencies area due to a continual need for infrastructure maintenance that is damaging to fish habitat (WSDOT 2007). A bald eagle nest is located within this reach, and the spit at Contractor's Creek is a haulout area for harbor seals.

Eelgrass and *Ulva* are continuous along Reach LLL. Sand lance spawn along the Gardiner shoreline and on the north side of Contractor's Point (Penttila, 2000; Long et al., 2005). Aerial photos show that large salt marsh occurs at Gardiner (Ecology, 2001); although truncated by a road, it appears to provide habitat suitable for juvenile salmonids. This salt marsh is also important waterfowl and shorebird habitat. Riparian vegetation in this segment is generally good, with some clearing for views. A pristine area occurs south of Gardiner (Ecology, 2001). Gardiner Lagoon is located in a small glacial depression with a narrow barrier spit enclosing tidal marsh and lagoon habitat. A small stream enters the marsh near its west end. Eagle Creek estuary on the Clallam/Jefferson County line is a bar bound estuary with salt marsh and potential for fish use (Correa, 2002). Sand lance spawn continuously from the County line south through Gardiner (Penttila, 2000).

Protection Island north of Discovery Bay is a National Wildlife Refuge and Washington State Seabird Sanctuary, with a few residential properties (Murray and Ferguson 1998). The Island is not subject to County shoreline jurisdiction. It harbors significant marine mammal populations and 80 percent of the nesting seabirds in Puget Sound, including rhinoceros auklets, pigeon guillemots, black oystercatchers, and glaucous-winged gulls (Nightingale, 2000; Jefferson County, 2002).The surrounding waters and County shorelines provide foraging areas for these animals. Two geoduck tracts north of Protection Island are classified as approved for shellfish harvest; however these areas were closed for 21 days in 2005 due to high levels of biotoxin (WDH, 2006a).

Within all shoreline reaches, 13.5 percent or less of the planning area is wetland (variation from reach to reach), with estuarine – intertidal the primary classification. No wetland data are available in Reach EEE. Significant areas of palustrine wetland (emergent, scrub/shrub, unconsolidated shore) are located within Reaches GGG, HHH, and III.

4.2.18.5 Land Use and Altered Conditions (Maps 12 and 22)

Land Use and Zoning

Land use along the shoreline is dominated by residential development in all reaches. Rural Residential zoning over more than 98 percent of the planning area reflects existing land use.

Transportation and Utilities

Within the marine planning area, Jefferson County and WDNR have mapped 4.4 miles and 11.6 miles of road, respectively. Along the Strait of Juan de Fuca, Lands End Lane, Porter Lane, and several roads within Cape George parallel the shoreline. Within Discovery Bay, from Beckett Point to the northern boundary of Reach LLL, Beckett Point Road, Cliffside Drive, South Discovery Road (State Route 19), Lower Aldema Beach Road, Madrona Beach Road, State Route 20, Woodman Road, Fairmount Road, Old Gardiner Road, Orcas Drive, Bachelor Road, and Gardiner Beach Road parallel the shoreline.

Shoreline Modifications

Shoreline modification statistics for these nearshore reaches are as follows:

- Reach EEE area: No bulkhead data, 3 stairways; 1 launch ramp.
- Reaches FFF, III, and JJJ: 2.5 miles of bulkhead (82 percent to 93 percent rock; concrete and/or wood in remaining bulkhead areas); 2, 11, and 4 stairways, respectively; 5 docks/piers in Reach III, 3 in Reach JJJ; 1 rail launch in Reach JJJ; 1 marina in Reach FFF.
- Reach GGG: 0.4 mile of bulkhead (74 percent concrete, 16 percent wood, and 9 percent rock); no stairs; 1 launch ramp.
- Reach HHH: 0.4 mile of bulkhead (96 percent wood and 4 percent concrete); 11 stairways; 2 docks/piers; 1 rail launch.
- Reaches KKK and LLL: 0.5 mile of bulkhead (97 percent to 100 percent rock, concrete in all remaining bulkhead areas); 1 stairway in Reach LLL; 1 dock/pier in both Reaches LLL and KKK.
- Facilities include a State Cleanup Site in Reach EEE.

The Cape George development has seen extensive clearing, possibly contributing to erosion (Ecology, 2001). Stormwater entering the nearshore is an issue at Cape George. Several private stormwater drains enter the beach and one large storm drain empties into a ravine, which then drains untreated into the bay (Correa, 2002).

The marina at Cape George, covering 1,917 square feet, is protected by a jetty that interrupts longshore transport of sediment and is constructed on a depositional beach or historic salt marsh and lagoon. In addition, there is extensive shoreline armoring near the marina. There is extensive armoring with seawalls and riprap along the northwest shore of Beckett Point (Ecology, 2001). Alongshore drift is interrupted on the north side of Beckett Point by a boat ramp, which has led to erosion on the down drift side of the boat ramp, toward the tip of the spit. Both the north and south sides of Beckett Point have several sizable bulkheads, which may be adversely affecting net shore-drift of sediment.

The shoreline armoring and fill along the Adelma Beach reach (Reaches HHH and III) may be affecting sediment recruitment into the nearshore (Correa, 2002). In addition, it may interrupt longshore transport and increase wave reflection, resulting in a coarsening of the beach.

South of Woodman, an aquaculture facility interrupts longshore transport of sediment (Correa, 2002). Between Woodman and the delta of Salmon and Snow Creeks, the backshore is isolated by a bulkheaded railroad grade that is 2.5 km long. At Fairmont there is extensive armoring including structures built on armored fill extending into the nearshore (Correa, 2002; Ecology; 2001). The salt marsh at Fairmont is isolated by the railroad grade (Correa, 2002). Due to failure of a culvert in early 2005, there may currently be limited tidal connection (Todd, personal communication, 2006).

The shared delta of Salmon and Snow Creeks, at the southern extent of Reach III, is subject to extensive modification. Snow Creek and Salmon Creek historically converged 100 meters south of Highway 101 and shared an estuary. However, due to rechannelization, Snow Creek and Salmon Creek now flow separately to the salt water. Snow Creek's estuarine function is largely lost due to channelization, dikes, fill, and truncation by the abandoned railroad grade. Likewise, Salmon Creek has lost estuary and salt marsh habitat due to truncation by the railroad grade. Mill ponds northwest of the mouth of Salmon Creek, which are located on a historic broad tide flat with fringing salt marsh (Todd, personal communication, 2006), have been truncated by road fill.

The Trend West condominiums in the JEF-27 reach are built on armored fill that extends over the intertidal, eliminating shallow water habitat essential for the migratory success of juvenile summer chum (Correa, 2002). The mouth of Contractor's Creek has been highly altered by being moved and forced through a series of undersized culverts. In addition, portions of Contractor's Point spit have been armored for a peripheral access road, eliminating 2 acres of historic salt marsh (Correa, 2002; Ecology, 2001; Todd et al., 2006). The spit is also covered in invasive non-native vegetation (Ecology, 2001).

Upland agricultural practices, stormwater runoff, and failing or lack of septic systems may also contribute non-point pollution to Discovery Bay (Berbells, 2003).

4.2.18.6 Public Access (Map 22)

Although the residents of Discovery Bay often have access to the bay through private easements, public access is limited. Members of the public often walk the beach from North Beach County Park within the City of Port Townsend down to Middlepoint. There is access at the head of Discovery Bay in the estuaries of Salmon and Snow Creeks on WDFW property. There is a public boat ramp maintained by the Port of Port Townsend in Gardiner. There is also a stretch of WDNR tidelands with boat access between Adelma Beach and Cape George.

4.2.18.7 Restoration Opportunities

Habitat could be restored at the mill ponds northwest of the mouth of Salmon Creek by removing fill. Likewise, removing the fill under the railroad grade and pulling back dikes would increase intertidal salt marsh habitat and water flow (Correa, 2002). The restoration of the combined estuary of Salmon and Snow Creek has received funding from the State Salmon Recovery Funding Board. This restoration will improve water flow and natural vegetation by removing dikes, and will also place LWD into the nearshore and estuary habitats. The removal of the bulkheaded railroad grade would increase shallow nearshore habitat and sediment recruitment into the nearshore.

Contractor's Point spit is highly altered and the restoration of the salt marsh and creek mouth would improve salmonid habitat.

4.2.19 Snow Creek and Salmon Creek (Discovery Bay)

4.2.19.1 Overview (Map 1a)

Snow Creek's headwaters are in the eastern foothills of the Olympic Mountains, draining a watershed area of approximately 22 square miles, with a mainstem length of about 10 miles. Flow is to the north to Discovery Bay (Correa, 2002). Salmon Creek originates on the northern slopes of Mount Zion, has a watershed area of 23.6 square miles, and flows 9 miles into Discovery Bay. Prior to development in the area, which resulted in the present channelized outlet at the east side of the valley, Snow Creek emptied into Salmon Creek near its estuary. During certain flood events, Snow Creek overflows into its original channel in the pasture, reestablishing some direct contact with Salmon Creek. Snow Creek still joins Salmon Creek in the intertidal area during low tides (Correa, 2002).

Over 90 percent of the watersheds are forested with coniferous forest in various stages of development. Both drainages have an average annual precipitation of 35.5 inches (Correa, 2002).

4.2.19.2 Freshwater Reaches (Map 9)

Snow Creek 1: River mouth to approximately RM 1.2.

Snow Creek 2: RM 1.2 to approximately RM 3.3, below Crocker Lake.

Salmon Creek 1: River mouth to approximately RM 0.75.

Salmon Creek 2: RM 0.75 to approximately RM 1.5.

4.2.19.3 Physical Environment (Maps 15, 22, and 25)

Over 50 percent of the Salmon-Snow Creek basin is underlain by till soils, and approximately 3,000 acres is covered by palustrine or estuarine wetlands, or hydric soils. A relatively low rate of groundwater recharge is predicted, which is largely controlled by the presence of bedrock, which covers about 72 percent of the subbasin (Parametrix et al., 2000). The Salmon Creek watershed is underlain primarily by the Crescent basalt formation consisting of basalt flows and mudflow breccias. The basalts are generally harder and more erosion-resistant than the sedimentary rocks in this area. A fault, running approximately east-west, terminates the basalt exposure on the watershed's southern boundary (Tabor and Cady, 1978). The lower watershed is characterized by sand, gravel, and clay deposited during glaciation. Material transported from the upper watershed forms a broad alluvial fan (Bernthal et al., 1999 as cited in Parametrix et al., 2000).

The lower reaches of Snow Creek, from the mouth to RM 4.1, course through a wide alluvial valley. The Snow Creek riparian zone, once dominated by conifers, is now dominated by deciduous trees and is rather narrow (76 percent is less than 66 feet wide) (Correa, 2002).

The Salmon Creek riparian zone has largely been converted to agriculture. Cattle exclusion fencing does exist in Reach 1 with the exception of access points for livestock watering. In 2002 WDFW purchased a 100-acre farm containing most of the summer chum habitat downstream of Uncas Road. Approximately 2,500 feet of new channel was constructed, and a riparian forest buffer was planted on this property (Latham, personal communication, 2006).

4.2.19.4 Biological Resources (Map 18)

Snow Creek and Salmon Creek support runs of coho, steelhead, and summer chum salmon. Coho and steelhead are listed as critical in SASSI, and summer chum are listed as threatened under the Endangered Species Act (Correa, 2002). Other fish species found here include sculpins (*Cottidae*), Pacific lamprey (*Lampetra tridentatus*), and brook lamprey (*L. richardsoni*) (Parametrix et al., 2000), as well as white sturgeon (*Acipenser transmontanus*) (Todd, personal communication, 2006).

The entire lower stream valley is described in the 1869-1870 coastal survey mapping (T-sheet) as a wetland upstream of the County road, with areas of scrub/shrub or wooded wetlands. Specifically, the lower 0.3 mile of stream valley was described as dominated by “salmonberry brier” (Todd et al., 2006).

Within the lower basin (reaches Snow Creek 1, Salmon Creek 1 and 2), 13.5 percent of the planning area is wetland. Within Snow Creek 2, 33 percent of the planning area is wetland. Between 40 percent and 70 percent of all wetland is classified as palustrine emergent. Forested, scrub/shrub, and open water palustrine wetlands represent the remaining wetland cover.

4.2.19.5 Land Use and Altered Conditions (Maps 12 and 22)

Land Use and Zoning

Zoning is 70 percent Rural Residential and 20 percent Commercial Agriculture along Snow Creek. Zoning is 90 percent Commercial Agriculture along lower Salmon Creek, and 98 percent Commercial Forest along upper Salmon Creek.

Land use in the Snow Creek and Salmon Creek basin is a mix of rural residential and agricultural land adjacent to the stream, and commercial forestry dominating the watershed.

Transportation and Utilities

Within the planning area of Snow Creek Reach 1, Jefferson County and WDNR have mapped 1.35 miles and 1.75 miles of road, respectively. West Uncas Road and National Forest Road 2986 are within the planning area of Salmon Creek. Highway 101, along with interchanges with Highway 104 and State Route 20, are all near or within the planning area of Snow Creek.

Shoreline Modifications

The estuary of both Salmon and Snow Creeks is heavily impacted by transportation, commercial development, and some residential development associated with the Highway 101 corridor that passes around the southern end of Discovery Bay. Lower Snow Creek has been channelized both upstream and downstream of Highway 101. A railroad grade also parallels the highway, transecting the delta. Extensive logging has occurred in these basins. The timber harvest rate in the Salmon-Snow watershed has been 19 to 23 percent, higher than the generally accepted rate of 16 percent (Parametrix, 2000).

WDFW operates a salmonid population monitoring weir on Snow Creek at approximately RM 0.8, and on Salmon Creek during August, September, and October at approximately RM 0.3. Both weirs restrict gravel, sediment, and LWD movement downstream. In Snow Creek, gravel and sediments are removed periodically and disposed of at an upland site. LWD is passed downstream and contributes to habitat structure (Correa, 2002). Activities at the Salmon Creek weir were scheduled to terminate in 2004.

A portion of Snow Creek below RM 3.5 has been armored with riprap.

Forestry and agricultural operations such as livestock and hay production have been identified as the main potential sources of non-point pollution (such as fecal coliform, excessive nitrogen loads, and sediment) in the Salmon-Snow subbasin. The Washington State Department of Health has listed an area within the southwest portion of Discovery Bay as threatened with closure due to increasing fecal coliform contamination, though recent trends may be improving (WDH, 2006a). Urban and residential use is sparse, and although failing septic systems and urban runoff occur within this subbasin, they are not considered major sources of non-point pollution (Parametrix et al., 2000).

4.2.19.6 Public Access (Map 22)

There is access at the head of Discovery Bay in the estuaries of Salmon and Snow Creeks on WDFW property.

4.2.19.7 Restoration Opportunities

Portions of Snow Creek could be re-meandered and riparian planting could take place to improve channel condition and riparian cover. The extensive restoration of the estuary by members of the Chumsortium, a local salmon recovery group that includes the North Olympic Salmon Coalition, should improve juvenile salmonid survival.

4.2.20 Crocker Lake (Discovery Bay)

4.2.20.1 Freshwater Reaches (Map 9)

Crocker Lake: 0.5 mile south of the upstream limit of Snow Creek 2.

4.2.20.2 Description

Crocker Lake is in the Snow Creek watershed, discharging to Anderson Creek, which flows to Snow Creek at RM 3.5. The total surface area of the lake is 74 acres. Crocker Lake is used as rearing habitat by coho salmon. The lake is closed to fishing due to the presence of the Snow Creek Research Station, operated by WDFW, downstream of the lake. Bald eagle habitat has been mapped across Crocker Lake and in the surrounding area.

Crocker Lake is an area of low-density residential and agricultural lands. Eighty-four percent of the planning area surrounding the lake has been mapped as wetland (primarily lacustrine – limnetic). Within the planning area of Crocker Lake, Jefferson County and WDNR have mapped 0.35 mile and 0.26 mile of road, respectively. Fuller Road, Lake View Drive East, East Snow Creek Way, Crocker Lake Road, and Highway 101 are all within the planning area of Crocker Lake.

There is a public boat launch on Crocker Lake. Possible restoration on Crocker Lake might include the planting of native riparian vegetation along its shores and the control of non-native reed canarygrass.

4.2.21 Additional Lakes in WRIA 17

There are several additional lakes in WRIA 17 that have been determined to be too small to qualify as shorelines of the state. Horseshoe Lake is just north of State Route 104, and is surrounded primarily by a narrow buffer of trees within commercial forestland. Washington Department of Natural Resources (WDNR) lists Horseshoe Lake in its Natural Heritage Program (NHP) database, for Low Elevation Freshwater Wetland and Western Spiraea (*Spiraea douglasii*) Shrubland. Horseshoe Lake, along with Teal Lake, is within WDNR's historic NHP for Golden Indian Paintbrush (*Castilleja levisecta*).

East Wahl Lake (also referred to as Twin Lakes) is north and east of Wahl Lake Road, and within Commercial Forest zoning. Surrounding lands are mostly forested. WDNR's historic NHP includes East Wahl Lake for Golden Indian Paintbrush (*Castilleja levisecta*), and its current NHP includes the lake for Three-Way Sedge (*Dulichium arundinaceum*) Seasonally Flooded Herbaceous Vegetation; Western Inflated Sedge (*Carex exsiccata*) Herbaceous Vegetation (Provisional); Baltic Rush (*Juncus balticus*) Herbaceous Vegetation; Western Spiraea (*Spiraea douglasii*) Shrubland; Oregon Crabapple (*Malus fusca*) Shrubland; Low Elevation Bog; and Low Elevation Freshwater Wetland.

