City of Bremerton
Shoreline Master Program

Shoreline Inventory and Analysis

Prepared for

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ACRONYMS AND ABBREVIATIONS

BMC	Bremerton Municipal Code
BMP	best management practice
BNSF	Burlington Northern Santa Fe
BP	before present
City	City of Bremerton
DAHP	Washington State Department of Archaeology and Historic Preservation
DDT	dichloro-diphenyl-trichloroethane
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EKNHA	East Kitsap Nearshore Habitat Assessment and Inventory
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GMA	Growth Management Act
HCP	Habitat Conservation Plan
LWD	large woody debris
NCDC	National Climate Data Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRHP	National Register of Historic Places
NWAA	Northwest Archaeological Associates
NWI	National Wetlands Inventory
OHWM	ordinary high water mark
PAA	Potential Annexation Area
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PSBRT	Puget Sound Biological Review Team
PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
RCW	Revised Code of Washington
RM	river mile
ROW	right-of-way

ACRONYMS AND ABBREVIATIONS (CONTINUED)

SASSI	Salmon and Steelhead Stock Inventory
SKIA	South Kitsap Industrial Area
SMA	Shoreline Management Act
SMP	Shoreline Master Program
TMDL	total maximum daily load
UGA	Urban Growth Area
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of National Resources
WHR	Washington Historic Register
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation

1. INTRODUCTION

1.1 PURPOSE

The City of Bremerton (City) is conducting a comprehensive Shoreline Master Program (SMP) update with the assistance of a grant administered by the Washington State Department of Ecology (Ecology) (Shoreline Master Act [SMA] Grant No. G1000007). Cities and counties are required to update their SMPs to be consistent with the state SMA, Revised Code of Washington (RCW) 90.58 and its implementing guidelines, the Shoreline Management Guidelines, Washington Administrative Code (WAC) 173-26.

Early steps in the comprehensive SMP update process include the inventory and characterization of shoreline conditions. The inventory and characterization (IC) provides a basis for updating the City's goals, policies, and regulations for shoreline management. The term 'shorelines' in this report refers to areas that meet the criteria for 'shorelines of the state' as defined by the SMA (see Section 1.3 – Shoreline Jurisdiction and Definitions). As shown in Map 1, the shorelines in the City are:

- Puget Sound
- Kitsap Lake
- Union River Reservoir and Union River between McKenna Falls and the Reservoir
- Twin Lakes
- Gorst Creek (lower portion)

Marine areas of Puget Sound are designated as a 'shoreline of statewide significance'. As such, additional policies apply to this shoreline since it is a statewide as well as local resource[1] (see Section 1.3 – Shoreline Jurisdiction and Definitions below).

This report describes the initial results of the shoreline inventory and characterization in accordance with Task 2.2 of the City's grant agreement with Ecology. It includes a general discussion of the ecosystem-wide processes that influence the City's shorelines and provides a detailed account of the ecological functions and land use patterns along each shoreline segment or reach.

This draft report will be revised and finalized based on comments from Ecology and the public. The final report will be used to guide other elements of the City's SMP update process including the development of shoreline policies, regulations, environment designations, and restoration strategies.

1.2 REGULATORY OVERVIEW

Washington's SMA was passed by the State Legislature in 1971 and adopted by the public in a referendum. The SMA was created in response to growing concerns about the effects of unplanned and unregulated development on the state's shoreline resources. As a result, the central goal of the SMA is 'to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines'.[2]

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[1] RCW 90.58.030(2)(e)

[2] RCW 90.58.020

The SMA is a joint state/local program. Local governments responsible for administration are charged with developing SMPs in accordance with state guidelines developed by Ecology. The guidelines give local governments discretion to adopt SMPs that reflect local circumstances and to develop other local regulatory and non-regulatory programs that relate to the goals of shoreline management.

The City developed its first SMP in 1992. Shoreline policies and regulations were reviewed in 2006. This IC report will provide the foundation for SMP policies and regulations under the current SMP update. The SMP will be maintained as a separate document that contains both policies and regulations.

1.3 SHORELINE JURISDICTION AND DEFINITIONS

According to the SMA, the City's SMP regulations apply to all 'shorelines of statewide significance', 'shorelines', and their adjacent 'shorelands'[3]:

> 'Shorelines of statewide significance' include portions of Puget Sound and other marine water bodies, rivers west of the Cascade Range that have a mean annual flow of 1,000 cubic feet per second (cfs) or greater, rivers east of the Cascade Range that have a mean annual flow of 200 cfs or greater, and freshwater lakes with a surface area of 1,000 acres or more.'
>
> 'Shorelines' are defined as streams or rivers having a mean annual flow of 20 cfs or greater and lakes with a surface area of 20 acres or greater.'
>
> 'Shorelands' are defined as the upland area within 200 feet of the ordinary high water mark (OHWM) of any shoreline or shoreline of statewide significance; floodways and contiguous floodplain areas landward 200 feet from such floodways; and all associated wetlands and river deltas.'
>
> 'Associated wetlands' means those wetlands that are in proximity to and either influence or are influenced by waters subject to the SMA4 (Figure 1-1). These are typically wetlands that physically extend into the shoreline jurisdiction, or wetlands that are functionally related to the shoreline jurisdiction through surface water connection and/or other factors.'

In any given area, the landward extent of shoreline jurisdiction is identified based on site specific factors such as the location of the OHWM. However, for planning purposes, shoreline jurisdiction can be assumed to include shorelands as generally depicted in Figure 1-1.

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[3] RCW 90.58.030

[4] WAC 173-22-030(1)

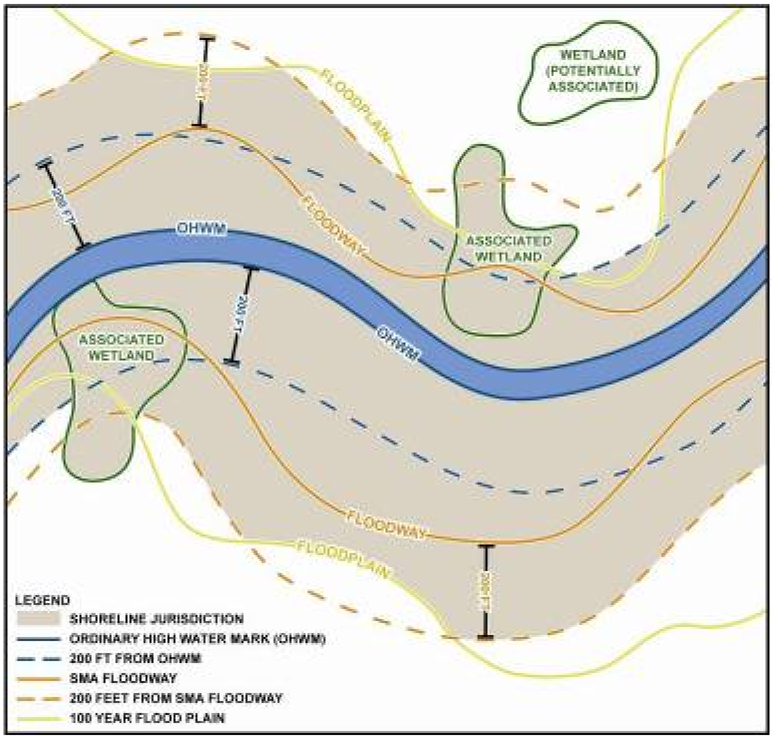

Figure 1-1. Graphic Depiction of the SMA Shoreline Jurisdiction

The area under the City's jurisdiction includes incorporated areas; the South Kitsap Industrial Area UGA (SKIA) was annexed by the City on April 1, 2009 and is included within the City boundaries (Map 1). The City of Bremerton has also identified several areas for potential annexation into the City: Bremerton East UGA, Bremerton West UGA, and Gorst UGA (Map 1). All of these Potential Annexation Areas (PAAs) would become part of the incorporated area under the City's jurisdiction. Shoreline areas are present in all three PAAs and the three PAAs are included in this report. The Shoreline Management Guidelines allow a city to pre-designate shoreline regulations within adopted UGAs.[5] Thus, adopted SMP regulations will be applicable to these areas upon annexation without requiring future amendment of the SMP.

1.4 RELATIONSHIP TO OTHER PLANS

The City's SMP works in concert with the City's Comprehensive Plan and a variety of other regulatory plans and programs to manage shoreline resources and regulate development near the shoreline. The Comprehensive Plan and associated Sub-Area Plans establish the general land-use pattern providing an overall vision for growth and development for City areas inside and outside shoreline jurisdiction.