Embody Lake lies just west of SR 19 and south of Embody Road. Adjacent zoning is Rural Residential 1:10, and surrounding land includes forest and open areas with some residential housing on the lake's west side. Embody Lake was identified by Tomassi et al. (2004) as Type 3 Core Habitat (composed mostly of historic wetlands, and selected primarily for their restoration and enhancement potential).

Delaney Lake lies east of Eaglemount Road. Surrounding land is primarily open, with scattered residential units set back from the eastern shoreline, and may be used for agriculture. Zoning is Rural Residential 1:20. Delaney Lake was identified by Tomassi et al. (2004) as Type 3 Core Habitat (composed mostly of historic wetlands, and selected primarily for their restoration and enhancement potential).

Browns Lake is a small lake, less than 9 acres in size, located approximately 0.6 miles to the northeast of Tarboo Lake. The lake is located in the headwaters of the Tarboo Creek watershed, which drains to Tarboo Bay. The County's wetland inventory maps wetlands extending around the shoreline of the lake and along the outlet stream. Adjacent zoning is entirely Commercial Forest. Land use is largely coniferous and mixed forest, with no recent logging activity. There is no public access to the lake and minimal development of any kind within the shoreline area.

Thorndyke Lake is a very small lake with less than one acre of open water according to Bahls et al. 2006. It is located approximately 0.3 miles to the north of the Hood Canal shoreline near the intersection of Thorndyke Road and Kelly Drive. NWI mapping and the County wetland inventory map the entire are as wetland. Adjacent zoning is a mix of Rural Forest, Commerical Forest, and Rural Residential. Land use is largely undeveloped, consisting of open areas and mixed forest. Residential land uses are located to the south of the lake, along Thorndyke Road and the Hood Canal shoreline. There is no public access to the lake and minimal development of any kind within the shoreline area.

Larson Lake lies just north of Larson Lake Road at French Road and approximately one mile to the northeast of Ludlow Lake. The lake is less than 5 acres in size, and from aerial photography appears to seasonally loose all open water areas. NWI mapping and the County wetland inventory map the entire are as wetland. Adjacent zoning is Commercial Forest and Inholding Forest, and surrounding land includes forest and open areas with some small structures and graded areas located to the north of the lake off of French Road. There is no existing public access to Larson Lake.

None of the lakes listed above are listed as impaired on Department of Ecology's 2004 Water Quality Assessment.

4.3 WRIA 20 – SOL DUC-HOH

The Sol Duc-Hoh WRIA includes the northwest corner of Jefferson County and parts of Clallam County (Figure 4-4). The largest basin in WRIA 20 is the Quillayute with its four major subbasins: the Dickey, Calawah, Bogachiel, and Sol Duc Rivers. Other basins include the Waatch, Sooes, Ozette, and Hoh systems, as well as several small independent streams. Within this WRIA are 569 streams and 1,355 stream miles.

Annual rainfall in the basin is the highest in the state, ranging from 80 inches near the coast to 240 inches in the Olympic Mountains. This region is often exposed to high wind and heavy rainstorms. Unlike many other areas of the state, this region has a significant portion of unlogged forestland, located in the ONP. In these undisturbed areas, temperate, coniferous, old-growth rainforests are dominated by Sitka spruce in the lowlands and western hemlock with silver fir in the higher elevations. Bigleaf maple is also a component of the rainforests. The old-growth conifers can reach up to 200 feet in height, and are characterized by somewhat open canopies and low densities.

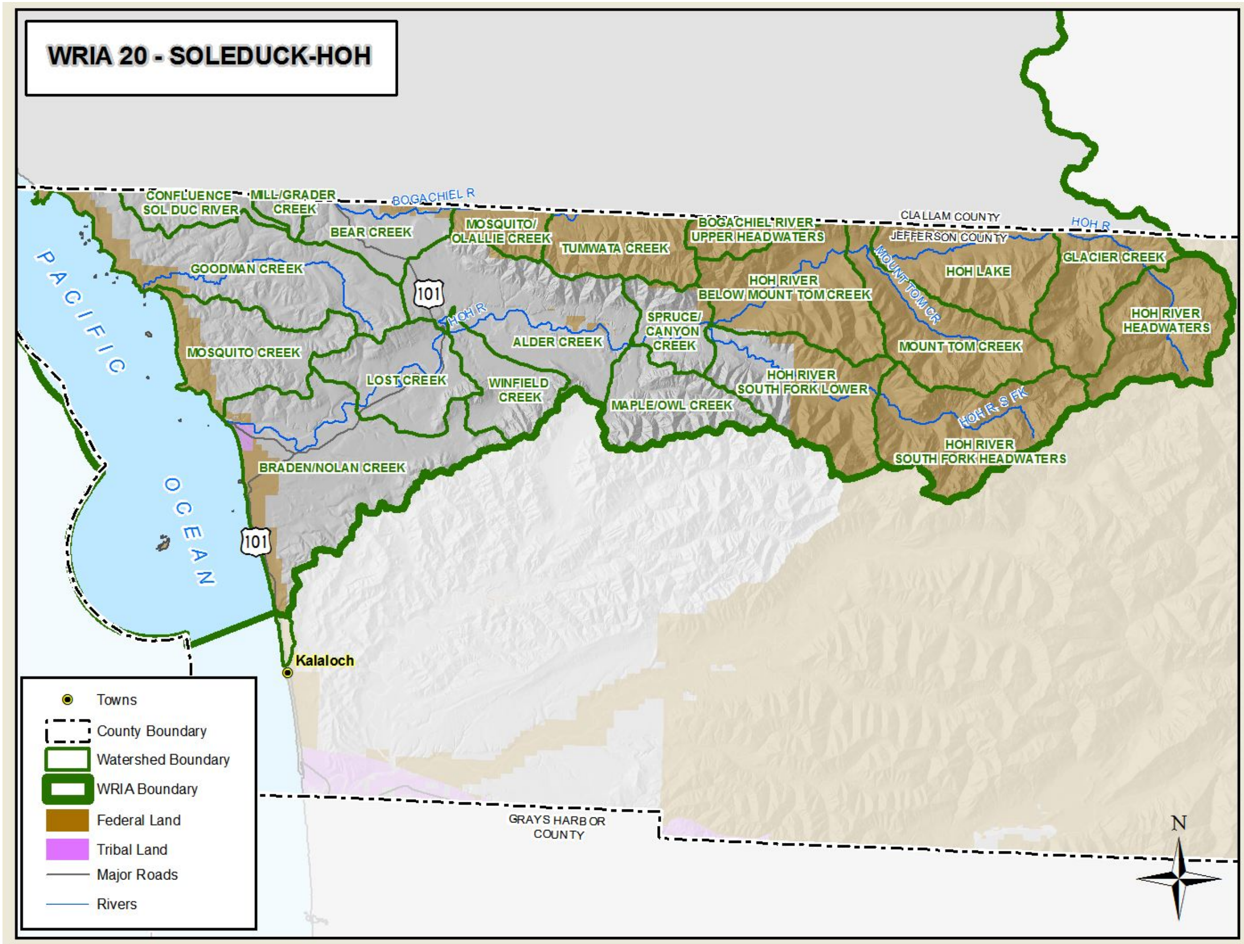
Outside of ONP boundaries, timber harvest generally began in this region in the 1920s-1930s, using rail to transport the logs. Road construction for log trucks began in the 1940s, and early roads often used side-cast technology on steep slopes, which still create sediment problems today. From the 1960s through the 1980s, extensive clearcutting and road construction occurred throughout the WRIA except in the ONP, which has remained undisturbed. Current timber harvest practices have improved to increase riparian buffers and reduce road impacts (Smith, 2000).

4.3.1 Bogachiel River (Bogachiel River Lower)

4.3.1.1 Overview (Map 1b)

The Bogachiel River has its headwaters in the Olympic Mountains in the Seven Lakes basin, and flows west to meet with the Quillayute River west of Forks in Clallam County (Map 20). The upper reaches of the Bogachiel River lie within the ONP, while the middle and lower reaches are used primarily for timber production and farming. The lower Bogachiel River area is agricultural and also supports the southern edge of the City of Forks. There is also a state fish hatchery near Forks (for summer and winter steelhead) at the confluence of the Bogachiel and Calawah Rivers (Hook, 2004). This report pertains to approximately 4 miles of the river upstream of the Clallam County line to the boundary of the ONP. The Bogachiel River is a shoreline of statewide significance.

Figure 4-4. WRIA 20 in Northwest Jefferson County



Washington State Department of Ecology

4.3.1.2 Freshwater Reaches (Map 10)

The entire length of the Bogachiel River within western Jefferson County and outside of federal land is treated as one reach. The reach extends from approximately RM 17 to RM 22.

4.3.1.3 Physical Environment (Maps 19 and 23)

Vegetation within the planning area is composed of 44 percent evergreen forest, 19 percent bare rock/sand/clay, and 17 percent deciduous forest. Transitional, shrub and brush rangeland, and mixed forest represent the remaining land cover.

Collapsing banks have been a problem in this section of the Bogachiel River, leading to sedimentation of the streambed. This erosion has also necessitated moving several roads back from the river. Channel incision has also exposed clay layers, the erosion of which has led to a worsening of sediment quality. This parameter is listed as “poor” (Smith and Caldwell, 2000). The area in the vicinity of Hemp Hill Creek is listed on the 303(d) list for high water temperatures and low dissolved oxygen.

Within the Bogachiel River reach, 14 percent of the planning area is wetland. The primary wetland classifications are palustrine forested and scrub/shrub (63 percent) and riverine upper perennial (37 percent).

4.3.1.4 Biological Resources (Map 19)

The Bogachiel River supports coho salmon; summer, fall, and spring Chinook salmon; and winter and summer steelhead trout. The coho and fall Chinook populations are listed as healthy, whereas the summer Chinook stock is listed as threatened. The status of the spring Chinook stock is unknown. The winter steelhead trout run is listed as healthy, and the status of the summer steelhead run is listed as unknown.

LWD levels are low downstream of Hemp Hill Creek and better upstream. Although systematic data are lacking, the riparian condition of this stretch of river is though to be "fair" (Smith and Caldwell, 2000).

Roads within the floodplain act as dikes, disconnecting potential off-channel habitat and increasing sediment input to the river.

4.3.1.5 Land Use and Altered Conditions (Map 23)

Land Use and Zoning

Land use in this reach of the Bogachiel River is primarily residential and forestry. Zoning within the reach planning area reflects this, with 55 percent of the area zoned Rural Residential, 29 percent ONF, and 11.6 percent Commercial Forest.

Transportation and Utilities

Within the planning area of the Bogachiel River, Jefferson County and WDNR have mapped 3.9 miles and 7.2 miles of road, respectively. Highway 101, South Bogachiel Road, and Kallman Road run along the south bank of the river reach. Undie Road runs along the north bank through the reach.

Shoreline Modifications

Some of the major habitat problems for the Bogachiel mainstem include "poor" riparian and LWD conditions downstream of the ONP boundaries, as well as an aggraded mainstem that worsens downstream (Smith, 2000). The lack of LWD on the mainstem has led to increased water velocity and sediment transport on the mainstem of the Bogachiel. This in turn has increased channel incision and exposed unstable clay layers. This incision has released sediment into the river and has resulted in a level of fines greater than 17 percent. Collapsing banks from the Hemp Hill confluence to Highway 101 have required localized road relocation (Hook, 2004). No information on shoreline modifications specific to this reach is available.

4.3.1.6 Public Access (Map 23)

Except for areas of federally owned national forest and park, land along the Bogachiel reach is privately owned by timber companies and individuals.

4.3.1.7 Restoration Opportunities

Restoration opportunities identified for the Bogachiel River include increasing the amount of LWD in areas rated as "poor," routing road sediments to the forest floor rather than to stream channels, decommissioning side-cast roads, and improving road surfacing to reduce sediment inputs into streams (Smith, 2000).

4.3.2 Goodman Creek (Goodman Creek)

4.3.2.1 Basin Overview (Map 1b)

Goodman Creek flows into the Pacific Ocean south of the Quillayute River and north of Mosquito Creek. The lower 2 miles of the stream are within the ONP, and the headwaters are in the coastal hills west of Highway 101. There is little information on this watershed.

4.3.2.2 Freshwater Reaches (Map 10)

Goodman Creek 1: From the ONP boundary upstream to the confluence with Minter Creek.

Goodman Creek 2: From the confluence of Minter Creek upstream to the divergence of the east and west forks.

Goodman Creek 3: East and west forks of Goodman Creek.

Minter Creek: From the confluence with Goodman Creek to the upstream extent of shoreline jurisdiction.

4.3.2.3 Physical Environment (Maps 19 and 23)

Land cover within the Goodman Creek basin planning area is 88 percent evergreen forest, with bare rock/sand/clay, deciduous forest, shrub and brush rangeland, and mixed forest representing the remaining land cover. Goodman Creek contains a high density of wetlands indicating high groundwater inputs. Approximately 52.4 percent of the area within Reach 1 is wetland; however, less than 7 percent of the planning area above the Goodman – Minter convergence is wetland.

Information concerning LWD and other habitat attributes in Goodman Creek are lacking; however, it has been noted that LWD was rated "good" in this basin, except where LWD and spawning gravel are lacking from Road G 2108 to the G 3000 bridge (Silver, personal communication, as cited in Smith, 2000). There is also a lack of deep pools and an alder-dominated riparian zone in the middle section of mainstem Goodman Creek (Silver, personal communication, as cited in Smith, 2000). Pool habitat, water temperature, and hydrologic maturity within Goodman Creek have been rated as poor.

Less than 7 percent of the planning area is wetland above the convergence of Goodman Creek and Minter Creek. Downstream of the convergence (Goodman Creek 1), 52 percent of the planning area is wetland. The primary wetland classification throughout the Goodman and Minter Creeks planning area is palustrine scrub/shrub and forested. In Goodman Creek Reaches 1 and 2 there are significant areas of riverine upper perennial wetland (NWI, 2005).

4.3.2.4 Biological Resources (Map 19)

Fall coho salmon and winter steelhead and cutthroat trout spawn in Goodman Creek but the status of these stocks is unknown (Smith, 2000).

4.3.2.5 Land Use and Altered Conditions (Map 23)

Land Use and Zoning

Land use within the Goodman Creek planning area is predominantly forestry. In the mainstem, land use is 66 percent to 100 percent commercial forest, and up to 33 percent rural residential. Within the Minter Creek reach, land use is 100 percent commercial forest.

Extensive logging within the Goodman Creek basin has increased the risk of damaging peak flow events. Evidence of changes is already noted, such as bank erosion, gravel bar movement, and scour (Smith, 2000).

Transportation and Utilities

WDNR has mapped 3.3 miles of road within this planning area. Utilities are unknown.

Shoreline Modifications

Three blocking culverts on left bank tributaries to Goodman Creek created by Roads G 3300 and G 3310 affect coho, steelhead, and cutthroat habitat. Blocking culverts are also created by Roads G 2170 and G 2100, affecting coho, cutthroat, and steelhead habitat on five right bank tributaries.

With a road density of 3.2 miles per square mile and a road erosion rate of 148 percent, Goodman Creek was rated "poor" for both road density and road erosion (Smith, 2000). Extensive logging within the basin has increased the risk of damaging peak flow events (Smith, 2000).

4.3.2.6 Public Access (Map 23)

The upper watershed is WDNR land.

4.3.2.7 Restoration Opportunities

The primary opportunities for restoration in this watershed involve replacement of culverts that are blocking access to anadromous habitat.

4.3.3 Mosquito Creek (Goodman Creek)

4.3.3.1 Overview (Map 1b)

There is little information on Mosquito Creek. The lower approximately 1.5 miles are within the ONP. The headwaters are in the coastal hills west of Highway 101.

4.3.3.2 Freshwater Reaches (Map 10)

Mosquito Creek 1: From the ONP boundary upstream to RM 5.2.

Mosquito Creek 2: From RM 5.2 to the upstream extent of shoreline jurisdiction.

4.3.3.3 Physical Environment (Maps 19 and 23)

Vegetation within the Mosquito Creek planning area consists of 84 to 89 percent evergreen forest, with the remainder composed of deciduous forest, shrub and brush rangeland, transitional, and mixed forest. Less than 4 percent of the Mosquito Creek planning area is wetland. More than 75 percent of these wetlands are palustrine forested, while the remainder are scrub/shrub.

Mosquito Creek had water temperatures that exceeded state standards. However, these areas are located in the ONP in old-growth forest and represent natural conditions (Smith, 2000).

4.3.3.4 Biological Resources (Map 19)

Fall coho and winter steelhead use this watershed for spawning; the health of these runs remains unknown (Smith, 2000).

4.3.3.5 Land Use and Altered Conditions (Map 23)

Land Use and Zoning

The middle and upper reaches of Mosquito Creek are surrounded by private and state timberlands. Land use in the Mosquito Creek planning area is more than 94 percent commercial forest, with 5.5 percent zoned Rural Residential in the upper reach.

Transportation and Utilities

WDNR has mapped 2.2 miles of road within the Mosquito Creek planning area. Mapped roadways provide access to the commercial forest and are predominantly unpaved.

Shoreline Modifications

There are several blocking culverts on Mosquito Creek. Sedimentation due to altered riparian conditions and forest road usage has degraded channel conditions.

Public Access

Mosquito Creek flows through WDNR land for about a mile just upstream of the ONP boundary.

4.3.3.6 Restoration Opportunities

There are several blocking culverts on Mosquito Creek. These should be replaced to open up anadromous fish habitat (Silver, personal communication, 2000).

4.3.4 Hoh River and Tributaries (Hoh River Lower, Middle and South Fork)

4.3.4.1 Overview (Map 1b)

The headwaters of the Hoh River are in the snowfields and glaciers of Mount Olympus. This glacially fed river flows out of the Olympic Mountains and winds across a broad floodplain through coastal hills. The upper watershed is protected in the ONP, and the lower mile of the river lies within the Hoh Indian Reservation.

The Hoh watershed, and other watersheds on the west side of the Olympic Peninsula, are subject to the greatest annual precipitation in the U.S. outside of Hawaii, ranging from 70 to 100 inches of precipitation at the coast, to 150 to 200 inches a year in the foothills of the Olympics. Although data are sparse for the higher elevations, during the 1957-1958 water year, 542 inches of snow was recorded at Blue Glacier at the headwaters of the Hoh River. Precipitation was 15 percent below normal that year in the lowlands. The temperate rainforest supports the growth of enormous moss-covered conifers and bigleaf maples. From the ocean to the ONP boundary the mainstem of the Hoh River is classified as a shoreline of statewide significance. Its larger tributaries—Nolan Creek, Winfield Creek, Maple Creek, Owl Creek, and the South Fork of the Hoh River—all are shorelines of the state.

4.3.4.2 Freshwater Reaches (Map 10)

Hoh River 1: From the Hoh Indian Reservation boundary upstream to the confluence with Nolan Creek.

Hoh River 2: From the confluence with Nolan Creek to the confluence with Winfield Creek.

Hoh River 3: From the confluence with Winfield Creek to the confluence with Maple Creek.

Hoh River 4: From the confluence with Maple Creek to the confluence with Owl Creek.

Hoh River 5: From the confluence with Owl Creek to the ONP boundary.

Hoh River South Fork: From the confluence with the mainstem to the upstream extent of shoreline jurisdiction.

Nolan Creek: From the confluence with the Hoh River mainstem to the upstream extent of shoreline jurisdiction.

Winfield Creek: From the confluence with the Hoh River mainstem to the upstream extent of shoreline jurisdiction.

Maple Creek: From the confluence with the Hoh River mainstem to the upstream extent of shoreline jurisdiction.

Owl Creek 1: From the confluence with the Hoh River mainstem to the impassable falls.

Owl Creek 2: From the falls to the upstream extent of shoreline jurisdiction.

4.3.4.3 Physical Environment (Maps 19 and 23)

The Hoh River is a gravel-bed stream with an average slope of 1.3 percent, falling about 3,950 feet in 56 river miles. The Hoh River has a large natural sediment load consisting of material ranging in size from predominantly silt (glacially derived rock flour) to cobbles. About 35 percent of the basin is covered by Quaternary surficial deposits of glacial and non-glacial origin, generally consisting of unconsolidated sand, gravel, silt, and clay. These deposits have an average thickness between 20 and 100 feet, but locally may be up to several hundred feet thick (Tabor and Cady, 1978 as cited in BOR, 2004). Underlying the surficial deposits are sedimentary and metamorphic bedrock composed predominantly of sandstone, conglomerate, siltstone, argillite, slate, and phyllite. The bedrock is exposed along the active channel in Spruce Canyon (RM 25.5 to 27.2) and Oxbow Canyon, and crops out in a few locations between Oxbow Canyon and the mouth of the Hoh River (BOR, 2004). The active channel width has ranged between 150 and 800 feet.

The mean daily flow for the period of record is 2,524 cfs. The majority of floods occur between November and March. It takes a discharge greater than 16,000 cfs at the USGS gauge (RM 15.4) to completely inundate the active channel (1.5- to 2-year flood), and a 10-year flood completely inundates the active channel and floodplain (BOR, 2004). Along the lower 4 miles, the river migrates across a 3,000-foot-wide floodplain bounded by glacial terraces and bedrock. The floodplain narrows to 400 feet at the river mouth where it is constricted by bedrock on both sides (Perkins Geosciences and TerraLogic GIS, 2004).

Historic channel migration zones (HCMZ) on the Hoh River between RM 17 and RM 40 are thoroughly described in BOR (2004). The CMZ on the lower 4 miles are described in Perkins Geosciences and TerraLogic GIS (2004). The HCMZ can be bounded by terraces composed of glacial material (till, outwash, or lacustrine sediments) or alluvium, alluvial fans, bedrock, or engineered bank protection (riprap, engineered logjam, bridge abutment, levees, road embankment). Overall, the active channel in the ONP is wider, more dynamic, has multiple channels and more LWD deposited, and runs straighter relative to the valley than reaches of the Middle Hoh.

The Middle Hoh receives significant flow from the South Fork and woody debris is not as common in the active channel flow path. Herrera (2004, in BOR, 2004) found more LWD within the HCMZ (relative to the active channel area) in the upstream ONP reaches than in the Middle Hoh reaches, creating pools and more complex channels. Logging and clearing of wood within the river channel limit the amount of large wood that may be recruited to these reaches downstream from the South Fork confluence (BOR, 2004).

Between the U.S. Highway 101 Bridge (RM 14.8) and the mouth of Nolan Creek (RM 6.2), meander migration rates have varied between 30 and 50 feet per year since 1939. Upstream from the Highway 101 Bridge (between RM 17 and RM 25), meander migration rates fall within the range of 13 to 76 feet per year (Herrera Environmental and Northwest Hydraulic Consultants, 2002 as cited in BOR, 2004). Average channel migration rates for the lower 4 river miles over the period 1952 to 1998 varied between 25 and 88 feet per year (Perkins and TerraLogic GIS, 2004).

Because it is fed by glacial meltwater, the Hoh River exhibits more stable flows in summer than in adjacent non-glacially influenced watersheds (Haggerty, 2003 as cited in 10,000 Years Institute, 2004). Rain-on-snow events below 610 m elevation frequently initiate floods from October to March (WDNR, 1999 as cited in 10,000 Years Institute, 2004). Winter peak flows approach 63,000 cfs at the Hoh oxbow gage, while extreme summer low flows can fall to around 300 cfs (Haggerty, 2003 as cited in 10,000 Years Institute, 2004). The hydrology of tributary streams outside ONP is predominately influenced by a combination of rainfall and both shallow and deep groundwater (WDNR, 1999 as cited in 10,000 Years Institute, 2004).

Vegetation within the Hoh River planning area is 25 percent to 50 percent evergreen forest throughout the mainstem (higher percentages in upper reaches), and 70 percent to 90 percent evergreen forest along tributaries. Bare rock/sand/clay, deciduous forest, shrub and brush rangeland, and mixed forest represent significant portions of land cover along mainstem lower reaches.

Riparian condition in the Hoh basin is variable. The upper reaches within the ONP remain in good condition. Historically, the watershed was dominated by large old-growth hemlock and Sitka spruce. However, in the middle reaches of the Hoh River prior to regulation, many of these areas were logged to the water's edge. Thus, most of the mainstem of the Hoh downstream of the South Fork has poor riparian condition, as well as lower Winfield Creek and Maple Creek. The riparian condition of the South Fork of the Hoh is rated as fair. Good riparian conditions occur in Nolan, upper Winfield, and Owl Creeks (Smith, 2000).

Wetlands compose 30 percent to 50 percent of the planning area along the mainstem and South Fork reaches, while less than 10 percent of the planning area is wetland along the tributary reaches. Riverine upper perennial wetlands are most common (more than 80 percent) in all reaches.

Water quality problems exist in the Hoh watershed. Portions of the following tributaries are on the 1998 Ecology 303(d) list for high water temperature: Anderson, Nolan, Small, Willoughby, Maple, Owl, and Canyon Creeks as well as a portion of the South Fork of the Hoh River. The background sediment yield from erosion of tributary channel beds was estimated at 531 tons per year for the Upper Hoh River, and 1,811 tons per year for the Middle Hoh, while the total sediment erosion from roads was estimated at 2,159 tons per year (Powell, 1999 as cited in BOR, 2004).

Mass wasting is a natural process in the Hoh River basin. About 90 percent of inventoried landslides in the Middle Hoh River watershed are either shallow rapid failures or debris flows, and about 80 percent of observed landslides are associated with human disturbance (timber harvest, roads, etc.) Debris flows regularly occur in areas such as Owl Creek and Maple Creek (BOR, 2004). A large, active, deep-seated landslide that has not been mapped enters the river on the right bank downstream of Nolan Creek, below RM 4. This slide is increasing in size and may have influenced a major channel shift that took place downstream during a flood event in October 2003 (Howell, 2004 as cited in 10,000 Years Institute, 2004).

4.3.4.4 Biological Resources (Map 19)

The Hoh River watershed supports breeding populations of bald eagle, harlequin duck, marbled murrelet, and spotted owl.

The Hoh River supports Chinook, coho, fall chum salmon, steelhead and cutthroat trout, and bull trout/Dolly Varden spawning. There are no barriers to anadromous fish on the mainstem of the Hoh River. All runs are thought to be of native origin with few outside introductions. The spring/summer Chinook run is thought to be stable with most spawning occurring within the ONP. Recent information indicates that the fall Chinook stock has shown a decline in spawning activity within the Hoh River tributaries and the side channels of the Middle Hoh River that have been impacted by sluice-outs and channel instability (Golder Associates, 2005). However, all of these Chinook runs have shown some recent decline. The fall chum run is in a long-term decline and was probably never abundant. The fall coho run is healthy, but again has shown some recent decline. Winter steelhead have maintained healthy levels within the Hoh system (Golder Associates, 2005). Quinault River steelhead are planted in the Hoh annually but have different run return timing and high exploitation rates, resulting in limited interaction with wild fish (Hook, 2004). The status of the Hoh cutthroat and bull trout runs is unknown.

It is thought that the Hoh River system supports the largest run of char on the coast (Smith, 2000). While the range of Dolly Varden trout (*Salvelinus malma*) overlaps with that of bull trout on the Olympic Peninsula, and they are difficult to differentiate, Dolly Varden do not occur in the Hoh River (10,000 Years Institute, 2004). Bull trout are thought to use the Hoh River as a migratory corridor and possibly spawn and rear in side channels of the mainstem; the majority of the redds have been identified within the ONP boundary (Hook, 2004; 10,000 Years Institute, 2004). Anecdotal evidence suggests that bull trout have historically found thermal refugia in Nolan, Winfield, and Owl Creeks. Tagged anadromous bull trout from the Hoh River were found to visit multiple adjacent estuaries during their lives including Kalaloch Creek (Brenkman, 2004 as cited in 10,000 Years Institute, 2004).

The Hoh River mainstem and Nolan Creek provide spawning and rearing habitat for anadromous salmonids and resident fish species, such as pink salmon, sockeye salmon, longnose dace (*Rhinichythys cataractae*), mountain whitefish (*Prosopium williamsoni*), shorthead sculpin (*Cottus confusus*), torrent sculpin (*C. rhotheus*), reticulate sculpin (*C. perplexus*), Pacific lamprey (*Lampetra tridentata*), and Olympic mud minnow (*Novumbra hubbsi*) (10,000 Years Institute, 2004).

Western Rivers Conservancy and the Wild Salmon Center are working to acquire over 7,000 acres of land along the Hoh River between ONP and the Pacific Ocean to serve primarily as a sanctuary for salmon and steelhead, while also providing protection for several wildlife species such as marbled murrelet, northern spotted owl, bald eagle, and bull trout (Western Rivers Conservancy, 2006).

4.3.4.5 Land Use and Altered Conditions (Map 23)

Land Use

Native Americans have been utilizing the Hoh River valley for many centuries. The entire Hoh watershed lies within the Usual and Accustomed Fishing Grounds of the Hoh Tribe. The Hoh valley was opened to homesteading by non-Indians in 1862, but documentation of land management history begins in the 1880s (Wray, 1999 as cited in BOR, 2004). In 1891, the Forest Reserve Act established the Olympic Forest Reserve which included the Hoh River valley, but the enforcement of this was suspended until March 1, 1898, so prospectors could make claims on their homesteads or trade the land for other public land in a different area (BOR, 2004). Valley bottom forests were initially logged around 1950; logging began in the 1960s along the steep South Fork, but most occurred from the 1970s through the 1990s (Perkins Geosciences and TerraLogic GIS, 2004).

Between the ONP and the Hoh Reservation, most of the land is currently working timberland either privately or WDNR owned and has been subject to timber harvest. Other uses include recreational and commercial fishing, and homesteads and agriculture (cattle). Gravel mines operated by private landowners and the WDNR are located in the Middle and Lower Hoh watershed (10,000 Years Institute, 2004). Within the planning area, 60 percent has been zoned Rural Residential along the mainstem (with areas of approximately 20 percent variation), 30 percent Local Agriculture (along upper and lower reaches of mainstem), and more than 80 percent Commercial Forest along all tributaries, except Nolan Creek, which is 54 percent Commercial Forest.

Transportation and Utilities

Roads were not constructed in the Hoh River basin until the 1930s (BOR, 2004). Jefferson County databases describe 14 miles of road in these reaches, while the WDNR database identifies 28 miles of road. Highway 101 is aligned near the south bank of the Hoh River from RM 4 to approximately RM 15.5 (within Reach Hoh River 2) and regularly passes within the mainstem river's wide planning area. At RM 15.5, the highway crosses the Hoh River and continues to the north, outside of the planning area. Other roadways within the planning area of the Hoh mainstem and tributaries are narrower in width and are frequently unpaved. Roads are mapped throughout the drainage basin but are most dense in the lower reaches.

Shoreline Modifications

Flood frequency has increased on the Hoh River in recent years. Potential reasons for this increase include changes in weather patterns; increases in cleared areas and roads due to timber harvest in the Middle Hoh resulting in increased total runoff and the magnitude of peaks flowing into the Hoh River during storms; and decreased forest cover canopy (Edmonds et al., 1998 as cited in BOR, 2004).

Large sections of Nolan Creek and a 200-foot section of Winfield Creek are impacted by cedar spalts (Silver, personal communication, 2006). Cedar spalts are waste wood left over from salvage operations. Instream accumulations can impede water flow, elevating water temperatures, and leach tannins into the water, thereby affecting water quality. This has contributed to sections of Winfield and Nolan Creeks being on the 1998 303(d) list for elevated water temperature (Ecology, 1998). Many other smaller tributaries (not shorelines of the state) to the Hoh River that are affected by cedar spalts include Pins Creek, Braden Creek, Sand Creek, Clear Creek, Elk Creek, Lost Creek, and Red Creek (Silver, personal communication, 2006).

Blocking culverts occur on the following tributaries as well as several unnamed smaller tributaries to the Hoh River: Dismal Creek, Alder Creek, Nolan Creek, Braden Creek, Canyon Creek, Cassel Creek, Mosquito Creek, Cedar Creek, Rock Creek, Elk Creek, Hell Roaring Creek, and Iota Creek. Numerous unnamed tributaries as well as many acres of floodplain habitat are also affected.

Constriction from a bridge in the South Fork Hoh River resulted in channel incision and channelization (Smith, 2000). Channelization due to lack of LWD has also resulted in sedimentation problems in Nolan and Owl Creeks.

Roads in the floodplain have also reduced floodplain habitat. During floods these act as dikes, isolating the river from the floodplain. Several streams are rated “poor” for floodplain impact, including the mainstem Hoh River and Owl Creek. Floodplain habitat is not only important as rearing habitat for salmonids, but also for groundwater recharge and flow moderation in the Hoh River (Smith, 2000). The Upper Hoh Road is of particular concern not only because it impacts floodplain habitat but because continued road maintenance costs millions of dollars. Traditionally, the County has shored up the road with rock riprap, which has an adverse effect on salmonid habitat. Recently however, engineered logjams have been placed to protect the road while improving salmon habitat. Although not all the logjams remained in place, they are still providing some protection for the road. A larger project by the Washington State Department of Transportation to protect Highway 101 using engineered logjams was completed in 2004. During storm events, forest roads contribute significant amounts of highly turbid water (1,728 tons of fines per year from 293 miles of road in the Middle Hoh) (WDNR, 1999 as cited in 10,000 Years Institute, 2004).

The most extensive human impacts in the reaches within the ONP are at the Hoh Ranger Station, the Rainforest Campground, and other facilities near RM 37. Another prominent human feature is Taft Pond, which was created by construction of the Park Road some time between 1950 and 1977. Park Road, which parallels the right HCMZ boundary between the Hoh Ranger Station and the park boundary, restricts movement of the channel along the right bank (BOR, 2004).

4.3.4.6 Public Access (Map 23)

There are five WDNR campgrounds along the Hoh River.