The SMA requires local governments to review any plans, regulations, and ordinances that apply to areas adjacent to shoreline jurisdiction. Those plans, regulations, and ordinances need to 'achieve a consistent use policy' in conformance with the SMA and the SMP.[6] This

[5] WAC 173-26-150

[6] RCW 90.58.340

means that the Comprehensive Plan and the development regulations of the City's municipal code must be consistent with the SMP.

One of the most important areas for consistency is between the SMP and critical areas development standards and use regulations. Environmentally critical areas including streams, wetlands, aquifer recharge areas, frequently flooded areas, fish and wildlife conservation, and geologic hazard areas are found throughout the City's shoreline jurisdiction. Although critical areas are to be identified and designated under the GMA, they must also be protected under SMA when located within the shoreline jurisdiction. The Washington State Legislature and the Growth Management Hearings Board have determined that local governments must adopt SMPs that protect critical areas within the shoreline to achieve no net loss of ecological function.[7]

The GMA also calls for coordination and consistency of comprehensive plans among local jurisdictions. Because SMP goals and policies are an element of the local comprehensive plan, the requirement for internal and intergovernmental plan consistency may be satisfied by watershed-wide or regional planning. Consistent with this provision, the City of Bremerton is coordinating with Kitsap County; the neighboring cities of Poulsbo, Port Orchard, Bainbridge Island, and the Suquamish Indian Tribe during the SMP update process.

1.5 ORGANIZATION OF THIS REPORT

This report includes the following information:

Section 2 describes the data sources used and general approach to the inventory and characterization.

Section 3 describes the study area and important biological resources.

Section 4 details the characterization of ecosystem-wide processes and process alterations.

Section 5 includes an analysis of conditions by watershed.

Section 6 describes the reach inventory and analysis.

Section 7 describes in general the management options for addressing protection or restoration of ecological functions.

Section 8 provides a summary of the functional analysis and a general description of restoration, protection and public access opportunities.

References are provided in Section 9.

[7] House Bill 1653

2. DATA SOURCES AND APPROACH

2.1 DATA SOURCES

A number of local, regional, state and federal agency data sources, maps, and technical reports were reviewed to compile this inventory and characterization report. This includes information pertaining to watershed conditions and ecosystem-wide processes, as well as data on local land-use patterns and ecological conditions of Bremerton's shorelines. Assessing conditions at these two distinct geographic scales, the watershed scale and the shoreline reach scale, is a key requirement of the SMP update process.[8] A series of maps depicting shoreline and watershed attributes accompanies this report (as summarized in Table 2-1). Important data sources include geospatial data from the City of Bremerton, the Kitsap County Geographic Information System (GIS) database, the East Kitsap Nearshore Habitat Assessment and Inventory (EKNHA), and the Puget Sound Nearshore Ecosystem Restoration Partnership (PSNERP) change analysis study. A complete list of data sources used to compile this IC report is included in Section 9.

Table 2-1. Shoreline Map List

Map No.	Map Title
1	Shoreline Planning Area
2	Regional Context
3A	Topography
3B	Waterbodies and Wetlands
4A	Surficial Geology
4B	Landslide and Seismic Hazard Areas
4C	Soils
4D	Hydric Soils
4E	Drift Cells
4F	Analysis Reaches
4G	Shoreforms
4H	Substrate Type
4I	FEMA Floodplains
5	Groundwater Resources – Aquifer Recharge Areas
6A	Wildlife Occurrences – Bald Eagle, Murrelet, Seabird Colonies
6B	Wildlife – Marine Mammals and Shellfish
7A	Fish Usage - Distribution
7B	Fish Usage – Salmonid Stock Status
7C	Fish Usage – Marine Fish/Forage Fish
8A	Nearshore Vegetation – Marsh
8B	Nearshore Vegetation – Kelp
8C	Nearshore Vegetation – Sargassum
8D	Nearshore Vegetation – Eelgrass
9	Priority Habitats and Species
10	Land Cover

[8] WAC 173-26-201

Map No.	Map Title
11	Impervious Surfaces
12	Water Quality Impairment and Sediment Contamination
13	Parks, Open Space, and Public Lands
14	Comprehensive Plan Land Use Zoning
15	Current Shoreline Designations
16A	Shoreline Modifications - Armoring
16B	Shoreline Modifications – Piers/Docks
16C	Shoreline Modifications – Pilings
17	Reach Rankings – Ecological Function and Restoration Potential

2.2 SHORELINE STUDY AREA BOUNDARIES

This IC report includes both a watershed or ecosystem scale, and a local scale, of analysis. The area included within the landscape or ecosystem-wide characterization extends outside of those areas that are subject to shoreline jurisdiction by the City, but includes surrounding areas that influence shoreline condition and function. In this report, the larger watershed or ecosystem-wide area is referred to as the study area. The study area is located entirely within Water Resource Inventory Area (WRIA) 15. The study area generally includes Dyes and Sinclair Inlets, and Port Washington Narrows in Puget Sound, their contributing watersheds (watersheds for streams entering these areas of the Sound), and the Union River watershed which drains to Hood Canal (Map 2).

2.3 DETERMINING SHORELINE PLANNING AREA BOUNDARIES

The approximate extent of shoreline jurisdiction within the municipal limits of the City and its designated PAA is shown in Map 1, and is referred to as the 'shoreline planning area.' In general this extent represents:

- Marine areas and tidal waters of Puget Sound within the City's municipal limits and PAAs, out to mid-bay;
- Lands within 200 feet of the mapped edges of Puget Sound within the City's municipal limits (Note: The mapped edge of Puget Sound is only marginally different than the OWHM);
- Lands within 200 feet of the mapped edges of Puget Sound within the designated PAA of the City;
- Lands within 200 feet of the mapped edges of the Union Reservoir, and Union River between McKenna Falls and the Reservoir;
- Lands within 200 feet of the mapped edges of Kitsap Lake;
- Lands within 200 feet of the mapped edges of Twin Lakes;
- All wetlands associated with the above areas;
- All floodways associated with the areas above; and
- Those portions of the 100-year floodplains currently mapped by the Federal Emergency Management Agency (FEMA), which are within 200 feet of the mapped floodway.

This area covers a total of approximately 53 linear miles, 11 linear miles within the designated PAAs, and less than one linear mile in Kitsap County, outside the PAA. Of those, approximately 46 miles are along Puget Sound; about one mile are along the Gorst Creek; less than one mile is along the Union River; about 2.3 miles along the Union Reservoir; 2.7 miles are along Kitsap Lake; and less than one mile are along Twin Lakes. The shoreline planning area encompasses approximately 858 acres.

Planning area boundaries were derived using existing information from the Kitsap County GIS database. The location of the 20 cfs flow point on streams was confirmed using best available information (U.S. Geological Survey [USGS], 1998).[9] For purposes of this report, the mapped edges of Puget Sound, lake, and stream shorelines are assumed to correspond to the approximate location of the OHWM. Field inspection is required to identify the actual OHWM location on a specific property to determine jurisdiction limits, regulatory setbacks and/or buffers. Likewise, shoreline jurisdiction may include 'associated' wetlands. Generally, a wetland's relationship to the shoreline must be determined in the field by on-site inspection.[10] The maps outlined in Section 2.1 above indicate all mapped wetlands as potentially associated wetlands and likely include some wetlands that do not meet the criteria of "associated" wetlands.

The shoreline planning area is intended for planning purposes only. As a result, the actual regulated boundaries of shoreline jurisdiction may differ from the area shown on Map 1, depending on information gathered on the ground at any specific location.

For purposes of the shoreline inventory and characterization, the shoreline planning area was divided into segments, called reaches. Reach designations were determined based on natural boundaries such as drift cells for marine shorelines or stream reaches, and similarity of landforms or shoreforms, as well as adjacent land cover or land uses. Drift cell boundaries and reaches were defined to be consistent with assessment units evaluated by the EKNHA and PSNERP nearshore studies. The extent and general description of individual shoreline reaches that comprise the City's shoreline planning area are summarized in Table 2-2 (see Map 4F).

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[9] USGS data regarding upstream boundaries for SMA streams and rivers (USGS, Water-Resources Investigations Report 96-4208) to confirm SMP jurisdictional boundaries.

[10] Additional associated wetlands may be present that are not depicted on the available maps.

Table 2-2. City of Bremerton Shoreline Planning Area

Shoreline Reach Name	Reach Numbers[11]	East Kitsap Inventory Unit ID Numbers	General Description	Approximate Size in acres[a] (Shoreline Length in feet)	Approximate Percentage of City's Shoreline (including PAA)
FRESHWATER SHORELINES					
Kitsap Lake North	1	NA	North, east, and northwestern shoreline of the lake.	48 (10,500)	1
Kitsap Lake South	2	NA	South and southwest shoreline of the lake; including large wetland that extends to the south.	16 (3,500)	<1
Twin Lakes	3	NA	Twin Lakes shoreline.	17 (3,800)	<1
Union Reservoir	4	NA	Entire Union Reservoir shoreline.	64 (14,000)	2
Union River	5	NA	Reach of the Union River downstream of the reservoir to McKenna Falls.	17 (3,800)	<1
Lower Gorst Creek	6	NA	Reach of Gorst Creek upstream of the estuary to point upstream where flows are below 20 cfs (within shoreline jurisdiction).	24 (5,250)	<1
MARINE SHORELINES					
Sinclair Inlet					
Blackjack Creek	34C	200, 202, 203, 502, 204, 504, 205, 503	South side of Sinclair Inlet east of Gorst	303 (14,752)	In study area but outside City & PAA
Gorst Estuary	34B	206, 505, 207, 208, 209[12], 210, 211, 212, 213, 506, 214, 215, 216, 217, 218, 219, 220	Sinclair Inlet Gorst Estuary to the PSNS	605 (28,605)	16
Puget Sound Naval Shipyard (PSNS)	34A	221, 222, 223, 224, 225	Puget Sound Naval Shipyard	383 (32,914)	18
Phinney Bay	37, 38, 85, 39	365, 366, 367, 368, 369, 370, 371, 372	Phinney Bay	266 (14,889)	8
Dyes Inlet					
Rocky	40, 41	373, 374,	Bass Point, Rocky Point,	164	3

[11] Reach numbers for marine shorelines correspond to drift cell numbers used in the East Kitsap County Nearshore Habitat Assessment.

[12] Approximate eastern limit of planning area; just to west of Anderson Creek.

Table 2-2. City of Bremerton Shoreline Planning Area

Shoreline Reach Name	Reach Numbers[11]	East Kitsap Inventory Unit ID Numbers	General Description	Approximate Size in acres[a] (Shoreline Length in feet)	Approximate Percentage of City's Shoreline (including PAA)
Point		375, 376, 377, 378, 379	and Mud Bay	(6,128)	
Mud Bay	42, 43	380, 382, 383, 385	Mud Bay	86 (7,385)	4
Marine Drive North	86, 44	386, 387, 388, 389	Tip of Marine Drive peninsula (between Mud Bay and Ostrich Bay)	99 (4,156)	2
Marine Drive	87	391, 392, 393, 394	Marine Drive Peninsula	113 (6,473)	4
Oyster Bay	48, 88, 49, 50	396, 399, 400, 401, 403, 408, 409, 411, 412, 413, 414	Inner portion of Oyster Bay to small peninsula separating Oyster Bay from Ostrich Bay	227 (14,725)	8
Ostrich Bay	140	416, 417, 419, 420, 421, 422, 423[13]	Western shore of Ostrich Bay to embayment north of Elwood Point	242 (11,766)	6
Erlands Point	51, 89, 52, 53	424, 426, 427, 428, 429,	From embayment to Erland's Point and into east side of Chico Bay	211 (7,270)	4
Chico Bay	138, 90	430, 431, 432, 433, 434	Chico Bay	188 (9,758)	In study area but outside City & PAA
Port Washington Narrows					
Port Washington Narrows West	35, 149, 151, 150, 36	351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 509	West side of Port Washington Narrows, Bremerton Waterfront to Phinney Bay	315 (14,263)	8
Port Washington Narrows East	137, 108, 135, 107	459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 470[14], 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 228	Windy Point to Point Herron on east shore of Port Washington Narrows	634 (29,250)	11
Point Herron	55, 56A	229, 230	Point Herron to current city limits	140 (4,388)	2

[13] Northern limit of planning area.
[14] Start of planning area limit.

Table 2-2. City of Bremerton Shoreline Planning Area

Shoreline Reach Name	Reach Numbers[11]	East Kitsap Inventory Unit ID Numbers	General Description	Approximate Size in acres[a] (Shoreline Length in feet)	Approximate Percentage of City's Shoreline (including PAA)
Port Orchard Bay	56B	231, 232, 507, 233, 234, 235[15], 236, 237, 239, 240	Shorelines along Bremerton side of Port Orchard Bay	247 (8704)	5

a Nearshore areas based on assessment units defined in the East Kitsap Nearshore Habitat Assessment and is larger than the area within shoreline jurisdiction; freshwater area Includes floodways, and floodplains within 200 feet of floodways based on existing mapping sources (see Map 1).

2.4 APPROACH TO ECOSYSTEM-WIDE CHARACTERIZATION

SMA guidelines require local jurisdictions to evaluate ecosystem-wide processes and their relationship to shoreline ecological functions.[16] Ecosystem processes generally refer to the dynamic interactions among physical, chemical, and biological components of an ecosystem that form and maintain aquatic resources at the watershed scale. Ecosystem processes interact with ecosystem structure to result in the functions of ecosystems. Ecosystem processes important in ecosystem function in the Puget Sound region include the movement of water (freshwater surface and groundwater, and marine currents and tides), sediment (through rivers and along marine shorelines), nutrients, pollutants and pathogens, organic matter (large woody debris as well as leaf litter and detritus), and organisms (dispersal or migration of plants and animals), and light energy or solar incidence.

In this report, ecosystem processes were characterized for marine and freshwater shorelines in the planning area by adapting approaches developed for Puget Sound watersheds. Ecosystem wide processes affecting freshwater shorelines were evaluating using an approach similar to that described in *Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes* (Stanley et al., 2005) and *Enhancing Transportation Project Delivery Through Watershed Characterization* (Gersib et al. 2004, updated in 2009). Ecosystem wide processes affecting marine shorelines were evaluated by adapting several current approaches developed specifically for nearshore planning in Puget Sound, including the studies of the Puget Sound Nearshore Ecosystem Restoration Partnership (PSNERP), Bainbridge Island nearshore processes (Williams et al. 2001, Williams et al. 2003, Fresh et al. 2004, Williams et al. 2004, Simenstad et al. 2006, Ruckelshaus and McClure 2007, Simenstad et al. 2009, Schlenger et al. 2010), and recent nearshore habitat assessments for Kitsap County (Borde et al. 2009, Judd 2009).

[15] End of planning area limit.

[16] WAC 173-26-201 (2)(c)

The purposes of the ecosystem-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. The information from the ecosystem-wide characterization will inform the reach analysis, and the discussions of management options and opportunities/constraints for protecting or restoring shoreline function. Steps in the ecosystem-wide characterization include:

- Use existing models and Best Available Science (BAS) to identify key ecosystem-wide processes affecting shoreline resources and functions in Bremerton;
- Use BAS and existing data to identify major stressors affecting processes and describe how processes are altered by these stressors;
- Use BAS and existing data to identify those areas on the landscape that are most important for ecological processes and shoreline resources in Bremerton;
- Use existing data to determine the relative extent to which those important areas and their processes have been altered; and
- Based on this evaluation, assess the current condition of processes and shoreline resources within the study area.

2.5 APPROACH TO REACH SCALE ANALYSIS

The inventory and characterization at the reach scale is intended to characterize in-water conditions for each of the SMA-regulated water bodies, as well as characterizing conditions adjacent to each water body. The reach scale analysis includes up-to-date information on land-use, zoning, public access, impervious surface, water quality, priority habitats and species, and shoreline modifications for each reach. The reach analysis for marine shorelines relies heavily on two recent, detailed assessments of shorelines in the planning area: the East Kitsap Nearshore Habitat Assessment and the PSNERP change analysis for Puget Sound. The reach analysis for freshwater shorelines relies heavily on watershed planning documents and salmon recovery plans for WRIA 15.

Information developed in the reach scale analysis will be used with the ecosystem-wide characterization to identify management options, as well as opportunities and constraints for shoreline development, protection, and restoration. Steps in the reach-scale analysis include:

- Use existing data to identify number and type of stressors affecting processes and shoreline conditions along each reach;
- Use existing data, and stakeholder, and Technical Advisory Committee input to identify the presence and condition of biological resources along each reach;
- Use existing data to identify existing and planned land uses, presence of infrastructure, and public access areas along each reach; and
- Assess the relative condition and process impairment of all reaches to develop a relative ranking or scoring of shoreline condition for each reach.

2.6 MANAGEMENT OPTIONS

Based on the watershed and reach characterizations, BAS, and existing information on the types of management options that exist for protecting and restoring shoreline functions in Puget Sound, important management options are identified and discussed.