4.3.4.7 Restoration Opportunities

Throughout the Hoh River basin, fish access to tributary and floodplain habitat could be improved by replacing barriers to fish passage. In addition, the removal of cedar spalts would increase habitat access and improve water quality. The acquisition and protection of existing high-quality floodplain habitat is a high priority. Riparian plantings of conifers could increase the long-term recruitment of LWD.

4.3.5 Cedar Creek (Hoh River Lower)

4.3.5.1 Basin Overview (Map 1b)

Cedar Creek is a small independent drainage south of the Hoh River. Most of the lower watershed is in the ONP. About a mile of the stream upstream of the ONP is within the shoreline of the state jurisdiction. This section runs through private timberland.

4.3.5.2 Freshwater Reaches (Map 10)

Cedar Creek has been treated as one reach, from the ONP boundary to approximately RM 6.6.

4.3.5.3 Physical Environment (Maps 19 and 23)

The Cedar Creek basin is 90 percent evergreen forest. Vegetation in the remainder of the planning area is recent clearcut, deciduous forest, shrub and brush rangeland, and mixed forest. Only 3 percent of the planning area is wetland, classified entirely as palustrine scrub/shrub. Other habitat data for the watershed are lacking.

4.3.5.4 Biological Resources (Map 19)

Cedar Creek supports coho and winter steelhead trout spawning. The status of these stocks is unknown (Smith and Caldwell, 2000).

4.3.5.5 Land Use and Altered Conditions (Map 23)

Land Use and Zoning

Land use in the Cedar Creek planning area is 52.5 percent commercial forest and 47.5 percent rural residential.

Transportation and Utilities

The WDNR database identifies 1.35 miles of road within the planning area.

Shoreline Modifications

Cedar Creek has been impacted by cedar spalts, has a reduced level of macroinvertebrates, and was rated as “poor” for water quality (Smith, 2000). Sedimentation and an altered riparian zone are problems in some reaches as well.

4.3.5.6 Public Access (Map 23)

There is no public access in this reach.

4.3.5.7 Restoration Opportunities

Opportunities include removing spalts, and surveying for and repairing other fish passage blockages (i.e., culverts).

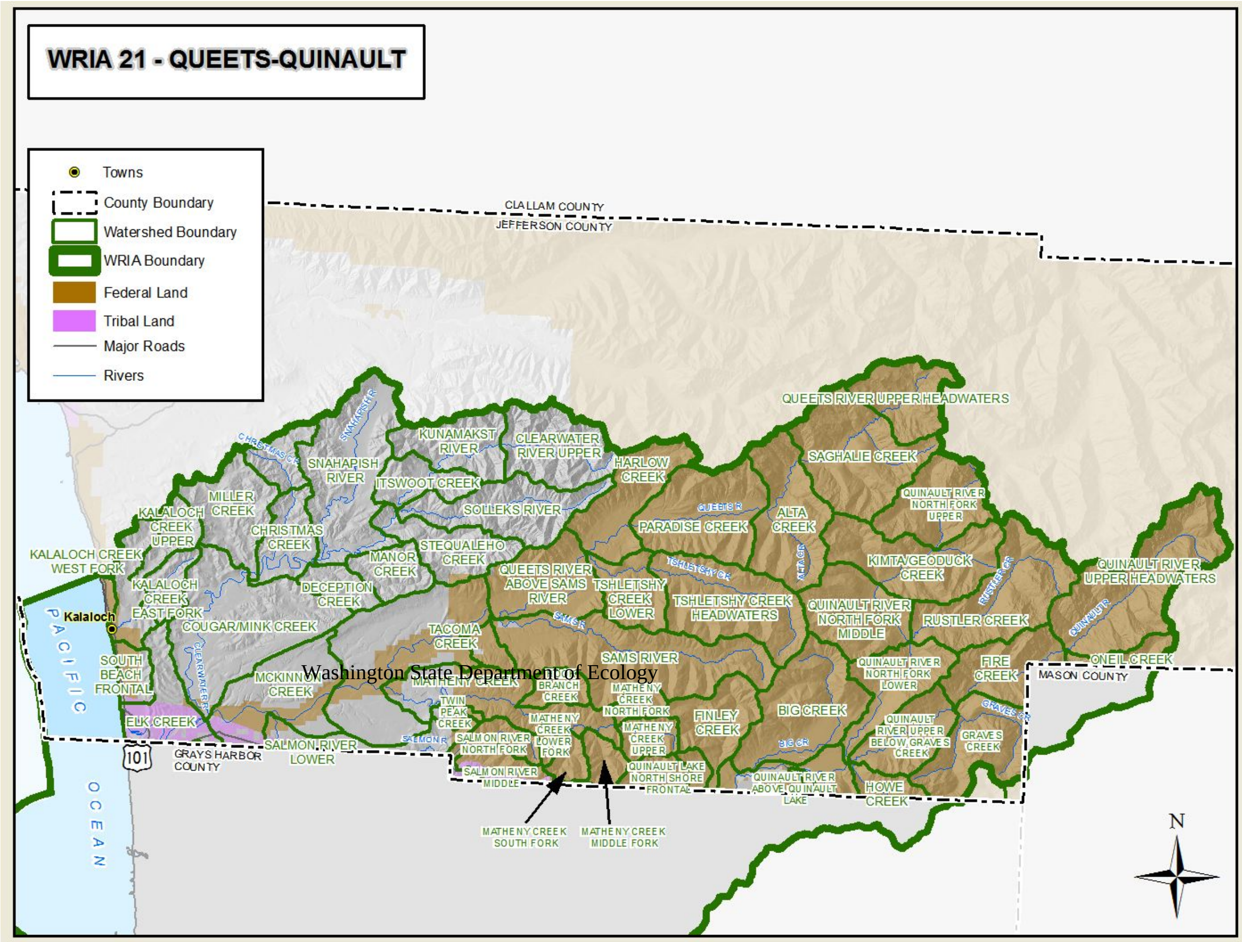
4.4 WRIA 21 - QUEETS-QUINAULT

The southwest corner of Jefferson County and parts of Grays Harbor County are in WRIA 21 (Figure 4-5). WRIA 21 includes Kalaloch Creek to the north and Conner Creek to the south. The largest basins within the WRIA are the Queets and Quinault basins.

Both the Queets and Quinault Rivers drain southwest from the glaciated Olympic Mountains, with peaks higher than 2,200 m. The rivers exit the mountains and flow across a 10 to 30 km wide coastal piedmont underlain by Quaternary glaciofluvial sediment. The Queets River drains a total area of about 1,170 km^2 and the Quinault River drains 1,134 km^2. During fall, winter, and spring, these basins are repeatedly subject to large storms from the southwest, delivering substantial rainfall at lower elevations and snow in the higher Olympic Mountains. Summers are relatively dry. The large precipitation volumes are reflected in high average flows. Average annual flow generation is 3.4 m^3/m^2 for the Queets basin and about 3.7 m^3/m^2 for the Quinault basin (O'Connor et al., 2003).

Current land uses within the Quinault and Queets basins include timber harvest, agriculture, fishing, recreation, and tourism. The major landowner in the Quinault basin is the ONP. The Quinault Indian Nation owns 32 percent of the basin, while the remainder is owned or managed by the USFS (13 percent) and private landholdings (4 percent). Present-day settlements are small and include the village of Taholah and the Amanda Park and Neilton areas in the Quinault basin, and the small communities of Queets and Clearwater in the Queets basin. Currently, two hatcheries operate within the Quinault watershed: the Quinault National Fish Hatchery, located near Cook Creek, and the Quinault pen rearing facility, located in Lake Quinault.

Figure 4-5. WRIA 21 in Southwest Jefferson County



4.4.1 Kalaloch Creek (Kalaloch Creek)

4.4.1.1 Overview (Map 1b)

Kalaloch Creek runs south through private and state timberland and then west through ONP to empty into the Pacific Ocean between the Queets and Hoh Rivers (Map 20). Shoreline of the state designation begins at the ONP boundary (roughly RM 1) and continues roughly 2 miles upstream to where the West Fork of Kalaloch Creek branches from the mainstem.

The Kalaloch basin is 13,649 acres in size including four small, unnamed, independent tributaries that drain to the Pacific Ocean to the south of Kalaloch Creek. Most of the drainage consists of either privately owned land (40 percent) or WDNR lands (41 percent). The ONP owns 18 percent of the basin, including the coastal strip and approximately 1 mile of lower Kalaloch Creek. The Quinault Indian Nation lands include 1 percent of the drainage.

4.4.1.2 Freshwater Reaches (Map 10)

Kalaloch Creek 1: From the ONP boundary to the impassable falls.

Kalaloch Creek 2: From the impassable falls to the upstream extent of shoreline jurisdiction.

4.4.1.3 Physical Environment (Maps 19 and 23)

The Kalaloch Creek planning area is composed of 94 percent evergreen forest. The vegetation in the remaining area is shrub and brush rangeland, and mixed forest. Only 4.4 percent of the planning area is wetland (palustrine scrub/shrub). Riparian conditions in the basin are mostly "fair" to "good" and hydrologic maturity is rated "good." (Smith and Caldwell, 2000).

Kalaloch Creek has a fairly confined channel due to topography, but channel conditions, floodplain connectivity, and sediment conditions are a data gap. The reach upstream from the ONP is on the 303(d) list for water temperature (Ecology, 1998).

4.4.1.4 Biological Resources (Map 19)

Kalaloch Creek supports coho salmon, winter steelhead, bull trout, and coastal cutthroat trout. Historically, a small run of chum salmon was also present in the watershed (Smith and Caldwell, 2000). All of these runs are wild, native stocks and their current status is unknown.

4.4.1.5 Land Use and Altered Conditions (Map 23)

Land Use and Zoning

Land use is predominantly forestry. Within the planning area, 66 percent to 85 percent is zoned Commercial Forest (with higher percentages in the upstream reach), and 25 percent Inholding Forest in the lower reach. The remainder of the planning area is composed of ONP and areas not zoned.

Although the timber harvest history for the private lands is not known, it is surmised that the WDNR lands were most heavily harvested between the 1940s and mid-1980s (Smith and Caldwell, 2000).

Transportation and Utilities

Road density is generally high in the Kalaloch Creek basin, at 4.08 miles of road per square mile of watershed. Within the planning area, WDNR has mapped 1.2 miles of road.

Shoreline Modifications

Shoreline modifications within the Kalaloch Creek planning area are primarily culverts. The WDFW SSHEAR database documented passage barriers at five culverts under Highway 101 within this drainage (WDFW, 2000b).

4.4.1.6 Public Access (Map 23)

None identified.

4.4.1.7 Restoration Opportunities

Smith and Caldwell (2001) identified several restoration opportunities in this basin, including:

- Address potential sediment sources from roads, especially roads with large fills or undersized culverts (those that do not meet 100-year flows plus debris).
- Address other road sediment problems, including specific road decommissioning, stabilization, and improvements. This also includes removal of side-cast material.
- Limit inappropriate removal of instream LWD.
- Increase channel complexity. Use instream structures as an interim part of a broader restoration plan in appropriate areas.
- Hardwood riparian areas that were historically conifer should be managed to allow conifer introduction through the planting and release of shade-tolerant trees with a goal to increase the size, abundance, and distribution of large conifers.

4.4.2 Clearwater River and Tributaries (Clearwater River Lower and Upper)

4.4.2.1 Overview (Map 1b)

The Clearwater River is a tributary of the Queets River that drains the foothills between the Queets and Hoh Rivers. It is a shoreline of statewide significance from downstream of the Miller Creek confluence to the ONP boundary (near the Clearwater's confluence with the Queets). Upstream of this it is classified as a shoreline of the state, as are the following system tributaries: Hurst Creek, Miller Creek, Christmas Creek, Snahapish River, Stequaleho Creek, and Sollecks River.

WDNR lands compose 79 percent of the Clearwater basin. These are managed as part of the Olympic Experimental Forest, which has the objective of managing the landscape for both habitat conservation and timber production. The riparian conservation plan for this forest includes both riparian and windthrow buffers. Upstream of the confluence with the Snahapish River, the mainstems of the Clearwater and Snahapish Rivers are part of the Clearwater Corridor Natural Resource Conservation Area (NRCA), an area also owned and managed by WDNR.

4.4.2.2 Freshwater Reaches (Map 10)

Clearwater River 1: From the ONP boundary to the confluence with Shale Creek.

Clearwater River 2: From the confluence with Shale Creek to the confluence with Miller Creek.

Clearwater River 3: From the confluence with Miller Creek to the confluence with Christmas Creek.

Clearwater River 4: From the confluence with Christmas Creek to the confluence with the Snahapish River.

Clearwater River 5: From the confluence with the Snahapish River to the confluence with Stequaleho Creek.

Clearwater River 6: From the confluence with Stequaleho Creek to the confluence with the Sollecks River.

Clearwater River 7: From the confluence with the Sollecks River to the impassable falls.

Clearwater River 8: From the falls to the upstream extent of shoreline jurisdiction.

Hurst Creek: From the confluence with the mainstem Clearwater River to the upstream extent of shoreline jurisdiction.

Shale Creek: From the confluence with the mainstem Clearwater River to the upstream extent of shoreline jurisdiction.

Miller Creek: From the confluence with the mainstem Clearwater River to the upstream extent of shoreline jurisdiction.

Miller Creek East Fork 1: From the confluence with the mainstem Miller Creek to the impassable falls.

Miller Creek East Fork 2: From the impassable falls to the upstream extent of shoreline jurisdiction.

Christmas Creek: From the confluence with the mainstem Clearwater River to the upstream extent of shoreline jurisdiction.

Snahapish River: From the confluence with the mainstem Clearwater River to the upstream extent of shoreline jurisdiction.

Stequaleho Creek 1: From the confluence with the mainstem Clearwater River to the impassable falls.

Stequaleho Creek 2: From the impassable falls to the upstream extent of shoreline jurisdiction.

Sollecks River 1: From the confluence with the mainstem Clearwater River to approximately RM 6.3.

Sollecks River 2: From RM 6.3 to the upstream extent of shoreline jurisdiction.

4.4.2.3 Physical Environment (Maps 19 and 23)

The Clearwater River planning area is 62 percent to 86.5 percent evergreen forest throughout the mainstem (higher percentages in upper reaches), and greater than 81 percent evergreen forest along the tributaries. Deciduous forest, pasture hay, recent clearcut, shrub and brush rangeland,

and mixed forest represent the remaining land cover. The entire Clearwater subbasin is rated "poor" for hydrologic maturity.

Wetlands compose 25 percent to 41 percent of the mainstem planning area below the Sollecks River, while less than 4.5 percent of the planning area along the tributaries and upper mainstem reaches is wetland. Wetland classifications include riverine upper perennial, and palustrine forested and scrub/shrub.

Stequaleho Creek rated "poor" for percent pool habitat. Segments of the Sollecks River rated from "poor" to "fair" for percent pool habitat. In addition, Snahapish River had segments that range from "poor" to "good." "Good" percent pool habitat was measured in Christmas, East Fork Miller, Hurst, and Shale Creeks, and the West Fork Snahapish River.

Water temperatures greater than the state Class AA standard (up to 20.1°C) were found in the lower Clearwater River.

4.4.2.4 Biological Resources (Map 19)

Chinook and steelhead spawn in the mainstem of the Clearwater River, Miller Creek, Christmas Creek, and the Sollecks and Snahapish Rivers. Coho spawn in the mainstem of the Clearwater River and all accessible tributaries. Chum salmon spawn in the lower mainstem of the Clearwater River. Fish access conditions have not been fully mapped in the Clearwater watershed.

Downstream of the Snahapish River confluence, "good" riparian conditions were found on 54 percent of the buffer, 27 percent rated as "fair," and 19 percent rated as "poor." Upstream from this, including the tributaries of the Snahapish and Sollecks Rivers, Stequaleho Creek and other tributaries, the riparian conditions were rated as 69 percent good, 19 percent fair, and 11 percent poor. Levels of instream LWD are unknown; however in the Snahapish River levels of old-growth LWD increased from 56 pieces per 100 meters of stream in 1982, to 63 pieces per 100 meters in 1993 (McHenry et al., 1998 as cited in Smith, 2000).

4.4.2.5 Land Use and Altered Conditions (Map 23)

Land Use and Zoning

The Clearwater basin is under intensive old-growth timber management by the WDNR, which manages over 80 percent of the drainage basin. As of 1980, the basin was 40 percent clearcut (Cederholm et al., 1980).

Land use along the Clearwater River mainstem below Shale Creek is zoned 41 percent Rural Residential, 32.5 percent Commercial Forest, and 22.3 percent Rural Forest. Above Shale Creek, land use is 76 to 100 percent Commercial Forest, with minimal Rural Residential zoning. More than 94 percent of land is zoned Commercial Forest along the tributaries, except Miller Creek East Fork, which is 76 percent Commercial Forest.

Transportation and Utilities

Road density is rather high (3.7 and 3.2 miles per square mile for lower and upper Clearwater basin, respectively) and there are likely many blockages to fish passage. As of 1980, over 650 km of logging road existed in the basin, and over half were built with side-cast construction (Cederholm et al., 1980). Jefferson County databases describe 4.2 miles of road in the planning area, while WDNR has identified 15 miles of road.

Sedimentation due to landslides and debris torrents has historically been a serious problem; much of this has been related to road failure and timber harvest activities. Levels of fine sediments in spawning gravels have been found to be directly related to road density. Salmonid egg mortality is directly related to higher levels of fine sediments in the spawning gravels. The rate of timber harvest has slowed in recent decades. The management of the upper Clearwater River as a Natural Resource Conservation Area (NRCA) by the WDNR should improve the situation. Side-cast roads have already been removed in the Miller and Christmas Creek drainages. However there is a data gap in determining if the rate of debris flow and sedimentation has actually decreased (Smith, 2000).

Utilities within the Clearwater River basin have yet to be inventoried.

Shoreline Modifications

Loss of off-channel habitat is a major concern in the Clearwater basin. Timber management along the Clearwater, Salmon, and Sams Rivers, and Matheny Creek has resulted in increased sediment inputs and loss of LWD recruitment (Smith, 2000).

The impact of roads on the floodplains has not been fully assessed in the Clearwater watershed. WDFW documented filled areas and blocked culverts to identify areas suitable for restoration. However, because there has not been a full study the full extent of the impacts is unknown. Likely the rating is not “good” (Smith, 2000).

4.4.2.6 Public Access (Map 23)

None identified.

4.4.2.7 Restoration Opportunities

In the Clearwater basin, blocking culverts should be replaced with fish-passable structures. Roads that are contributing to mass wasting and erosion should be either decommissioned or repaired so they no longer contribute fine sediments to the system. Riparian planting where trees are lacking would provide shade and increase LWD input over the long term.

The WDFW has mapped a total of 49 off-channel rearing habitat areas in the Clearwater River subbasin for potential enhancement or restoration opportunities (Smith and Caldwell, 2001).

Some restoration activity has occurred for sediment problems in the Clearwater subbasin. For example, side-cast removal projects have been completed in the Miller Creek and Christmas Creek watersheds.

4.4.3 Salmon River (Queets River and Salmon River)

4.4.3.1 Overview (Map 1b)

The Salmon River flows into the Queets River in ONP. On some maps this stream is marked as Salmon Creek. From its headwaters in the ONF and the Quinault Indian Reservation, the Salmon River flows through two sections of WDNR land and one privately held parcel as well as the Quinault Indian Reservation before flowing into the Queets River in the ONP.

4.4.3.2 Freshwater Reaches (Map 10)

The sections within the shoreline jurisdiction are less than 2 miles in total length, and are therefore considered a single reach.

4.4.3.3 Physical Environment (Maps 19 and 23)

Vegetation within the planning area is 97 percent evergreen forest. Shrub and brush rangeland and mixed forest compose the remaining land cover. Sitka spruce, Douglas fir, and western red cedar dominated the historical riparian vegetation, but with past land management, some conversion to younger conifers and hardwoods has occurred. A greater ratio of hardwoods to conifers than was historically present is found in many riparian stands, although hardwoods have always been a component of riparian stands along the mainstem Salmon River and larger tributaries. While many of the mainstem Salmon River riparian areas currently have a low recruitment potential rating for LWD, many of the tree sizes are approaching the diameter where they would be classified as “medium” size and rated as good recruitment potential (Smith and Caldwell, 2001). Land vegetation cover is rated as “good” for the Salmon River watershed, with only 19 percent immature vegetation in the lower Salmon River area. High-turbidity events are not common or chronic in the Salmon River.

4.4.3.4 Biological Resources (Map 19)

Chinook, coho, chum, sockeye, and pink salmon, and winter steelhead have been identified in the Salmon River. Most of the salmonid stocks within the Queets basin are currently believed to be healthy. Spring/summer Chinook are depressed, while all others are either healthy or unknown.

4.4.3.5 Land Use and Altered Conditions (Map 23)

Land Use and Zoning

Land use within the planning area is entirely forestry. Timber harvest began during the 1940s and 1950s in the Sams, Matheny, Salmon, and Clearwater subbasins, with the peak of timber harvest taking place between 1960 and the mid-1980s (Smith and Caldwell, 2001).

Transportation and Utilities

Within the planning area surrounding all basin reaches, WDNR has mapped 450 feet of road. Jefferson County databases have no mapped roads within the planning area. Unpaved National Forest Roads Nf 2446, Nf 2405, and Nf 2331 all pass within the planning area.

Shoreline Modifications

An assessment of culverts found no blocking culverts in the lower Salmon River in 1998 and 1999, and thus the lower river was rated as "good" for fish habitat access. No loss of fish habitat access from culverts or other structures was found in the North, Middle, and South Forks of the Salmon River. In addition, fish access to the floodplain was found to be good and there was no evidence that land use actions had isolated floodplain habitat.

The Salmon River watershed analysis team noted that timber harvest and road construction have increased the amounts of sediment entering the Salmon River tributaries over natural levels, which results in a "poor" rating for sediment quantity (Smith and Caldwell, 2001).

4.4.3.6 Public Access (Map 23)

No information.

4.4.3.7 Restoration Opportunities

Opportunities appear limited in this area. Improved road management in the watershed could help to improve altered sediment processes.

4.4.4 Matheny Creek (Queets/Matheny Creek)

4.4.4.1 Overview (Map 1b)

Matheny Creek originates on the slopes of Matheny Ridge and Higley Peak and flows west through a narrow valley with a moderate gradient through its lower 14.5 miles to its confluence with the Queets River at RM 15.8 (Phinney and Bucknell, 1975). A majority of this watershed is within ONP.

4.4.4.2 Freshwater Shoreline Reaches (Map 10)

The segment of Matheny Creek that falls within shoreline jurisdiction extends from the ONP boundary upstream to the ONF boundary.

4.4.4.3 Physical Environment (Maps 19 and 23)

Land cover within the planning area is 68 percent evergreen forest. Bare rock/sand/clay (15 percent), shrub and brush rangeland (4 percent), and mixed forest compose the remaining land cover (7 percent). Most of Matheny Creek rated "poor" for hydrologic maturity.

Riparian timber harvest and lack of LWD in the lower 2.7 miles of Matheny Creek have contributed to channel widening. This, coupled with increased sediment yields in headwater regions, has caused aggradation, which in turn, has contributed to loss of off-channel habitat.

Water temperatures greater than the state Class AA standard were found in lower Matheny Creek, and it is listed on the 2004 303(d) list for temperature (Ecology, 2006).

4.4.4.4 Biological Resources (Map 19)

Matheny Creek provides spawning, rearing, and migratory habitat for Chinook, coho, and chum salmon as well as steelhead (Phinney and Bucknell, 1975; Smith and Caldwell, 2001). Spawning occurs upstream as far as RM 14.5 (Phinney and Bucknell, 1975). Deposition of fine sediment and embedded substrates indicate degraded spawning habitat in the unconfined, lower-gradient reaches of Matheny Creek (RM 0 to 2.7).

Wetlands compose 27.7 percent of the planning area. Of this, 67 percent are riverine upper perennial, 15 percent are palustrine scrub/shrub, and 15 percent are palustrine forested.

4.4.4.5 Land Use and Altered Conditions (Map 23)

Land Use and Zoning

Land use within the planning area is 99 percent commercial forestry, and 1 percent ONF and ONP. Timber harvest began during the 1940s and 1950s in the Sams, Matheny, Salmon, and Clearwater subbasins, with the peak of timber harvest taking place between 1960 and the mid-1980s (Smith and Caldwell, 2001).

Transportation and Utilities

Within the planning area surrounding all basin reaches, WDNR has mapped 0.3 mile of road. Jefferson County databases have no mapped roads within the planning area. Unpaved National Forest Road Nf 2405 and an unnamed road which crosses the stream are both aligned within the planning area.

Shoreline Modifications

There are large numbers of in-channel disturbances in Matheny Creek tributaries. Management-related mass wasting events include coarse and fine sediment inputs from channel-adjacent landslides, and shallow rapid landslides triggered by clearcuts or roads (USFS, 1995 as cited in Smith and Caldwell, 2001). Road-related problems include fill and side-cast failure and fine sediment delivery, and are often associated with mid-slope locations. This results in a “poor” rating for sediment quantity for Matheny Creek (Smith and Caldwell, 2001).

Two bridge crossings have been identified on Matheny Creek that constrict the river channel at the point of crossing. A short distance (140 feet) of bank hardening was identified in Matheny Creek at RM 0.4.

4.4.4.6 Public Access (Map 23)

WDNR owns and uses the land adjacent to the Matheny Creek 1 reach as timberland. There is no current or planned public access to the stream or planning area.

4.4.4.7 Restoration Opportunities

Recent road stabilization and decommissioning projects are addressing these issues (McConnell, personal communication, 2001 as cited in Smith and Caldwell, 2001).

4.4.5 Quinault River (Quinault River Upper)

4.4.5.1 Overview (Maps 1b and 28)

The Quinault River drains the southeastern Olympic Mountains, with the upper watershed completely protected in ONP. The headwaters are in the vicinity of Mount Anderson and Mount Christie. The Quinault River then flows into Lake Quinault, a 3,729-acre natural lake. Downstream of the lake, the Quinault River flows for 33 miles to the Pacific Ocean. The total watershed area is 293,880 acres. The lowlands in the western part of this watershed contain several hundred feet of glacial deposits with lake and swamp deposits formed in interglacial periods. The low terrain downstream of Lake Quinault contrasts with the steep slopes and high relief of the areas around Lake Quinault and in the headwaters.

Yearly precipitation is high, averaging 146 inches at Lake Quinault. In the upper watershed, much of this precipitation falls as snow, while most falls as rain downstream of the lake. The steep topography and shallow soils of the upper watershed generate both a quick hydrologic response and a high susceptibility to mass wasting events. In contrast, the relatively flat terrain and outwash silts and clays downstream of the lake result in a low susceptibility to mass wasting events and a slower hydrologic response. Because Lake Quinault traps all sediment coarser than silt, the river downstream of the lake is a product of the interactions between the floodplain and the surrounding coastal piedmont (the area between the mountains and the ocean).

Most of the watershed lies within the Sitka spruce and silver fir vegetation zones. Mountain hemlock and subalpine and alpine meadows border the mainstem and North Fork Quinault Rivers. The most common historic disturbances within the watershed have been wildfire and windstorms. Windstorms typically come from the southwest, heavily affecting the coastal plain and the windward mountain slopes. The most common recent disturbance within the watershed has been timber harvest, which has included clearcutting, broadcast burning, and planting of Douglas fir (Smith and Caldwell, 2001).

4.4.5.2 Freshwater Reaches (Map 28)

A 4.9-mile section of the Quinault River downstream of the park boundary and upstream of the Grays Harbor county line is classified as a shoreline of statewide significance. This section of river is upstream of Lake Quinault.

4.4.5.3 Physical Environment (Map 28)

The upper Quinault River is aggrading behind Lake Quinault, a natural lake that traps most sediment and wood transported from the Olympic Mountain headwaters. On the upper Quinault River, logjams promote bar growth and consequent channel shifting, short-distance avulsions, and meander cutoffs, resulting in mobile and wide active channels. The average floodplain width is 2,470 m; the active channel width averages 240 m, which is almost everywhere at least twice as wide as the low-flow channel. The average channel migration rate was found to be 12.7 $\pm$ 3.3 meters per year between 1900 and 1994. Floodplain channel erosion occurs at a rate of about 0.2 percent of the floodplain area per year, with a corresponding floodplain half-life (length of time in which the channel occupies half of the total floodplain area) of 300 to 500 years. Floodplain width does not correlate with local geologic controls such as low-flow width, active channel width, or the frequency of low-flow channels, but is more directly related to overall sediment, wood, and flow regimes (O'Connor et al., 2003).

Water quality in the Quinault River, just upstream of the lake, can be poor with elevated temperatures in the summer. This may be a natural condition due to low elevation and channel width.

4.4.5.4 Biological Resources (Map 28)

The Quinault River has healthy runs of fall Chinook, sockeye, winter steelhead trout, bull trout, and Dolly Varden. Even though they are currently classified as "healthy," runs of coho, sockeye, and winter steelhead have declined as compared to historical levels. The spring/summer run of Chinook is rated as depressed. The stock status of chum and pink salmon, cutthroat trout, bull trout, and Dolly Varden is unknown. All of these species use this stretch of river to spawn or rear.

4.4.5.5 Land Use and Altered Conditions (Map 28)

Land Use and Zoning

Prior to the Cosmopolis and Quinault River Treaties (circa 1855), the Quinault watershed was claimed by the Quinault Tribe as their ancestral homeland and was used for subsistence fishing, hunting, and use of plants for food, medicine, and tools. Formal land ownership began with the Quinault River Treaty in 1855. Euroamerican settlers arrived in the late 1880s, resulting in subsistence farming and grazing in valley bottomlands, primarily in the Quinault Lake and Cook Creek watersheds. Timber harvest began in earnest in 1916, when cedar was salvaged from the 300-acre "Neilton burn." Railroad construction provided access for timber harvest in the Quinault River and Cook Creek watersheds between 1917 and 1940. Extensive road construction and subsequent timber harvesting occurred between 1950 and 1980. While the level of old-growth harvesting has declined in recent years, second-growth forest management and specialty forest products continue to be economically important.

In 1978, the Quinault Nation embarked on a program to reacquire lands on the reservation to return them to tribal ownership and coordinated management. Most or all lands within the Quinault Indian Reservation and USFS ownership have been harvested at least once. This includes the lowlands, Quinault valley, and areas on Higley and Quinault Ridges. Much of the Cook Creek watershed and the lands north and east of Lake Quinault were declared part of the

Olympic Forest Reserve in 1897. The USFS managed the area until the establishment of the Olympic National Park (ONP) in 1938. The USFS designated the Quinault Recreation Area in 1922 and the Quinault Research Natural Area in 1932. The Colonel Bob Wilderness was included in the federal wilderness areas in 1984 (James, 1999 as cited in Smith and Caldwell, 2001).

Current land uses within the basin include timber harvest, fishing, and tourism. The major landowner is the ONP, which includes all of the Mount Lawson and Enchanted valley watersheds. The Quinault Indian Nation owns 32 percent of the basin, comprising most of the area downstream of Lake Quinault. The USFS manages 13 percent of the watershed, including the eastern part of the Cook Creek watershed and the southwest half of the Lake Quinault watershed between Quinault Ridge and the upper Quinault River. Private landholdings compose only 4 percent of the lands in the basin. Rayonier Timberlands Company is the largest private landholder, managing 14,030 acres in the Cook Creek area (Quinault Indian Nation and USFS, 1999 as cited in Smith and Caldwell, 2001). State lands managed by the WDNR encompass 0.1 percent of the drainage area.

Present-day settlements are small and include the village of Taholah and the Amanda Park and Neilton areas. Currently, two hatcheries operate within the watershed. The Quinault National Fish Hatchery is located near Cook Creek, and the Quinault pen rearing facility is located in Lake Quinault.

Transportation and Utilities

Within the planning area surrounding all basin reaches, WDNR has mapped 0.3 mile of road. Jefferson County databases have no mapped roads within the planning area. Unpaved National Forest Road Nf 2405 and an unnamed road which crosses the river are both aligned within the planning area.

Shoreline Modifications

No information.

4.4.5.6 Public Access (Map 28)

The ownership of this section of river is the ONP on the northern bank, and a mix of private and ONF land on the south bank. The vast majority of the river's watershed within this reach is protected either in ONP or in National Forest riparian reserve and wilderness.

4.4.5.7 Restoration Opportunities

None identified.

4.5 OTHER WEST END SHORELINES (MAPS 1B AND IC)

Sufficient information was not available to fully address all of the tributaries to the major west county rivers (i.e., Clearwater, Hoh, Bogachiel, Queets, and Quinault) and significant percentage of the river miles that meet the SMP jurisdiction criteria (20 cfs mean annul flow or more) occur on federal or tribal land and are not under County jurisdiction. Information on the tributary streams that are within county jurisdiction is provided in Appendix D.

5.0 PRELIMINARY RECOMMENDATIONS FOR DESIGNATIONS AND BUFFERS

5.1 SHORELINE ENVIRONMENT DESIGNATIONS

The Ecology guidelines (WAC 173-26-211) recommend a shoreline classification system with six basic environment designations. According to the guidelines, "*This classification system shall be based on the existing use pattern, the biological and physical character of the shoreline, and the goals and aspirations of the community as expressed through comprehensive plans as well as the criteria in this section. Each master program's classification system shall be consistent with that described in WAC 173-26-211 (4) and (5) unless the alternative proposed provides equal or better implementation of the act.*" The six environment designations described in the WAC are as follows:

- High Intensity
- Shoreline Residential
- Urban Conservancy
- Aquatic
- Rural Conservancy
- Natural

The purpose and criteria for each of the Ecology recommended designations are shown in Table 5-1.