2.7 OPPORTUNITIES AND CONSTRAINTS

Based on the results of the ecosystem-wide and reach characterizations, areas in each reach where opportunities exist for protection, restoration, or enhancement of shoreline function, or enhancement of public access, were identified. Recent studies of Kitsap County and Central Puget Sound nearshore areas were also reviewed for opportunities and constraints. More detailed restoration actions will be developed under the next phase of the SMP update with development of the restoration plan.

3. STUDY AREA: GENERAL CONDITIONS AND BIOLOGICAL RESOURCES

3.1 STUDY AREA

The City of Bremerton is located on the western side of Puget Sound, in the central portion of Kitsap County, about 15 miles west of Seattle. Jurisdictional shorelines in the City lie within Water Resource Inventory Area [WRIA] 15, which encompasses all of Kitsap County and portions of Mason, Pierce, and King Counties (Vashon Island). Bremerton is located in the eastern portion of WRIA 15, or the East Kitsap Watershed, and most of the area is comprised of numerous small drainages flowing directly into Puget Sound. The study area for freshwater shorelines includes drainage areas or sub-basins for the major streams and lakes, such as Gorst Creek, Kitsap Lake, and the Union Reservoir (Figure 3-1; Map 1). Portions of the study area to the west and southwest of Gorst drain into the Union River and ultimately into Hood Canal (Map 2).

The marine waters of Puget Sound have been divided into sub-basins based on geography, oceanographic conditions (circulation, bathymetry, wave exposure), and common socio-economic issues and interests. Sub-basins are classified somewhat differently by different studies, however. The Bremerton area falls within the South Central Puget Sound (SCPS) basin as defined by PSNERP (Figure 3-1), and within the North Central Action Area as defined by the Puget Sound Partnership (PSP). For this ecosystem-wide characterization, the study area for marine shorelines is defined as roughly equivalent to the North Central Action (see red box in Figure 3-1, and Map 1), and encompasses Dyes and Sinclair Inlets, as well as the Port Washington Narrows, which connects Dyes and Sinclair Inlets, and a portion of Port Orchard Bay north of Sinclair Inlet.

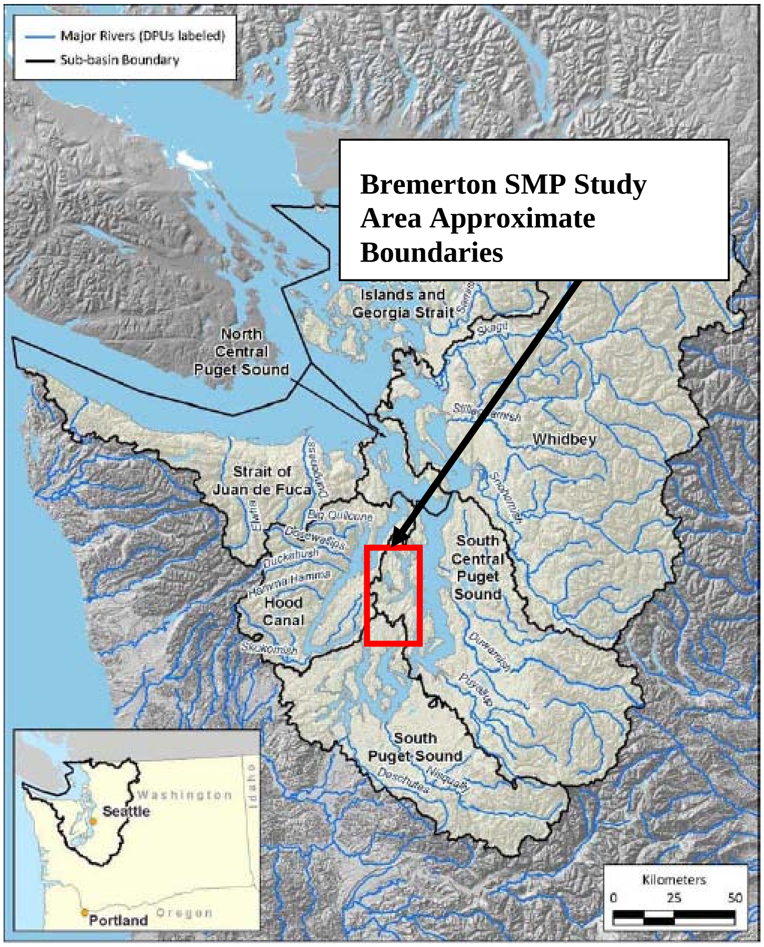

Figure 3-1. Study area for the ecosystem-wide characterization of Bremerton shorelines; adapted from PSNERP.

Conditions within the study area that may affect ecosystem-wide processes and local conditions include climate, geology, hydrology and oceanographic processes, land use and development, and potentially the effects of climate change.

3.1.1 Climate

Bremerton's climate is influenced by the temperate maritime patterns that define the overall climate of the Puget Sound lowlands (Mass 2009). In general, the climate is characterized by mild, wet winters, and warm, dry summers. Temperatures do not vary dramatically between winter and summer. Winter temperatures typically range from 30 – 50º F, and summer temperatures typically range from lows around 50º F to highs around 80º F (National Climatic Data Center Summary [NCDC] for Washington State).

Precipitation is strongly seasonal, with about two thirds of the rain falling between November and March. Precipitation typically occurs as frequent, low-intensity, and long-duration storms. Annual precipitation in the Puget Sound Lowlands typically ranges from 32 to 37 inches. Bremerton precipitation averages about 39 inches per year, with higher precipitation (about 50 inches per year) falling at Green Mountain (Haring 2000). Snow is rare at the relatively low elevations within the study area.

Strong winter storms can be associated with high winds; prevailing winter winds are from the south/southwest. Wind storms can produce storm surges in low-lying coastal areas, especially when storm winds align with flood tides. Saturated soils and long-duration storms during the winter can also result in flooding of low-lying areas adjacent to streams and rivers.

3.1.2 Geology and Topography

3.1.2.1 Geology

The East Kitsap Watershed is geologically and topographically similar to other areas in the Puget Sound region, reflecting the influences of mountain building and glacial activity. During the Eocene Epoch (approximately 38-55 million years ago), the East Kitsap Watershed was located at the western edge of the North American continent. Sediments were deposited in the coastal environment to the west of North America. Plate tectonic movement of the oceanic plate under the North America plate caused ocean and continental shelf rocks and sediment to be scraped off. These attached onto North America approximately 7-12 million years ago. Continued eastward movement uplifted these rocks and formed the hills and mountains of the Olympic Peninsula and underlying the Kitsap Peninsula. The underlying volcanic bedrock is overlaid with several thousand feet of marine sedimentary rocks. Green and Gold mountains, located west of Bremerton, are composed of these ocean floor rocks. The Pleistocene Epoch (or Ice Age), which began about 2 million years ago, formed most of the geologic features present in the watershed today. Cordilleran Ice Sheets, which originated in the coast and insular mountains of British Columbia, moved south to the southern end of the Puget Sound basin near Olympia. Up to 3,500 feet of glacial ice covered the Kitsap Peninsula. Geologic units from at least five major and several minor glacial advances have been identified in the Puget Sound basin, although only three are exposed (visible) in Kitsap County.

Each glacial advance is characterized by a similar set of geologic events. Advancing ice blocked rivers, which normally drained to the north and formed lakes in the southern portion of the Puget Sound basin. Widespread, fine-grained, lacustrine sediments were deposited by meltwater streams. Glacial till (a compact unsorted mix of clay, sand, and gravel, looking much like concrete) was then deposited directly under the glacier as it overrode the outwash sediments. Local recessional outwash sand and gravel deposits later formed from melt water as the front of the ice sheet receded to the north. Non-glacial intervals between the advances are characterized by fluvial (stream) sediments and peat.

The Fraser Glaciation, which occurred from 15,000 to 13,500 years ago, was the last glacial advance in the central Puget Sound basin (Deeter 1979). It eroded or covered much of the previous deposits. Deposits from the Fraser Glaciation in the area are characterized by silt and clay overlain by thick advance outwash sand, abundant till cover, and only local recessional outwash. Recessional meltwater outwash streams, much larger than present day streams, eroded and formed the larger valleys in the area. Valleys with "underfit" streams and estuaries or drowned river mouths were formed by the greater flow rates of outwash streams and a lower sea level during the Fraser Glaciation.