Table 5-1. Ecology Recommended Shoreline Environment Designation Menu (WAC 173-26-211)

SED	Purpose	Main Criteria
High Intensity	Provide high intensity water-oriented commercial, transportation, and industrial uses while protecting ecological functions and restoring functions in degraded areas. Allow full build out of existing high intensity areas before expanding this designation to include new areas.	• Inside Urban Growth Areas and incorporated municipalities • Currently support or planned to support and suitable for high intensity uses
Shoreline Residential	Accommodate residential development.	• Inside Urban Growth Areas and incorporated municipalities • Predominantly single-or multi- family development or planned and platted for development
Urban Conservancy	Protect and restore ecological functions in urban and developed settings.	• Potential for ecological restoration • Floodplains that should not be intensively developed • Areas that retain ecological function even though they are partially developed • Have potential for development that incorporates ecological restoration

SED	Purpose	Main Criteria
Aquatic	Protect, restore, and manage unique characteristics and resources of the areas waterward of the ordinary high water mark.	• Lands waterward of the ordinary high water mark • May include wetlands
Rural Conservancy	Protect, conserve, and restore ecological functions to provide ecological protection, sustain resource use, and provide recreational opportunities.	• Applies to areas outside the urban growth area or municipal city limits • Supports resource-based uses such as agricultural, forestry, or recreation • Supports human uses but subject to environmental limitations such as steep slopes, or flood prone areas
Natural	Protect and restore shoreline areas that are free from human influence or include minimally degraded functions. Restrict uses to maintain ecosystem-wide functions.	• Supports ecosystems that have particular scientific or educational interest • Ecologically intact and performing irreplaceable functions or processes • Unable to support new development or uses without impact or risk to ecological functions

These WAC designations differ from those that are currently in effect in Jefferson County (see Maps 21, 22, and 23 for existing designations). To comply with the state's requirements, the County's existing SED system must be updated to match WAC 173-26-211. The County has some discretion to develop different designations or identify parallel environments where appropriate. However, alternative designations must provide a similar level of shoreline protection.

The proposed SED menu for Jefferson County outlined in this chapter is modeled on the WAC but includes a few minor modifications that are appropriate for the local conditions. The High Intensity (HI), Shoreline Residential, (SR) Aquatic (A), and Natural (N) designations proposed for Jefferson County are consistent with the WAC in terms of the purpose and criteria for designation. However, the Conservancy (C) designation is proposed in place of the WAC-recommended Rural Conservancy and Urban Conservancy designations, since there is no compelling reason to differentiate between rural and urban areas in Jefferson County where the Conservancy designation is concerned. Also, a special designation--Priority Aquatic (PA)—is proposed for high value in-water areas

The suggested menu provides a range of designations to suit different types of shorelines from those that are or could be developed for high intensity uses, including water-dependent uses (High Intensity), to those areas that are dedicated to residential development (Shoreline Residential), to those that have relatively intact ecological functions and are able to accommodate lower intensity uses (Conservancy), to those that are most sensitive to disturbance and/or provide the highest levels of ecosystem function (Natural). Areas waterward of the ordinary high water mark would be designated Aquatic and the most vital in-water salmon streams/nearshore areas and highest value marine shellfish habitats would be designated Priority Aquatic (Table 5-2).

Table 5-2. Jefferson County Recommended Shoreline Environment Designation Menu

SED	Purpose	Main Criteria
High Intensity	Ensure optimum use of shorelines that are either presently urbanized or planned for urbanization and provide economic development and recreational opportunities at a higher scale and intensity than can be achieved in more ecologically sensitive shoreline areas.	• Within designated urban growth areas (UGAs), rural areas of more intense development (RAMIDs), rural village centers (RVCs), resort complexes, rural crossroads (RCs), and resource based industrial zones (RBIZs) • Heavy industrial areas outside of UGAs, RAMIDS, RVCs or RCs • Do not meet the criteria for the Natural, Public Conservancy, Conservancy or Shoreline Residential environments • Suitable for high intensity uses other than residential uses (e.g., commercial and industrial use)
Shoreline Residential	To accommodate residential development and appurtenant structures and provide appropriate public access and recreational uses in areas where medium and high density residential developments and services exist or are planned.	• Shoreline areas inside UGAs, Rural Areas of More Intense Development or Master Planned Resorts • Do not meet the criteria for the Natural, Public Conservancy, Conservancy or High Intensity environments • Predominantly single-family or multifamily residential development or are planned and platted for residential development
Conservancy	Provide for sustained resource use, public access and public recreation while protecting ecological functions, conserving existing ecological, historical and cultural resources.	• Private and/or publicly owned lands (upland areas landward of OHWM) of high recreational value or with valuable historic or cultural resources or potential for public access • Inside or outside of urban growth areas, rural village centers, and rural crossroads • Do not meet the designation criteria for the Natural or Public Conservancy environments • Currently supporting low-intensity resource-based uses • Currently accommodating very low density residential uses • Can support low-intensity water-oriented uses without significant adverse impacts to shoreline functions or processes
Natural	To protect those shoreline areas that are relatively free of human influence and/ or that include intact or minimally degraded shoreline functions and processes.	• Ecologically intact and performing an important or irreplaceable function or ecosystem-wide process that would be damaged by human activity; • Represents a type of ecosystem or geologic feature that is of particular scientific and/or educational interest; • Unable to support new development or uses without significant adverse impacts to ecological functions or risks to human safety; • Potential to return to near natural conditions with minimal or no restoration activity; • Possesses serious development limitations due to the presence of environmental hazards.
Aquatic	To protect, restore, and manage unique characteristics and resources of the areas waterward of the ordinary high water mark.	• Lands waterward of the ordinary high water mark • May include wetlands
Priority Aquatic	To protect to the highest degree possible and, where feasible, restore	• Lands waterward of the ordinary high water mark • The most vital salmon streams and nearshore areas

SED	Purpose	Main Criteria
	waters and their underlying bedlands deemed vital for salmon and shellfish.	• The highest value marine shellfish habitats • Documented Endangered Species Act-listed salmonid streams and marine habitats (summer chum, chinook, and steelhead) • Estuaries that support Endangered Species Act-listed salmonid rearing • Other freshwater shorelines that provide habitat for salmonid species (coho, fall chum, pink, and cutthroat) and are relatively undeveloped

Using the proposed designation menu as a guide, preliminary SED recommendations were developed for each shoreline reach (Tables 5-3 to 5-5 and Maps 29-31 in Appendix C). The initial recommendations were determined based on the inventory information that was available and appropriate, summarized in the preceding chapters. Some of this data was only available for eastern Jefferson County. Specific consideration was given to the presence of the following key ecological and land use attributes:

- Degree of ecological function (function score as identified by Diefenderfer et al., 2006)
- Degree of stress (stressor score as identified by Diefenderfer et al., 2006)
- Salmonid Nodal Corridor/ Refugia (as identified by May and Peterson, 2003)
- Nearshore Salmonid Refugia (as identified by May and Peterson, 2003)
- Salmonid Use
- Salt Marsh / Lagoon / Intertidal Wetland (as identified by Todd et al., 2006)
- Terrestrial Priority Species Use
- Erosive/ Hazardous Slope/CMZ
- Zoning (and assessor's information on parcel density and vacant parcels)
- Public Land
- Public Tidelands
- Commercial Shellfish Status

The initial results of this analysis are presented in Table 5-3 to 5-5 (Readers are encouraged to review the SED maps in Appendix C for a more precise depiction of the proposed SEDs for each reach). These tables show the initial designations that were developed for the marine and river shores based on the inventory and the revised SED recommendations that were developed with extensive input from the STAC and SPAC after detailed review of oblique aerial photography for each section of the marine shoreline. The oblique photos allowed a more precise assessment of feeder bluffs, riparian conditions, extent of shoreline modification, land use intensity, and other factors that are essential for developing SEDs recommendations. As a result the revised recommendations represent the best available information regarding SEDs for Jefferson County.

In some cases, multiple designations are recommended for a given shoreline reach, and the approximate 'break' in the designation boundary is provided. In general reaches or portions of reaches were designated Natural if they had minimal shoreline modification (stairs, bulkheads, etc) or other high quality/pristine habitat characteristics (very limited development), or were important feeder bluffs or otherwise unsuitable for development (due to geological conditions, presence of environmentally sensitive areas, or other factors). Reaches or portions of reaches were designated Shoreline Residential if they were platted and/or developed for relatively high-density residential development and showed signs of more intense modification/use. Shorelines that are currently devoted to higher intensity uses and/or located in areas planned for higher intensity development including marinas and commercial developments received a High Intensity designation. All other shorelands received a Conservancy designation.

An Aquatic or Priority Aquatic designation is recommended for all areas waterward of ordinary high water mark--essentially creating a parallel designation for all shorelines (one for the shoreland or upland area and one for the water). The Priority Aquatic designation provides a higher level of protection to in-water areas than the Aquatic designation, so priority Aquatic areas are well protected even when paired with designations that allow more intensive uses in the shoreland area (e.g., Shoreline Residential). Priority Aquatic areas include the deltas of all the major rivers draining eastern slope of Jefferson County; important bays and estuaries such as Quilcene Bay, Discovery Bay, Tarboo Bay, Thorndyke Bay, Squamish estuary, and Ludlow estuary; and portions of the Toandos Peninsula, Kilisut Bay and Oak Harbor (see SED maps for more information).

For streams or lakes that are potential shorelines of the state, but currently not designated as such per WAC 173-18 or 173-22 (see section 1.3.2.1), a default Conservancy designation is recommended until additional information is gathered. The same applies to associated wetlands that are not otherwise formally designated.

Shoreline environment designations are one determinant of how individual shoreline reaches are to be used, developed and managed/protected. For example, the types of uses allowed along a given shoreline reach will generally vary depending on the designation. The level of allowed development density would also vary by SED. In many other respects, shoreline reaches will be managed and regulated equally regardless of designation differences. Initial recommendations are to require the same shoreline buffer (from OHWM) for each type of shoreline (marine, river, or lake) regardless of the SED. Vegetation management, water quality, and other environmental protection standards would also be generally consistent regardless of SED. Specific management recommendations are available for public review in the draft SMP which is available at the Jefferson County Community Development Department.

5.2 PRELIMINARY BUFFER RECOMMENDATIONS

The recommended shoreline buffer[1] for lakes is 100 feet. For river and marine shores, the recommended buffer is 150 feet, consistent with the existing County critical areas regulations in JCC 18.22.270. One hundred and fifty feet is also the buffer standard adopted by Whatcom County for marine shorelines. King County currently applies a 165-foot buffer to Type S shorelines outside of urban growth areas via the King County critical areas ordinance. Kitsap County is proposing to adopt a 150 foot marine shore buffer in certain shoreline environment designations as a result of a decision by the Central Puget Sound Growth Management Hearings Board (CPSGMHB).[2]

[1] The terms buffer refers to the horizontal distance that structures would have to be set back, landward, from the ordinary high water mark. The buffer area would be required to be maintained in a vegetated, undisturbed and undeveloped condition to protect shoreline functions and processes. Policies and regulations could be developed to require increases or allow reductions in buffer width as appropriate to reflect site-specific conditions.

[2] Hood Canal, et al., v. Kitsap County, CPSGMHB Consolidated Case No. 06-3-0012c. See also http://www.kitsapgov.com/dcd/lu_env/cao/remand/planning_commission_status_mem_122806.pdf

Levings and Jamieson (2001) cite findings from the Canadian Ministry of Forestry in British Columbia recommending buffers of 300 to 450 feet for marine shores depending on the type of shore, wind conditions, and other factors. Depending on the specific nearshore resources being protected and the specific functions being provided by the buffer, recommended widths may differ.

The effectiveness of riparian buffers for protecting water quality depends on a number of factors including soil type/stability, vegetation type, slope, annual rainfall, type and amount of pollution, surrounding land uses, and buffer width. Soil stability and sediment control are directly related to the amount of impervious surface. In areas where riparian vegetation has been removed and soils have been compacted, soils are less capable of intercepting and absorbing rainfall (May, 2003). Water that is not absorbed/intercepted by vegetation runs off the surface leading to erosion, siltation, burial of aquatic environs, and introduction of contaminants into water and can increase potential for landslides. Pollutants such as excess nutrients, metals, and organic chemicals are commonly found in stormwater and agricultural runoff, usually in particulate form. Sediment control therefore is essential for removing a large percentage of the pollutant load (May, 2000). In general, a 50-foot buffer is estimated to be approximately 60 percent effective at removing sediments, while an 82- to 300-foot buffer would remove approximately 80 percent of sediment load (Brennan and Culverwell, 2004; Pentec 2001). Although sediment carried into nearshore marine environments will seldom be of a magnitude to significantly compromise water clarity, the minimum recommended buffer width for sediment control and pollutant removal is 98 feet (30 meters) (May, 2003).

According to the literature, buffer widths as small as 27 feet could reduce nitrogen by as much as 60 percent, while widths up to 200 feet would be required to reduce nitrogen by 80 percent (Desbonnet et al., 1994, in Pentec, 2001). Minimum buffer recommendations for controlling agricultural runoff are 79 feet for 20 percent slopes with slight erosion, and 160 feet for 30 percent slopes with severe erosion (Brennan and Culverwell, 2004). Control of fecal coliform inputs from agriculture or septic systems to acceptable levels for primary contact recreational use could be achieved by a 115 feet buffer (Young et al., 1980, in Pentec, 2001).

For wildlife, the principal functions of riparian buffers are to provide habitat and travel corridors, microclimate regulation, organic input, and to ameliorate the impacts of human disturbance such as light and noise (Parametrix et al., 2005). Bald eagles, kingfishers, and other birds use logs on beaches, tideflats, and estuarine channels as perches (which provide visibility for foraging, resting areas), and to reduce flight times (energy conservation) between foraging areas and nesting sites. Herons and egrets will use drifted trees that are partially out of the water, as well as floating logs and log rafts for foraging and resting. Cormorants, pelicans, small shorebirds, and some waterfowl also require perches and platforms for rest between periods of foraging to spread their wings to dry their feathers and for preening themselves. As rotting trees on land near the water become limiting, purple martins and other cavity-nesting birds will use rotting snags on beaches for nesting. Gulls use log beaches and estuarine meadows for breeding. Logs function to visually isolate adjacent nests, provide thermoregulatory benefits for egg development, and cover for newly hatched chicks. Logs enable gulls to spend less time protecting the nest and more time foraging, resulting in increased survival of chicks. LWD is suspected to serve similar functions for other ground nesting wildlife. In addition, LWD and beach wrack provide habitat structure for species that are prey for fish and wildlife (Brennan and Culverwell, 2004).

For Washington State, the average width reported to retain riparian function for wildlife habitat is 288 feet (Knutson and Naef, 1997). No requirements for riparian corridor connectivity have been established in scientific literature; however Booth et al. (2002, in King County, 2004) recommend riparian buffer zones that minimize road and utility crossings as well as overall clearing.

Microclimatic influences on air that passes through riparian vegetation include humidity, temperature, and wind speed. This in turn affects plant growth, therefore influencing ecosystem processes such as decomposition, nutrient cycling, plant succession, and plant productivity. (Snohomish County, 2005). The minimum recommended buffer for microclimate protection is 328 feet (May, 2003).

Recent studies have shown that riparian vegetation on open marine shorelines may play an important role in producing terrestrial insect prey for juvenile salmon. Eelgrass beds are known to provide habitat for numerous fish and invertebrates, abundant fish prey production, as well as spawning habitat for herring. Buffer recommendations have not been made for protection of fish prey production function.

Shade provided by riparian vegetation along marine shorelines is not likely to influence marine water temperatures due to mixing and tidal fluctuations, but may be an important factor in moderating water temperature in pocket estuaries. Solar radiation is also an important factor determining distribution, abundance, and species composition of upper intertidal organisms (Brennan and Culverwell, 2004). Moisture and direct solar radiation also influence egg viability of intertidal-spawning forage fish such as surf smelt and sand lance (Penttila, 2001). Buffer recommendations range from 98 to 262 feet for natural temperature regulation and shading, or providing equivalent shading as a mature forest (May, 2003).

Large woody debris provides a multitude of functions in aquatic ecosystems including habitat structure. In the marine riparian zone, vegetation and large woody debris trap and stabilize sediments in salt marshes and on beaches, creating back beaches, berms, and spits. Beach logs retain moisture that becomes important to the establishment and survival of dune plants, which further stabilize sediments, provide wildlife habitat, and contribute nutrients to the system. In the lower intertidal and subtidal areas, LWD may become immobilized and become colonized by sessile invertebrates, algae, and mobile invertebrates for feeding opportunities, refuge, and spawning substrate, thereby increasing habitat complexity and attracting other species in search of prey, refuge, or spawning substrate. In riverine environments, more than half of all large woody debris is recruited from within 15 feet of streams. About 90 percent of all large woody debris comes from trees growing within about 50 feet of streams (Herrera, 2005). Appropriate widths for natural levels of recruitment and retention have been reported as one Site Potential Tree Height (SPTH) (May, 2003). The minimum buffer width recommended for LWD recruitment is 1 SPTH, or approximately 165 meters (May, 2003).

Because most buffer recommendations have been developed for riverine systems, marine buffer requirements may need to be adjusted to account for the effects of wind, salt spray, desiccation, and general microclimatic effects (Brennan and Culverwell, 2004).