Surface geology in the study area is a complex mix of these glacial deposits, which include unconsolidated silts, sands and gravels and typically cover a hardpan lying just below the surface (PSCRB 1989). In the study area watersheds (Chico Creek, Gorst Creek, Union River), bedrock underlies the upper sections of watershed tributaries whereas the lower areas are underlain by glacial till, recessional outwash, and advance outwash deposited during the last ice-sheet advance. Following the final retreat of the Fraser Glaciation, more recent alluvial deposits from weathering, erosion and sedimentation have continued to shape the landscape (Sossa 2003). Bluffs along the Puget Sound are being eroded and re-deposited as beaches and spits. Streams are eroding their banks and then depositing sediments in floodplains, wetlands, and bays. Soils in the region were formed from the complex deposits of the most recent glaciation and are relatively young.

The complex mixture of surficial deposits is reflected in the diversity of substrates found along marine shorelines. Most beaches in Puget Sound are a mix of sand and gravel sediments from glacial till and outwash eroded from coastal bluffs (Finlayson 2006). Sediments eroded from upland areas and carried to the Sound by rivers and streams tend to be finer sands and muds that form deltas and extensive mud flats in sheltered bays.

Seismic Activity

The Puget Sound region as a whole is in an area of active plate tectonics and seismic activity. Puget Sound is part of the Cascadia subduction zone, where the Juan de Fuca plate is moving under the North American plate. Several fault lines cross Puget Sound and are associated with seismic activity (Map 4B). Movement along the quaternary fault lines that cross Bremerton, or other seismic events could cause liquefaction of the relatively loose soils that are commonly present along river and stream channels, lakes, and stream deltas and some marine shorelines. Soil liquefaction is a phenomenon in which pore pressure in loose, saturated, granular soils increases during ground shaking resulting in a reduction of shear strength of the soil (a quicksand-like condition). As a result of this reduction in shear strength, ground movement during earthquakes can be severe and results in increased damage compared to other types of soils. Soils susceptible to liquefaction include non-engineered fills and loose alluvium such as present in the head of Sinclair Inlet, the shores of Kitsap Lake, and locally along small streams (Map 4B).

3.1.2.2 Topography, Bathymetry, Geomorphology

Most of the upland and freshwater portions of the study area consist of low, rolling hills with moderate slopes. Higher areas occur in the upper watershed of Sinclair Inlet to the west of Bremerton with some steep slopes (>50% slopes). The highest point is Green Mountain at about 1,500 feet. The most dramatic feature of the study area is the long marine shoreline of Puget Sound, formed by several inlets and many smaller bays.

Puget Sound itself is a large, fjord-like estuary where freshwater from numerous rivers mixes with saltwater from the Pacific Ocean. The Sound contains many sub-estuaries where larger rivers and small streams enter the Sound and create a mix of tidal freshwater, brackish, and salt marsh wetlands. As is typical of fjord-like estuaries elsewhere, Puget Sound is characterized by relatively deep basins that drop off steeply from a narrow fringe of shallow nearshore areas adjacent to the shoreline. Most of the Puget Sound shoreline in the study area has moderate to low banks, or areas with no appreciable bank – bays and estuaries, although higher, steep sloping bluffs occur along Port Washington Narrows.

Bremerton lies within the Central Basin of Puget Sound, which includes the area between the southern tip of Whidbey Island and Commencement Bay (Ebbesmeyer 1984, Burns 1990). The study area is relatively more sheltered and shallow than most of the Central Basin. Two small sub-basins occur in the study area: Dyes Inlet and Sinclair Inlet (Map 2). The main basin of Dyes Inlet is deepest near the center, at about 150 feet, but the many bays are generally shallow (<35 feet). Sinclair Inlet is deepest at the eastern end (about 130 feet) while the head of the bay is <10 feet deep.

Geomorphology: Landforms and Shoreforms

The diversity of substrates resulting from the complex geologic history creates a wide range of landforms and shoreforms (or coastal landforms) that support the area's diversity of habitats and biological communities. Landforms and shoreforms that are important to shoreline ecological functions are categorized into three general types: upland areas of contributing watersheds; freshwater systems (groundwater, streams, lakes, wetlands); and nearshore or coastal. Uplands, freshwater, and nearshore areas form a connected mosaic of habitats that is important in maintaining the biological communities and ecological functions of the City's shorelines.

Major upland and freshwater landforms in the study area include (Montgomery and Buffington 1998, Buffington et al. 2003)

- rolling uplands;
- stream valleys with typical pool-riffle morphology, channel migration zones, and small floodplains;
- wetlands in topographic depressions, on lakeshores, and on slopes; and
- lakes with deeper open water and shallow littoral zones.

Due to the City's extensive area of marine shorelines, coastal landforms or shoreforms have an important influence on shoreline ecological functions along Bremerton's shorelines (Shipman 2008; PSNERP 2010). Coastal landforms in the study area include very small areas of rocky shoreline (Figure 3-2); bluff-backed beaches with a relatively narrow beach backed by high bluffs to low banks (Figure 3-3); relatively wide barrier beaches; stream deltas; several types of embayments such as open coastal inlets, barrier estuaries (Figure 3-4), barrier lagoons, and closed lagoons/marshes; and artificial shoreforms such as filled areas, structures, or armoring (Figure 3-5).

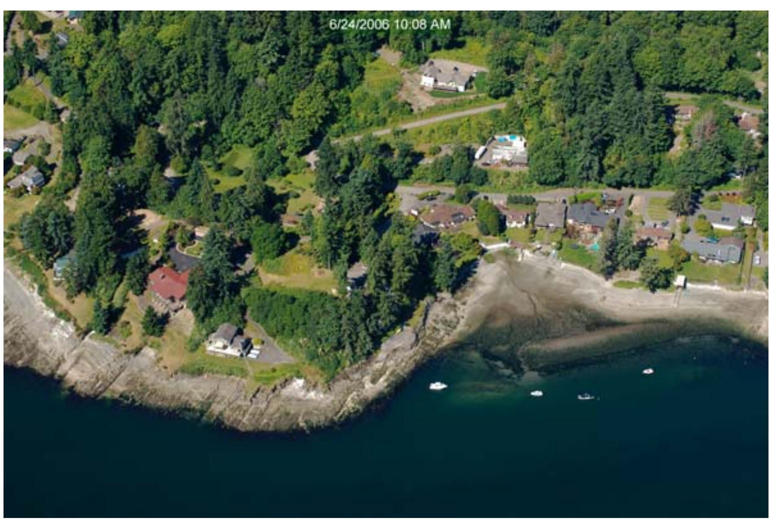

Figure 3-2. Rocky shoreform at Bass Point (Ecology, Washington Coastal Atlas).

Figure 3-3. Bluff-backed beaches along Port Washington Narrows (Ecology, Washington Coastal Atlas).

Figure 3-4. Barrier estuary in Phinney Bay; spit has been developed and a channel cut across the spit (Ecology, Washington Coastal Atlas).

Figure 3-5. Artificial shoreforms associated with the Puget Sound Naval Shipyard include overwater structures, fill, and armoring (Ecology, Washington Coastal Atlas).

3.1.2.3 Hydrology

The East Kitsap Watershed lies between the backbones of the Kitsap Peninsula and Bainbridge Island, resulting in a narrow strip of land with many short streams that drain to the west side of Central Puget Sound. Streams in the study area are typical lowland type streams with generally moderate gradients. Upper reaches of streams are typical Puget Lowland headwater streams with low gradients that originate with perched groundwater in lakes and wetlands on upland plateaus and hills (Williams et al. 1975, Buffington et al. 2003). Numerous wetlands occur in the study area (Map 3B). Considerable deciduous growth, interspersed with stands of conifers, farmland, and urban/suburban development is common on all streams. None of the streams are supported by snow runoff, as the maximum elevation in East Kitsap is less than 500 meters.

Stream profile characteristics are, for the most part, pool-riffle in nature with water quality and aquatic insect production highly conducive to anadromous fish production (Williams et al. 1975, May and Peterson 2003). Stream power is generally low, limiting the ability of streams to transport sediment. Where streams flow off the higher rolling hills and plateaus down to the shore of the Sound, steeper ravines can create confined channels with greater sediment transport capacity Due to the small size of most streams, large, extensive floodplains are not found in the study area. Flood zones defined by the 100-year flood elevations and flood hazard factors occur along almost the entire marine shoreline and the Kitsap Lake shoreline; FEMA defines the floodplain elevation as 13 feet NAVD (FEMA Flood Hazard Maps; Flood Zone A, Map 4I).