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Table 5-3. Preliminary SED Recommendations by Shoreline Reach – Marine Shores

		Factors Used to Recommend Designations										Proposed Environment Designation (These designations are superseded by SEDs shown on the official SED map)		
Reach	**Area**	**High Function** x=YES	**Low Stress** x=YES	**Salmonid Nodal Corridor/ Refugia** x=YES	**Nearshore Salmonid Refugia**	**Salt Marsh / Lagoon / Intertidal Wetland**	**Erosive/ Hazardous Slope**	**Zoning**	**Public Land**	**Public Tidelands**	**Commercial Shellfish Status**	**Original SED Recommendation (May 2007)**	**Revised STAC/SPAC Recommendation**	**Priority Aquatic**
A	Fulton Creek and Associated Near Shore			x			x	RR, PPR	x	x	*A*	Conservancy	Conservancy, Natural at creek delta	#
B	Fulton Creek and Associated Near Shore						x	RR		x	*A*	Conservancy	Conservancy	
C	Fulton Creek and Associated Near Shore			x	p			RR, AL			*A*	Conservancy	Conservancy; Natural at McDaniel Cove	#
D	Duckabush River and Black Point			x	p	S (small)	p	RR, AL		x	*A*	Conservancy (numerous shoreline modifications)	Natural at McDaniel Cove, Conservancy and SR at north end	#
E	Duckabush River and Black Point	x	x	x	x	S	x	RR	x	x	*A*	Natural at mouth of Duckabush River and on feeder bluff on south side of Quatsop Point, Conservancy (Impacts from HWY 101)	Natural at Duckabush delta	#
F	Duckabush River and Black Point					S (small)	x	RR		x	*A, U*	Conservancy	Conservancy and some SR	
G	Duckabush River and Black Point							RR			*U*	High Intensity (dense development)	SR	
H	Duckabush River and Black Point						x	RR	x	x	*P*	High Intensity (Marina, modified shore)	ST and HI on inner Pleasant Harbor bay	
I	Dosewallips River and Brinnon Shoreline					S (small)	p	RR	p		*U, R, P*	Conservancy	SR	
J	Dosewallips River and Brinnon Shoreline			x	p	S	x	RR, PPR, AL, RVC, Olympic NF	x	x	*A, R*	Natural at mouth of Dosewallips and Jackson Creek, Conservancy, NA at Seal Rock CG, Shoreline Residential at Brinnon, High Intensity at RVC	Natural at mouth of Dosewallips and Jackson Creek, Conservancy, SR at Brinnon	#
K	Jackson Shoreline	x				S, L		RR, CC	p	x	*A*	Conservancy	Natural and Conservancy	#
L	Jackson Shoreline			x		S (small), L (small)	x	RR, PPR, National WR	x	x	*A, U*	Natural (Pulali Pt), Conservancy	Conservancy	
M	Quilcene Bay		x			L (small)	x	RR, PPR, CF	x	x	*A*	Natural (undeveloped, high bluff)	Natural	#
N	Quilcene Bay	x	x	x			x	RR, CF, RF	x	x	*A, C*	Natural	Natural, HI at marina	#
O	Quilcene Bay	x		x		S, L, IW	x	RR, AP, AL, PPR (small)	x	x	*A, U, C*	Natural	SR at South end; HI at marina; Natural at Big Quilcene delta; Conservancy at Little Quilcene mouth; SR at East Quilcene	#
P	Quilcene Bay	x	x		p	IW	x	RR		x	*A, U*	Natural	SR at north end;	#

NOTES:

x=YES (extensive coverage) | p=partial coverage | NA = Not Applicable (no county jurisdiction)
S=salt marsh | L=lagoon | IW=Intertidal Wetland

RR=rural residential | CF=Commercial Forest | PPR=Parks/ Preserves/ Recreation Areas | CC=Crossroad | HI=Heavy Industrial
AL=Local Agriculture | AP=Commercial Agriculture | RF=Rural Forest | MPR=Master Plan Resort | RVC=Rural Village Center

A=approved | *U*=unclassified | *P*=prohibited | *C*=conditional | *R*=restricted
SR = Shoreline Residential | HI = High Intensity | # = SED applies to at east part of reach

		Factors Used to Recommend Designations										Proposed Environment Designation (These designations are superseded by SEDs shown on the official SED map)		
Reach	Area	High Function	Low Stress	Salmonid Nodal Corridor/ Refugia	Nearshore Salmonid Refugia	Salt Marsh / Lagoon / Intertidal Wetland	Erosive/ Hazardous Slope	Zoning	Public Land	Public Tidelands	Commercial Shellfish Status	Original SED Recommendation (May 2007)	Revised STAC/SPAC Recommendation	Priority Aquatic
													Conservancy; Natural at Fisherman's Pt.	
Q	Dabob Bay	x	x	x	p	S, L, IW	x	RR, PPR, CF, AL (small)	x	x	*A*	Natural	Natural at Red Bluff; Conservancy; Natural mostly from Broad Spit to north end of reach	#
R	Dabob Bay			x		S, IW	x	RR, CF	x	x	*A*	Natural	Conservancy, except Natural at spit on west side of Tarboo Bay	#
S	Dabob Bay			x	p	S, L, IW	x	RR, CF, AL, Military Res., RF (small)	x	x	*A*	Natural, NA on military land	Mostly Natural, but Conservancy north of camp Harmony	#
T	Southern Toandos Peninsula, Thorndyke Bay, and Squamish Harbor	x	x	x		S (small), L (small)	x	RR		x	*A, P*	Natural	Natural except for head of Fisherman's Harbor	#
U	Southern Toandos Peninsula, Thorndyke Bay, and Squamish Harbor		x			S (small), L (small)	x	RR		#	*A*	Natural (undeveloped, high bluff)	Natural	#
V	Southern Toandos Peninsula, Thorndyke Bay, and Squamish Harbor	x	x	x	p	S, L	x	RR, Military Res., CF, RF, IF	x	#	*A, P*	Natural	Natural except Conservancy just north and south of Thorndyke Bay; SR at Bridgehaven; Natural on inner shore near South Point Road; SR on south side of Squamish estuary	#
W	Southern Toandos Peninsula, Thorndyke Bay, and Squamish Harbor	x		x	x	S, L	x	RR	p	x	*A*	Possible parallel designation with Natural south of Shine Road and Shoreline Residential north of Shine Road	Natural at Squamish estuary, otherwise SR	#
#	Hood Canal Bridge to Tala Point	x	x			S, L	x	RR	x	x	*A*	Conservancy at Wolfe SP/Natural	Natural at Termination Point and Bywater Bay, some Conservancy just south of Bywater Bay	#
Y	Hood Canal Bridge to Tala Point					S, L (small)	p	RR		x	*A*	Conservancy	Conservancy and Natural	#
Z	Hood Canal Bridge to Tala Point	x	x				x	RR		x	*A, U*	Natural (landslides, undeveloped)	Natural	

NOTES:
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AL=Local Agriculture AP=Commercial Agriculture RF=Rural Forest MPR=Master Plan Resort RVC=Rural Village Center

A=approved *U*=unclassified *P*=prohibited *C*=conditional *R*=restricted
SR = Shoreline Residential HI = High Intensity # = SED applies to at east part of reach

		Factors Used to Recommend Designations										**Proposed Environment Designation (These designations are superseded by SEDs shown on the official SED map)**		
Reach	**Area**	**High Function**	**Low Stress**	**Salmonid Nodal Corridor/ Refugia**	**Nearshore Salmonid Refugia**	**Salt Marsh / Lagoon / Intertidal Wetland**	**Erosive/ Hazardous Slope**	**Zoning**	**Public Land**	**Public Tidelands**	**Commercial Shellfish Status**	**Original SED Recommendation (May 2007)**	**Revised STAC/SPAC Recommendation**	**Priority Aquatic**
AA	Hood Canal Bridge to Tala Point	x	x			S, L	x	RR	x	x	*A*	Natural (feeder bluff, small lots but many vacant parcels)	Natural at Pt Hannon, Conservancy at White Rock and Tala Pt, SR	
BB	Port Ludlow				p	S, L (small)	x	RR, MPR (Single family)			*P, U, A*	Shoreline Residential	SR	#
CC	Port Ludlow			x		L	x	MPR (Single family, Multi family, Village Commercial Center, Resort Complex/Community Facilities)		p	*P*	Shoreline Residential, Conservancy at Ludlow Creek estuary	SR, Conservancy at Ludlow estuary, HI at Marina	
DD	Port Ludlow	x				L (small)	x	RR, MPR (Single family, Resort Complex/Community Facilities)		x	*P, U*	Shoreline Residential, High Intensity	South end of reach is HI, SR at north end of reach	
EE	Mats Mats Bay			x		S (small)		RR		x	*U, A, C*	Natural (undeveloped)	Mostly SR, with Conservancy at Basalt Pt, HI at marina	
FF	Oak Bay					S, L (small)		RR		x	*A*	Shoreline Residential	SR	
GG	Oak Bay							RR		x	*A*	Shoreline Residential	SR	
HH	Oak Bay			x			x	RR		x	*A*	Shoreline Residential	SR	
II	Oak Bay					S, L		RR, PPR	x	x	*A, U*	Natural (Portage, undeveloped)	Conservancy	#
JJ	South Indian Island and Marrowstone Island					S, L		Military Res.	other fed	p	*A, U*	NA	NA	
KK	South Indian Island and Marrowstone Island	x				S, L	x	RR, Military Res.	other fed	x	*A, U*	NA, Natural on County lands on Marrowstone	Natural at Kinney Pt and Scow Bay portage, otherwise SR	#
LL	South Indian Island and Marrowstone Island					S (small), L (small)	x	RR, AL, PPR	x	x	*U*	Natural, Conservancy on Fort Flagler	Conservancy and Natural at Fort Flagler and Lilip Pt	
MM	South Indian Island and Marrowstone Island	x				S, L	x	PPR	x	x	*U*	Conservancy (Fort Flagler)	Natural	
NN	South Indian Island and Marrowstone Island					S	x	PPR	x	x	*U*	Natural, Conservancy on Fort Flagler	Natural except at boat launch	
OO	South Indian Island and Marrowstone Island					S	x	RR, PPR	x	x	*A, U, P (SMALL)*	Natural, Conservancy on Fort Flagler	Natural at Walan Pt, Conservancy	
PP	South Indian Island and Marrowstone Island	x				S, L	x	RR	x	x	*A, C*	Natural (undeveloped)	Conservancy and SR	
QQ	South Indian Island and Marrowstone Island					S (small)	x	RR, CC	p	x	*A, C*	Natural (undeveloped)	SR, HI at boat launch	#
RR	South Indian Island and Marrowstone Island	x					x	RR		x	*A*	Natural (undeveloped)	SR	#
SS	South Indian Island and Marrowstone Island	x				S, L	p	RR, Military Res.	other fed	x	*A*	Natural (undeveloped)	Natural	#
TT	South Indian Island (Navy)	x	x			S, L	p	Military Res.	other fed	x	*A*	NA	NA	

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AL=Local Agriculture AP=Commercial Agriculture RF=Rural Forest MPR=Master Plan Resort RVC=Rural Village Center

A=approved *U*=unclassified *P*=prohibited *C*=conditional *R*=restricted
SR = Shoreline Residential HI = High Intensity # = SED applies to at east part of reach

		Factors Used to Recommend Designations										Proposed Environment Designation (These designations are superseded by SEDs shown on the official SED map)		
Reach	**Area**	**High Function**	**Low Stress**	**Salmonid Nodal Corridor/ Refugia**	**Nearshore Salmonid Refugia**	**Salt Marsh / Lagoon / Intertidal Wetland**	**Erosive/ Hazardous Slope**	**Zoning**	**Public Land**	**Public Tidelands**	**Commercial Shellfish Status**	**Original SED Recommendation (May 2007)**	**Revised STAC/SPAC Recommendation**	**Priority Aquatic**
UU	Indian Island (Navy)	x	x			S	x	Military Res.	other fed	x	*A, P, U*	NA	NA	
VV	Indian Island (Rat Island)	x	x			S	x	Un zoned island	other fed	x	*U, P*	NA (or Natural if county jurisdiction)	Natural	
WW	Indian Island (Navy)	x	x			S	p	Military Res.	other fed		*P, U*	NA	NA	
##	Indian Island (Navy)	x				S (small)	x	Military Res.	other fed	x	*U, A*	NA	NA	
YY	Port Townsend Bay					S, L (small)		RR		x	*A, P, U*	High Intensity (marina)	HI, SR, Conservancy	
ZZ	Port Townsend Bay				p	S	x	RR, RVC	p	x	*U, A, P (SMALL)*	Shoreline Residential (low bank residential)	HI, SR, Conservancy	#
AAA	Port Townsend Bay			x	x	S, L (small)	x	RR	x		*U*	Shoreline Residential or High Intensity, Conservancy at estuary	Natural, Conservancy at Chimacum estuary	#
BBB	Port Townsend Bay	x	x		p	S, L	x	RR, PPR	x	x	*U*	Conservancy	Natural	#
CCC	Port Townsend Bay (portion outside of City)					L	x	RR, PPR, HI, PT UGA	x	x	*U, A, P*	High Intensity	Natural near State Park, HI	
DDD	City of PT shoreline	x	x					PT UGA	x	x	*U, A*	NA	NA	
EEE	City of PT shoreline	x	x				x	RR, PT UGA	x	x	*U, A, P*	NA and Natural in County jurisdiction (feeder bluff, unstable slopes)	Natural outside City	
FFF	Strait of Juan de Fuca and Discovery Bay	x				L	x	RR, AL		x	*U, A*	Conservancy	Natural, SR and HU at Cape George	
GGG	Strait of Juan de Fuca and Discovery Bay	x				S, L	x	RR			*A*	Conservancy	SR at Beckett Pt, Natural south of Pt.	
HHH	Strait of Juan de Fuca and Discovery Bay	x				S, L	x	RR			*A*	Conservancy	Natural, SR at Adelma Beach, Conservancy south of Adelma Beach	#
III	Strait of Juan de Fuca and Discovery Bay	x			x	S, L	x	RR, NC		x	*A, U*	Conservancy, Natural at Salmon /Snow estuary mouth	Natural, SR and Conservancy at creek mouth	#
JJJ	Strait of Juan de Fuca and Discovery Bay	x					x	RR	p	x	*A, U (SMALL)*	Conservancy	SR, HI, Natural, and Conservancy north of Kalset Pt	#
KKK	Strait of Juan de Fuca and Discovery Bay	x	x			S	x	RR			*A*	Conservancy	Natural, some Conservancy at north end	#
LLL	Strait of Juan de Fuca and Discovery Bay	x				S, L	x	RR		x	*A*	Conservancy	Natural, Conservancy at Contractor's Pt and north of Pt to County line	#
IslandX	Sitting in Strait of Juan de Fuca					L	x	National WR	x	x	*U, A*	NA	NA	
IslandXI	Sitting in Strait of Juan de Fuca					L	x	National WR	x	x	*U, A*	NA	NA	

NOTES:

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SR = Shoreline Residential HI = High Intensity # = SED applies to at east part of reach

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SR = Shoreline Residential HI = High Intensity # = SED applies to at east part of reach

Table 5-4. Preliminary SED Recommendations by Shoreline Reach – Rivers[3]

		Factors Used to Recommend Designations						
Reach	**Area**	**Salmonid Use**	**Salmonid Nodal Corridor/ Refugia**	**Terrestrial Priority Species Use**	**Erosive/ Hazardous Slope or CMZ**	**Zoning**	**Public Land**	**Recommended SED**
Big Quilcene River1	Big Quilcene River	m,s,r	x	x	x	RR, AL, RF, RVC	x	Natural , Conservancy
Big Quilcene River2	Big Quilcene River	m,s	x	x	x	RR, CF, Olympic NF	x	Conservancy
Bogachiel River	Bogachiel River	m,s,r		close proximity	e/l h	CF, RR, RF	x	Conservancy
Cedar Creek	Cedar Creek	m,s,r				RR, CF	x	Conservancy
Chimacum Creek1	Chimacum Creek	m,s,r	x	x		RR	x (inholding forest)	Natural
Chimacum Creek2	Chimacum Creek	m, s	x			AP, RR, PPR	x	Shoreline Residential
Chimacum Creek3	Chimacum Creek	m, s	x			RR, PPR, CC	x	Shoreline Residential
Chimacum Creek4	Chimacum Creek	m,s,r	x	x		AP, RR, PPR (small)	x (partial)	Conservancy
Christmas Creek	Clearwater River	s,r			e/l h	CF, RF	x	Conservancy
Clearwater River1	Clearwater River	m,s,r		x	e/l h	RR, RF, AL, CF	x	Conservancy
Clearwater River2	Clearwater River	m,s				CF, RF		Conservancy
Clearwater River3	Clearwater River	m,s		x		CF,RF		Conservancy
Clearwater River4	Clearwater River	m,s				CF,RF,IF	x	Conservancy
Clearwater River5	Clearwater River	m,s		x	e/l h	CF,IF,RR	x	Conservancy
Clearwater River6	Clearwater River	m,s				CF	x	Conservancy
Clearwater River7	Clearwater River	m,s		x	e/l h	CF	x	Conservancy
Clearwater River8	Clearwater River	m,s		Merlin in close proximity	e/l h	CF	x	Conservancy
Dosewallips River1	Dosewallips River	m,s,r	x	x	x	RR, CF, RF, RVC, PPR, AL	x	Natural

[3] Conservancy is the recommended default designation for all undesignated shorelines.