The glacial deposits described above create a complex mix of layers of permeable deposits that rapidly infiltrate water (aquifers), with impermeable deposits such as compacted till, silts and clays that limit or prevent the infiltration of water (aquitards). Large areas of permeable deposits can be important aquifer recharge areas (Map 4A and Map 5). As a result of this complex mix of deposits, the study area contains several aquifers and aquitards within the subsurface. When impermeable deposits lie below permeable deposits, water infiltrating through permeable layers will be stopped at the aquitard and flow along this layer. Springs and seeps occur where this water discharges at the ground surface. This mix of layers therefore controls subsurface water movement from the upland to the lowland, as well as water movement to the streams and creeks that occupy former glacial outwash channels (Deeter et al. 1979).Groundwater flow into Sinclair and Dyes Inlets has not been documented but is thought to be 'substantial' (Lincoln and Collias 1975, PSCRBT 1990).

The headwaters of the Union River are impounded for Bremerton's main water supply. About 65% of the City's potable water comes from the Union River, with additional water supply from wells located near Anderson and Gorst Creeks, and north of east Bremerton (CDM 2005).

3.1.2.4 Oceanographic Processes

The marine nearshore area of the study area is irregular and composed of numerous bays, harbors, and lagoons, with varied topography and slope. Combined, there are approximately 53 miles of marine shoreline in the study area. The majority of the shoreline within the study area is relatively protected from severe weather conditions and experiences only moderate- to low-energy wind and wave conditions.

The protected nature of the study area marine waters and lake of large freshwater inputs from large rivers means that tidal currents and flows are important in driving local circulation patterns and water exchange. Low tides expose numerous small to moderate-sized tide flats in the bays and at the head of the inlet. Currents are generally weak except for in the Port Washington Narrows (about 4 knots; NOAA 1988). Flushing time for marine waters is about four days. Tideflats at the head of the inlet are exposed during low tides. Currents in Sinclair Inlet are relatively weak – about 0.8 knots, resulting in a low flushing rate with an estimated flushing time of about 14 days. The low flushing rates in both Dyes and Sinclair Inlets means that contaminants entering the inlets are not flushed out but can remain in place and become concentrated, degrading water quality and habitat.

3.1.2.5 Sediment

Streams in the study area are relatively small with moderate gradients and do not move large amounts of sediments compared to the larger river systems in Puget Sound. Steep slopes in the upper watersheds west of Gorst are moderately erosive and contribute sediment to floodplains, stream channels, and stream mouth estuaries (Map 3A and Map 4B). Tidal currents erode and deposit sediment in flats, marshes, and estuaries, creating complex channel networks. These channel networks redistribute organic matter, influence salinity gradients in estuaries, and provide access and refugia for fish and invertebrates.

The sediment that forms beaches and other shoreforms throughout Puget Sound, and in the study area, is predominantly from eroding coastal bluffs. Some areas of the steep coastal bluffs along Port Washington Narrows and in Bremerton East are highly erodible and are important sources contributing sediment to the nearshore (Figure 3-6). Sediment is eroded, moved, and deposited in a series of littoral drift cells. In areas where shorelines are protected from wave energy, streams entering the nearshore deposit fine sediments such as muds and sands. The large, relatively enclosed area of Sinclair Inlet has no appreciable net transport of sediment due to weak currents and limited wave action.

Figure 3-6. Recent slide areas on coastal bluffs contributing sediment to Bremerton's nearshore along Port Washington Narrows (Ecology, Washington Coastal Atlas).

3.1.3 Land Conversion, Development, and Management

The study area has undergone a series of changes in land cover and development over the past two hundred years that have altered marine and freshwater shorelines. The study area is within the traditional territory of the Suquamish Tribe, Salish-speaking people who occupied lands between present-day Gig Harbor, Bainbridge Island and Whidbey Island (Spier 1936, Suttles and Lane 1990). The Suquamish Tribe's traditional area included Puget Sound roughly from Vashon Island north to the Fraser River. The study area includes locations where the Tribe hunted for waterfowl, game, and marine mammals, fished for salmon and other finfish, gathered shellfish, gathered food plants, and practiced plant food horticulture (Suttles and Lane 1990, Ruby and Brown, 1992, Larson and Lewarch 1995, Waterman 2001). Pre-European contact settlements were often located along major waterways, and heads of bays and inlets. Wetlands provided a number of food or medicinal plants, and larger streams such as Chico Creek, Union River, and Gorst Creek were important sources of salmon and other fish. The Kitsap Lake area supported hunting, being noted for a large deer population (Snyder 1968).

Settlement of Puget Sound by non-indigenous peoples began in the 1850s. Subsequent to the Treaty of Elliott Point in 1855, tribes were relegated to reservations, and rapid development and resource consumption ensued. In addition to the creation of settlements and small towns, early land-use activities included dredging for harbors to improve navigation, constructing rail corridors, and land clearing associated with agriculture and forestry. Logging expanded rapidly with European settlement and several mills were established, including the early William Renton mill at Port Orchard (Perry 1977). In the early 20th century, the Kitsap Lake Development Association began construction of a water system to serve residences on the northwestern shores of the lake (cited in Berger and Hartmann 2007).

As population in the area grew, land-uses in lowland areas transitioned from forestry and agriculture to urban development, including medium- and high-density residential, commercial, and industrial development. Industrial land-use was established at various locations, including along the Bremerton and Port Orchard waterfronts. Development in the Bremerton area throughout the 20th century was linked to the Naval facilities in the area, such as the Puget Sound Naval Shipyard, built in 1891 (Perry 2002), the Naval Undersea Warfare Center Division Keyport constructed before World Work I, and the Trident Submarine Base at Bangor, established in 1944 (Perry 1997). Navy-built railroads are located along Sinclair Inlet and connecting Shelton, Bangor, and Bremerton. Recent development along the marine shorelines includes the Washington State Ferry Terminal and the Bremerton marina.

3.1.3.1 Existing Land Use

Land uses in the study area include relatively concentrated industrial, commercial, military, and residential land uses in urban areas along the marine shorelines, with largely forested and undeveloped lands in the interior. Relatively undeveloped areas occur in the upper Gorst watershed, the South Kitsap Industrial Area, and the area around Union Reservoir. The military/industrial development of the Puget Sound Naval Shipyard (PSNS) occupies an area along the north shore of Sinclair Inlet. Commercial land uses dominate in the Gorst area just west of the mouth of Gorst Creek. Between the PSNS and Ostrich Bay, land uses are primarily dense to moderately dense residential, with some commercial areas along the Bremerton waterfront. The WSDOT ferry terminal and Port of Bremerton marina are located at the Bremerton waterfront just north of the PSNS.

Recreational, commercial, and tribal harvest of salmon, other finfish, and shellfish are significant activities. The largest fishery is tribal harvest of chum and Chinook salmon in Sinclair Inlet. The Suquamish Tribe operates a Chinook hatchery on Gorst Creek in cooperation with the City, WDFW, and the Poggie Club (Haring 2000). Sinclair and Dyes Inlets, as well as the adjacent waters of Puget Sound, are part of the Suquamish Tribe's usual and accustomed fishing area (UA).

3.1.3.2 Climate Change

Changes in climate can have dramatic consequences for ecosystem processes and ecological functions. Fluctuations in climate occur naturally at a range of temporal scales from thousands of years (ice ages), to decades (El Nino-Southern Oscillation: ENSO), to daily changes in temperatures. These fluctuations in climate have, in large part, shaped the landscape through fluvial, glacial, and nearshore processes. Although there is much uncertainty surrounding the type and extent of climate change that is anticipated to occur due to increased greenhouse gas emissions (GHG), some general predictions suggest that global climate change will affect Bremerton's shorelines.

The Intergovernmental Panel on Climate Change (IPCC) has published several reports that indicate that there is an overall warming climate trend (for example, see the Technical Summary IPCC, 2007 http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Pub_TS.pdf). The exact implications of this trend for specific regions, such as the Puget Sound, are unclear. The climate impacts Group at the University of Washington (cses.washington.edu) has used climate models to identify some possible climate impacts in the Puget Sound:

- Continued warming on the order of 0.2 to 1.0ºF;
- Possible decrease in summer precipitation and increase in winter precipitation with little change in the annual mean (http://cses.washington.edu/cig/pnwc/cc.shtml).

Taken together, these factors have the potential to influence the functioning of Puget Sound ecosystems. Warmer temperatures could result in higher summer water temperatures, having the potential to negatively impact several water quality parameters. Additional winter rainfall has the potential influence flow regimes.

For Bremerton's shorelines, one of the most important anticipated effects of climate change in the Pacific Northwest is sea-level rise. Sea level rise will likely change coastal processes and habitats, if water elevations increase as predicted. A recent study has been published by the National Wildlife Federation (NWF) on sea level rise and coastal habitats in the Pacific Northwest (National Wildlife Federation, July 2007). This study evaluated the Puget Sound, southwestern Washington, and northwestern Oregon coasts specifically, and identified 11 different sites within the Puget Sound for sea-level modeling. The model used a range of sea-level rise scenarios as predicted by the IPCC from 0.08 meter (3.0 inch) increase in global sea levels by 2025 to a 0.69 meter (27.3 inches) increase to 2100. Sea-level rise within this range is anticipated to affect water dependent uses and infrastructure, as well as coastal habitats and fish and wildlife dependent upon the coastal areas of the Puget Sound. Predicted habitat changes in the Puget Sound, including coastal areas in the study area, are loss of estuarine beach and tidal flat areas, reduction in tidal marshes, saltwater intrusion into freshwater wetlands and brackish marshes, and increased shoreline erosion (NWF, 2007).

3.2 HABITATS AND BIOLOGICAL RESOURCES

Habitat units are local scale features and are defined as the biological and physical features of the environment that are critical sites for biological and ecosystem health, and ecological function on a local scale. Habitats and biological resources are affected by ecosystem-wide processes and process alterations. Habitats are also defined by environmental factors that modify or influence physical and biological structure. In freshwater systems, the most important of these are inundation or flow regime, substrate type, water depth and velocity, light, temperature, and dissolved oxygen. In the nearshore, the most important of these are energy regime/exposure, substrate type, water depth (includes light), tidal regime/tidal range, and salinity. Habitat units that can be defined for the study area are listed in Table 3-1 and 3-2, with major landforms, constituent components, and biological communities defined following Dethier (1990), Kunze (1994), Montgomery and Buffington (1998), Buffington et al. (2003), Madden et al. (2008), and Shipman (2008).

Biological resources that play a critical role in ecological function and/or provide important benefits to people are sometimes referred to as 'valued ecosystem components' (VEC) (Leschine and Peterson 2007). The following section discusses some of the key VECs in the study area that are influenced by ecosystem-wide processes and perform valued ecological functions.

3.2.1 Terrestrial Habitats – Contributing Watersheds

Terrestrial habitat resources within the study area influence adjacent freshwater and marine shorelines and include terrestrial forests, steep slopes and ravines above streams, and riparian areas. Lowland forests are dominated by western hemlock, Douglasfir, and western redcedar. Forests provide breeding, feeding, and migration areas for a wide range of wildlife including large and small mammals, reptiles, songbirds and raptors, and insects and other invertebrates (Kruckeberg, 1991). Notable species in the Bremerton study area or region include: black-tailed deer, elk, black bear, bats, cougars, beavers, raccoons, and many rodents. Forested areas support a diverse array of bird species including songbirds, crows, and raptors. Many of these terrestrial wildlife species rely on shoreline habitats (lakes, rivers and marine shores) for at least some of their life stage requirements. Forested areas are also important areas for ecosystem-wide processes that affect adjacent shorelines, including movement of water, sediment, and large woody debris.

3.2.2 Freshwater Systems

Major landforms, habitats, and biological communities are listed in Table 3-1.

3.2.2.1 Streams and Riparian Areas

Stream ecosystems are complex and influenced by a suite of landscape processes including surface water hydrology, groundwater hydrology, sediment supply, nutrient supply, and riparian zone structure and condition. Changes in surface water processes have a major impact on ecological function and floodplain and hyporheic habitat conditions (Poff and Ward 1989). Changes in surface flow regimes can transform sediment supply and water quality, and can directly influence the patchwork mosaic of instream habitat resulting from natural fluvial processes (Leopold, Wolman & Miller 1964). This diversity of habitats in stream channels supports a rich macroinvertebrate community, as well as anadromous and resident fish.

Research has shown that coastal rivers of the Pacific Northwest link temperate forests with adjacent marine ecosystems and serve as transport pathways for nutrients in both directions (McClain et al. 2003). According to McClain et al. (2003), streams and river accumulate nutrients from groundwater and terrestrial sources and transport them downstream, during which time numerous chemical and biological interactions repeatedly cycle the nutrients between organic and inorganic forms. This process is known as nutrient spiraling (Webster and Patten 1979).

Table 3-1. Upland and freshwater landforms, habitat components, and biological communities.

Hydrogeomorphic System	Major Landforms	Habitat Componen ts	Habitats / Biological Communities
• Puget Lowland Headwater Channels • Moderate to low gradient channels originating on rolling uplands, frequently from headwater lakes or wetlands.	Stream channel	Pool/riffle	Resident fish Anadromous fish Benthic macroinvertebrates Riparian forests Shrub/emergent wetlands
• Puget Lowland Confined Channels • Moderate to high gradient confined channels in steep ravines; transition from uplands to coastal deltas or estuaries	Stream channel	Step pool	Resident fish Anadromous fish Benthic macroinvertebrates Riparian forests
• Puget Lowland Unconfined Alluvial Channels • Low gradient channels in relatively broad valleys	Stream channel Channel migration zone	Pool/riffle Floodplain Hyporheic zone	Resident fish Anadromous fish Benthic macroinvertebrates Riparian forests Shrub/emergent wetlands
• Depressional and Slope Wetlands • Precipitation influenced wetlands occurring in low points or depressions in the landscape; seasonally fluctuating water levels. • Groundwater discharge influenced wetlands on	Flats Slopes Depressions	Wetland depression Seeps and springs	Emergent, shrub, and forested wetland vegetation Amphibians Reptiles Small mammals Raptors and songbirds

Table 3-1. Upland and freshwater landforms, habitat components, and biological communities.

Hydrogeomorphic System	Major Landforms	Habitat Componen ts	Habitats / Biological Communities
slopes where seeps or springs from groundwater discharge provide perennial source of water.			
• Lakes/Lacustrine Wetlands • Precipitation or groundwater influenced areas of permanent open water.	Depressions	Open water Littoral zone Fringing wetlands	Resident fish Phytoplankton and zooplankton Benthic macroinvertebrates Freshwater bivalves Submerged, floating, and emergent aquatic vegetation Emergent, shrub, and forested wetland vegetation Amphibians Reptiles Songbirds and Raptors Small mammals
• Artificial/Anthropogenic	Shoreline Modification: Armoring Causeways/ Roads Overwater structures Fill Dredged Channels	Bulkheads/ seawalls Revetments Tires Roadways Railroads Jetties Docks Piers Pilings Boat ramps Log booms Fill/structures in littoral	Typically lack vegetation Can be colonized by native and non-native biofouling communities

Riparian vegetation contributes to a wide range of ecological functions within shoreline areas. Vegetation contributes to habitat functions for a range of fish and wildlife species. Healthy environments for aquatic species are linked with the surrounding terrestrial ecosystem including vegetation cover. Riparian zones contribute to healthy streams by dissipating energy and inhibiting sediment input, regulating the erosional processes that move sediment, and mechanically filtering and/or storing upland sediments before they can enter stream channels (Knutson and Naef, 1997). Riparian vegetation also performs water quality functions related to pollutant removal, primarily through denitrification, and trapping or storing of phosphates and heavy metals that are adsorbed to fine sediments.

One of the most crucial 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).

Commonly recognized functions of the shoreline vegetation include:

- Providing shade necessary to maintain the cool temperatures required by salmonids, spawning forage fish, and other aquatic biota.
- Providing organic inputs critical for aquatic life.
- Providing food in the form of various insects and other benthic macroinvertebrates. Stabilizing banks, minimizing erosion, and reducing the occurrence of landslides. The roots of trees and other riparian vegetation provide the bulk of this function.
- Reducing fine sediment input into the aquatic environment through storm water retention and vegetative filtering.
- Filtering and vegetative uptake of nutrients and pollutants from groundwater and surface runoff.
- Providing a source of LWD into the aquatic system. LWD is the primary structural element that functions in streams to provide hydraulic roughness element to moderate flows. LWD also serves a pool-forming function in streams, providing critical salmonid rearing and refuge habitat. Abundant LWD increases aquatic diversity and stabilization, and provides cover for juvenile salmonids from birds, fish and other predators.
- Regulating of microclimate in the stream-riparian corridors.
- Providing critical wildlife habitat, including migration corridors and feeding, watering, rearing, and refugia areas.