NOTES:
x=YES
m=presence/migration s=spawning r=rearing
RR=rural residential CF=Commercial Forest PPR=Parks/ Preserves/ Recreation Areas CC=Crossroad HI=Heavy Industrial
AL=Local Agriculture AP=Commercial Agriculture RF=Rural Forest MPR=Master Plan Resort RVC=Rural Village Center
E/lh=erosion/landslide hazard area cmz=channel migration zone (FOR EAST COUNTY RIVERS ONLY X=Yes)

		Factors Used to Recommend Designations						
Reach	**Area**	**Salmonid Use**	**Salmonid Nodal Corridor/ Refugia**	**Terrestrial Priority Species Use**	**Erosive/ Hazardous Slope or CMZ**	**Zoning**	**Public Land**	**Recommended SED**
Duckabush River1	Duckabush River	m,s,r	x	x	x	RR, RF, CF, Olympic NF,	x	Natural, Shoreline Residential
Fulton Creek1	Fulton Creek	m,s,r	x		x	CF, RR		Natural
Fulton Creek2	Fulton Creek	m,s	x		x	CF		Natural
Goodman Creek1	Goodman Creek	m,s				CF		Conservancy
Goodman Creek2	Goodman Creek	m,s			e/l h	CF, RR	x	Conservancy
Goodman Creek3	Goodman Creek	m			e/l h	CF, RR	x	Conservancy
Hoh River South Fork1	Hoh River	m,s,r		x	e/l h	CF, IF, Unzoned	x	Conservancy
Hoh River1	Hoh River	m,s,r		x	cmz	CF, AL, RR, RF, Unzoned	x	Conservancy
Hoh River2	Hoh River	m,s,r		x	e/l h	RR, AL, CF, RF, Unzoned	x	Conservancy
Hoh River3	Hoh River	m,s		x	cmz	RR, CF, RF, Oly NF, Unzoned	x	Conservancy
Hoh River4	Hoh River	m,s		x	cmz	RR, AL, CF, Unzoned		Conservancy
Hoh River5	Hoh River	m,s,r		x	cmz	RR, AL, CF, Unzoned	x	Conservancy
Hurst Creek1	Clearwater River	m,s,r		x		CF, RF	x	Conservancy
Kalaloch Creek1	Kalaloch Creek	m			e/l h	CF, RR, IF, Oly NP	x	Conservancy
Kalaloch Creek2	Kalaloch Creek	m			e/l h (partial)	CF		Conservancy
Little Quilcene River1	Little Quilcene River	m, s	x		x	RR, RF, CF, RVC, AL		Natural, Conservancy
Little Quilcene River2	Little Quilcene River	m, s			x	CF, RF, RR	x	Conservancy
Maple Creek	Hoh River	m		x	e/l h	CF, RR, Unzoned	x	Conservancy
Matheny Creek1	Matheny Creek	m,s		x	e/l h	CF	x	Conservancy

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AL=Local Agriculture AP=Commercial Agriculture RF=Rural Forest MPR=Master Plan Resort RVC=Rural Village Center
E/lh=erosion/landslide hazard area cmz=channel migration zone (FOR EAST COUNTY RIVERS ONLY X=Yes)

		Factors Used to Recommend Designations						
Reach	**Area**	**Salmonid Use**	**Salmonid Nodal Corridor/ Refugia**	**Terrestrial Priority Species Use**	**Erosive/ Hazardous Slope or CMZ**	**Zoning**	**Public Land**	**Recommended SED**
Miller Creek	Clearwater River	s,r			e/l h	CF, RF	x	Conservancy
Miller Creek East Fork1	Clearwater River	s,r				CF, RF	x	Conservancy
Miller Creek East Fork2	Clearwater River	s,r				CF	x	Conservancy
Minter Creek	Goodman Creek	m		x	eh	CF	x	Conservancy
Mosquito Creek1	Mosquito Creek	m				CF	x	Conservancy
Mosquito Creek2	Mosquito Creek	m				CF, RF		Conservancy
Nolan Creek	Hoh River	m,s				CF, RR	x	Conservancy
Owl Creek1	Hoh River	m,s		x	e/l h	CF, AL	x	Conservancy
Owl Creek2	Hoh River	m			e/l h	CF	x	Conservancy
Rocky Brook	Dosewallips River	m,s	x	x	x	RR		Conservancy
Salmon Creek1	Snow Creek	m, s, r	x			AP, RR, CC, AL, RF, CF (small)	WDFW (UNCAS school)	Conservancy
Salmon Creek2	Snow Creek	m, s	x		e/l h	CF, RF, RR (small)		Conservancy
Salmon River	Salmon River	m,s,r		x	e/l h	CF	x	Conservancy
Shale Creek	Clearwater River	m,s,r		x	e/l h	CF	x	Conservancy
Snahapish River	Clearwater River	m,s,r		x	e/l h	CF	x	Conservancy
Snow Creek1	Snow Creek	m, s	x			RR, AP, CC, AL	WDFW (UNCAS school)	Conservancy
Snow Creek2	Snow Creek	m, s	x	close proximity	e/l h	RR, AP, AL		Conservancy
Solleks River1	Clearwater River	m,s				CF	x	Conservancy
Solleks River2	Clearwater River	s				CF	x	Conservancy
Stequaleho Creek	Clearwater River	m,s				CF	x	Conservancy
Stequaleho Creek2	Clearwater River	p			e/l h	CF	x	Conservancy
Winfield Creek	Hoh River	msr		x	e/l h	CF, RR	x	Conservancy

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AL=Local Agriculture AP=Commercial Agriculture RF=Rural Forest MPR=Master Plan Resort RVC=Rural Village Center
E/lh=erosion/landslide hazard area cmz=channel migration zone (FOR EAST COUNTY RIVERS ONLY X=Yes)

Table 5-5. Preliminary SED Recommendations by Shoreline Reach – Lakes[4]

		Factors Used to Recommend Designations					
Reach	**Basin**	**Salmonid Use**	**Terrestrial Priority Species Use**	**Zoning**	**Public Land**	**Water Quality Impairment**	**Recommended SED**
Anderson Lake	Chimacum		x	PPR	x	Total Phosphorus	Natural
Beausite Lake	Chimacum			RR, CF, RF	x		Conservancy
Crocker Lake	Snow Creek	m,s,r	x	RR	x	Fecal Coliform	Natural and Conservancy
Gibbs Lake	Chimacum	m,r	x	PPR	x	Total Phosphorus	Natural
Lake Leland	Little Quilcene	m	x	RR, AL, PPR	x	Invasive Species	Conservancy
Lords Lake	Little Quilcene	m		IF	(inholding forest)		Natural
Ludlow Lake	Port Ludlow			CF			Natural
Mill Pond	Port Townsend Bay		x	HI, RR			High Intensity
Peterson Lake	Chimacum	m		CF, RF			Natural
Rice Lake	Donovan			RR, CR, RF			Natural
Sandy Shore Lake	Southern Toandos Peninsula, Thorndyke Bay, and Squamish Harbor	m		CF		Total Phosphorus	Conservancy
Tarboo Lake	Dabob Bay		x	CF, IF	x	Total Phosphorus	Natural
Teal Lake	Squamish Harbor			RR			Natural
Wahl Lake	Southern Toandos Peninsula, Thorndyke Bay, and Squamish Harbor			CF			Natural

[4] Conservancy is the recommended default designation for all undesignated shorelines.

NOTES:
x=YES
m=presence/migration S=spawning R=rearing

RR=rural residential CF=Commercial Forest PPR=Parks/ Preserves/ Recreation Areas CC=Crossroad HI=Heavy Industrial
AL=Local Agriculture AP=Commercial Agriculture RF=Rural Forest MPR=Master Plan Resort RVC=Rural Village Center

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Appendix A – Grant Agreement With Ecology

Appendix B – Maps From Neil Harrington's 2005 Shoreline Inventory And Analysis Report

Appendix C – Final Inventory And Characterization Map Folio

Appendix D – Assessment Of Conditions For Additional Streams Designated By Ecology's Updated List Of Streams/Rivers Meeting The Definition Of Shorelines Of The State In Jefferson County

APPENDIX D - Assessment of Conditions for Additional Streams Designated by Ecology's Updated List of Streams/Rivers Meeting the Definition of Shorelines of the State in Jefferson County

Stream	Reach # with Revised Jurisdiction	WRIA	Drainage	Modification Type	Description	Associated Inventory Section	Associated Inventory Pg. #	Land Use Zoning	Current SMP Designation (Downstream if New)	Biological Resources	Additional information
Dowans Creek	New	20	Bogachiel River	addition	Addition of 1.6 miles of Dowans Creek; not previously considered jurisdictional	4.3.1	4 91	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
East and West Forks Goodman Creek	3	20	Goodman Creek	subtraction	Reduction of Goodman Creek Reach 3. The new limit is 0.4 miles upstream of the E/W fork convergence along E fork	4.3.2	4 94	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Minter Creek	1	20	Goodman Creek	subtraction	Reduction of Minter Creek, 20 CFS limit now extends 2.8 miles above convergence with Goodman Creek	4.3.2	4 94	Commercial Forest	Conservancy	Priority Fish Use - Migratory (Map 19)	
Mosquito Creek, N Fork Mosquito Creek	2	20	Mosquito Creek	subtraction / addition	LB Trib no longer Jurisdictional, Mainstem now ends at convergence with N Fork, Addition of 1.1 miles along N Fork Mosquito Creek	4.3.3	4 96	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Nolan Creek	1	20	Hoh (Reach 1/2)	subtraction	Reduction of Nolan Crk, 20 CFS limit now extends 4.3 miles above convergence with Hoh	4.3.4	4 97	Rural Residential / Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Anderson Creek	new	20	Hoh (Reach 2)	addition	Addition of 0.5 miles of Anderson Crk; not previously considered jurisdictional	4.3.4	4 97	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Hell Roaring Creek	new	20	Hoh (Reach 2)	addition	Addition of 1.7 mile of Hell Roaring Crk; not previously considered jurisdictional	4.3.4	4 97	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	Inventoried Landslide Hazard (Map 16)
Winfield Creek	1	20	Hoh (Reach 3)	subtraction	Reduction of Winfield Creek, 20 CFS limit now extends 4.0 miles above convergence with Hoh River	4.3.4	4 97	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	Inventoried Landslide Hazard (Map 16)
Winfield Creek LB Tributary	new	20	Winfield Creek to Hoh (Reach 3)	addition	Addition of 1.1 miles of Winfield Creek LB Tributary; not previously considered jurisdictional	4.3.4	4 97	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	Inventoried Landslide Hazard (Map 16)
Alder Creek	new	20	Hoh (Reach 3)	addition	Addition of 1.3 miles of Alder Creek; not previously considered jurisdictional	4.3.4	4 97	Rural Residential / Rural Forest / Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Elk Creek	new	20	Hoh (Reach 3)	addition	Addition of 3.1 miles of Elk Creek; not previously considered jurisdictional	4.3.4	4 97	Commercial Forest	Conservancy		
Willoughby Creek	new	20	Hoh (Reach 3)	addition	Addition of 0.4 miles of Willoughby Creek; not previously considered jurisdictional	4.3.4	4 97	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	

APPENDIX D - Assessment of Conditions for Additional Streams Designated by Ecology's Updated List of Streams/Rivers Meeting the Definition of Shorelines of the State in Jefferson County

Stream	Reach # with Revised Jurisdiction	WRIA	Drainage	Modification Type	Description	Associated Inventory Section	Associated Inventory Pg. #	Land Use Zoning	Current SMP Designation (Downstream if New)	Biological Resources	Additional information
Maple Creek	1	20	Hoh (Reach 3/4)	adjustment	Upstream extent of Maple Creek adjusted, Maple Creek mainstem subtracted 1.1 miles and major RB trib added 0.8 miles to 20 CFS upstream extent	4.3.4	4 97	Commercial Forest	Conservancy	Priority Fish Use - Migratory (Map 19)	Inventoried Landslide Hazard (Map 16)
Owl Creek	2	20	Hoh (Reach 4)	subtraction	Reduction of Owl Creek, 20 CFS limit now extends 5.5 miles above convergence with Hoh	4.3.4	4 97	Commercial Forest	Conservancy	Priority Fish Use - Migratory (Map 19)	Inventoried Landslide Hazard (Map 16)
Cedar Creek	1	20	Cedar Creek	subtraction	reduction of Cedar Creek; 20 CFS limit now extends 2.4 miles above ONP boundary	4.3.5	4 103	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Kalaloch Creek	2, portion of 1	21	Kalaloch Creek	subtraction	Kalaloch Crk Reach 2 no longer jurisdictional; 20 CFS limit now extends 6.5 miles above ONP boundary	4.4.1	4 105	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	Inventoried Landslide Hazard (Map 16)
East Fork Kalaloch Creek	new	21	Kalaloch Creek	addition	Addition of 1.5 miles of East Fork Kalaloch Crk; not previously considered jurisdictional	4.4.1	4 105	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Clearwater River	8	21	Clearwater	subtraction	Reduction of Clearwater Reach 8 by 1.1 miles			Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Hurst Creek	subtraction	21	Clearwater (Reach 1)	subtraction	Reduction of Hurst Creek, 20 CFS limit now extends 4.2 miles above convergence with Clearwater	4.4.2	4 107	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Miller Creek	1	21	Clearwater (Reach 3)	subtraction	Reduction of Miller Creek, 20 CFS limit now extends 4.2 miles above convergence with Clearwater	4.4.2	4 107	Rural Forest / Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning/Rearing (Map 19)	
EF Miller Creek	2	21	Clearwater (Reach 3)	subtraction	Reduction of EF Miller Creek, 20 CFS limit now extends 4.2 miles above convergence with Clearwater	4.4.2	4 107	Rural Forest / Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning/Rearing (Map 19)	Inventoried Landslide Hazard (Map 16)
Shale Creek	1	21	Clearwater (Reach 3)	subtraction	Reduction of Shale Creek, 20 CFS limit now extends 3.6 miles above convergence with Clearwater	4.4.3	5 107	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Christmas Creek	1	21	Clearwater (Reach 4)	subtraction	Reduction of Christmas Creek, 20 CFS limit now extends 4.9 miles above convergence with Clearwater	4.4.2	4 107	Rural Forest / Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning/Rearing (Map 19)	
Deception Creek	new	21	Clearwater (Reach 4)	addition	Addition of 1.1 miles of Deception Creek; not previously considered jurisdictional	4.4.2	4 107	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	

APPENDIX D - Assessment of Conditions for Additional Streams Designated by Ecology's Updated List of Streams/Rivers Meeting the Definition of Shorelines of the State in Jefferson County

Stream	Reach # with Revised Jurisdiction	WRIA	Drainage	Modification Type	Description	Associated Inventory Section	Associated Inventory Pg. #	Land Use Zoning	Current SMP Designation (Downstream if New)	Biological Resources	Additional information
Snahapish River Tributary	new	21	Clearwater (Reach 4)	addition	Addition of 1.0 miles of unnamed Snahapish River tributary; not previously considered jurisdictional	4.4.2	4 107	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Manor Creek / South Fork Manor Creek	new	21	Clearwater (Reach 4)	addition	Addition of 1.9 miles of SF Manor Creek ; not previously considered jurisdictional	4.4.2	4 107	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Stequaleho Creek	2	21	Clearwater (Reach 6)	subtraction	Reduction of Stequaleho Creek, 20 CFS limit now extends 5.4 miles above convergence with Clearwater	4.4.2	4 107	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Solleks River	2	21	Clearwater (Reach 6)	subtraction	Reduction of Solleks River, 20 CFS limit now extends 5.1 miles above convergence with Clearwater	4.4.2	4 107	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Solleks River Tributary	new	21	Solleks River	addition	Addition of 0.9 miles of Solleks River Trib ; not previously considered jurisdictional	4.4.2	4 107	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Kunamakst Creek	new	21	Clearwater (Reach 7)	addition	Addition of 1.1 miles of Kunamakst Creek; not previously considered jurisdictional	4.4.2	4 107	Commercial Forest	Conservancy	Priority Fish Use - Migratory/Spawning (Map 19)	
Upper Clearwater River Tributary	new	21	Clearwater (Reach 8)	addition	Addition of 1.1 miles of Upper Clearwater River Tributary; not previously considered jurisdictional	4.4.2	4 107	Commercial Forest	Conservancy		
McKinnon Creek	new	21	Queets (Lower)	addition	Addition of 0.4 miles of McKinnon Creek ; not previously considered jurisdictional	4.4.3	4 111	Commercial Forest	No previous designation	Priority Fish Use - Migratory (Map 19)	Inventoried Landslide Hazard (Map 16)
Mud Creek	new	21	Queets (Lower)	addition	Addition of 1.2 miles of Mud Creek ; not previously considered jurisdictional	4.4.3	4 111	Commercial Forest	No previous designation	Priority Fish Use - Migratory/Spawning (Map 19)	Inventoried Landslide Hazard (Map 16)
Tacoma Creek	new	22	Queets (Lower)	addition	Addition of 1.3 miles of Tacoma Creek ; not previously considered jurisdictional	4.4.3	4 111	Commercial Forest	No previous designation	Priority Fish Use - Migratory/Spawning (Map 19)	Inventoried Landslide Hazard (Map 16)
Sams River	new	22	Queets (Pocket within Federal lands)	addition	Addition of 1.2 miles of Sams Creek; not previously considered jurisdictional	4.4.3	4 111	Commercial Forest	No previous designation	Priority Fish Use - Migratory/Spawning (Map 19)	Only left (south) bank within non-federal lands