Stream and wetland riparian vegetation is largely intact in the upper Gorst watershed, around the Union Reservoir, Anderson Creek, unnamed stream entering Port Washington Narrows opposite Rocky Point, and along unnamed stream in East Bremerton UGA. Riparian vegetation is somewhat intact in portions of Chico Creek downstream of Kitsap Lake, and along unnamed short stream entering Sinclair Inlet south of where SR 3 and Navy Yard Way join.

Anadromous and Resident Fish

Streams in the study area support a number of salmonids and resident fish, the most common species being coho, fall chum, resident cutthroat, and winter steelhead. There are no native runs of Chinook salmon in streams draining to Puget Sound from the east side of the Kitsap Peninsula, including Sinclair Inlet and tributaries. Fall-run Chinook salmon in Sinclair Inlet are supported entirely by Gorst Creek hatchery production, operated by the Suquamish Tribe in cooperation with the Poggie Club and City of Bremerton. Ocean-type Chinook salmon occur in several stream basins in Sinclair Inlet (Blackjack and Gorst Creeks), with an estimated 10,000 adult Chinook salmon typically returning to Gorst Creek (WDFW 2007). Juvenile Chinook salmon are known to occupy shallow water habitat throughout Sinclair and Dyes Inlets (Fresh et al. 2006). Migratory adults returning to natal area streams would also be present within the marine waters of Sinclair Inlet, Port Washington Narrows, and Dyes Inlet in late summer and early fall.

Both fall and summer chum occur in the study area, with most of the streams in the area supporting fall chum (see Map 7A). Hood Canal chum salmon occur in the lower reaches of the Union River system and are presumed to migrate west through Admiralty Inlet on leaving Hood Canal, although it is possible that some juveniles may move into Puget Sound and forage along the shorelines, potentially including the SMP study area, before migrating to sea.

Chum salmon on spawning migrations may enter rivers from June to March. Adults will move into rivers when river flows increase after a period of rain. Chum salmon spawn in a wide variety of locations. In general, chum salmon are reported to spawn in shallower, slower-running streams and side channels more frequently than do other salmonid species (Salo 1991). They usually spawn at the head of riffles and in areas of upwelling groundwater, but may also spawn in intertidal zones of streams at low tide (Salo 1991). Hood Canal summer chum spawn from early September to late October, and late fall chum spawn from mid-November to mid-January (WDFW and WWTIT 1994).

Chum salmon are capable of adapting to saltwater soon after emerging from gravel, and rear in freshwater for a few days to several weeks before migrating downstream to saltwater (Salo 1991). Downstream migration may take only a few hours or days in rivers where spawning sites are close to the mouth of the river, or it may take several months if the migration distance is long. In Washington, downstream migration occurs from late January through May (Johnson et al. 1997). In the Hood Canal river systems, out-migration starts in March and continues through April. Chum salmon spend 3 to 5 years at sea before returning to their native stream to spawn, die, and regenerate the cycle. Chum salmon juveniles, like other anadromous salmonids, use estuaries to feed before beginning long-distance oceanic migrations. However, chum and ocean-type Chinook salmon usually have longer residence times in estuaries than do other anadromous salmonids (Salo 1991). Migration of chum salmon juveniles out of estuaries appears to be closely correlated with prey availability, and larger individuals move offshore earlier.

Although several area streams support winter-run steelhead, juveniles apparently rarely occur in the nearshore marine habitat in the study area vicinity (Fresh et al. 2006).

Salmonid stock status is rated as ‘Healthy’ or ‘Unknown’ in most streams in the study area. Healthy segments include tributaries in the Union River system, one tributary on Gorst Creek and several small tributaries on Chico Creek (Map 7B). Listed status under the ESA is ‘Threatened’ for most streams in the study area.

3.2.2.2 Freshwater 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).

Wetlands are comparable to rain forests and coral reefs in productivity (Mitsch and Gosselink 2000, Sipple 2002). They support extensive ecological function because they are structurally diverse, providing an array of unique niches that increase biodiversity (Knutson and Naef 1997), and provide breeding and rearing habitat for invertebrates, fish, amphibians and reptiles (Sipple 2002). In fact, over 67 percent of all terrestrial vertebrate species in Washington are either wetland-dependent or use wetlands (Kauffmann et al. 2001).

Wetlands also indirectly impact other aquatic resources by facilitating landscape processes. Wetlands improve water quality by acting as a sink for sediment, nutrients, and metals and toxic compounds and help maintain watershed hydrology by storing surface water and recharging groundwater (Hruby 1999, 2000, 2003).

The patterns of hydrology in a landscape determine the presence, structure, and function of wetlands. Hydroperiods, inundation depth, and water source all influence wetland function (Mitsch and Gosslink 2000). Wetland hydrology is similar to streams (Booth and Reinelt 1993), and development can decrease the amount of water available to a wetland through drainage or decreases in groundwater inputs, increase inputs via overland flow or runoff into wetlands, which may also increase fluctuation in water levels (Euliss and Mushet 1999). Drier wetlands are also destroyed more frequently on urban fringes (Holland et al. 1995).

Changes in hydrology can also influence sediment dynamics through erosion, deposition and vegetation burial. In addition, agriculture (Baker 1992) and urbanization (Booth 1991) increase sediment loading in wetlands. Agriculture and urbanization also increase nutrient inputs, which can increase BOD and reduce species diversity.

Mapped locations for freshwater wetlands are concentrated in the area to the south and west of Kitsap Lake, in the headwaters of Chico Creek and Gorst Creek, headwaters of Anderson Creek, in the Union River system, and in the area to the south of the South Kitsap Industrial Area.

Wetlands associated with shorelines include the large wetland along the south shoreline of Kitsap Lake, small wetlands along the shore of the Union Reservoir, wetlands in the Gorst estuary, and small wetlands along the shore of Oyster Bay, Ostrich Bay, Mud Bay and Phinney Bay.

3.2.2.3 Lakes

Lakes are deeper areas of open fresh water with wave-swept shores (Fuller 1997). Lakes store surface water and are a source of groundwater inputs. Thus they attenuate flood flows and are important sources of water for domestic consumption and irrigation. Lake shore and lake view properties are also highly valued for their aesthetic appeal and recreational value.

Lakes are biologically diverse and provide habitat for numerous aquatic and terrestrial species that live along or near a natural lakeshore (Henderson et al. 1999). Aquatic plants and plankton (tiny plants and animals) form the base of a very productive food web that supports fish and other wildlife. Submergent and emergent aquatic plants provide cover for fish, amphibians, insects, birds, and numerous other organisms. Aquatic plants also provide important substrate for algae and bacteria that filter pollutants such as nutrients and toxins. Shoreline and upland plants provide food and cover for insects, birds, amphibians, and mammals; protect soils from surface and lakeshore erosion; and are an important factor for protecting water quality.

The biological, chemical, and physical processes and functions of lakes are changed as a result of modifications to contributing watershed or riparian shoreline vegetation. Removal of vegetation can increase shoreline erosion, sedimentation from the watershed, inputs of nutrients to the lake, and reduce shading and inputs of leaf litter, insects and other organic matter to the lake. Boat generated waves can increase shoreline erosion and sedimentation, increasing turbidity and contributing nutrients. Phosphorous is typically the limiting nutrient in most lakes and the supply of phosphorous limits plant growth and primary production (Henderson et al. 1999). Dissolved oxygen enters via diffusion from the air and as a product of photosynthesis, and is vital for aquatic plants and animals.

An increase in nutrients to lakes (eutrophication) affects water quality by enhancing the growth of algae and other aquatic plants, increasing turbidity, contributing to harmful algal blooms, increasing decomposition and biological oxygen demand and reducing the amount of oxygen available to fish and other animals (Odum 1963). Nutrient rich lakes tend to have high amounts of aquatic vegetation, large amounts of oxygen consumed by decomposition of the organic matter from these plants, and low levels of dissolved oxygen. Excessive nutrients or inputs of fine sediment from surface erosion in the watershed or along the shoreline reduces transparency of the water and reduces the depth to which light can penetrate, reducing plant growth.

Lakes are not common in the study area. Kitsap Lake is the major natural lake in the study area; Kitsap Lake is fed by a series of headwater wetlands to the south of the lake, and discharges to the north into the Chico Creek drainage. Union Reservoir is the second largest lake in the study area and was created by damming the Union River to supply drinking water to the City. Twin Lakes, two small lakes to the southwest of the Union Reservoir, occupies a small depressional area and does not have an outlet.

Wetlands associated with Kitsap Lake at the far south end of the lake provide substantial water quality benefits for tributaries flowing into the lake as well as substantial habitat for a variety of species.

Nearshore geomorphic systems, habitats, and biological communities are summarized in Table 3-2.

3.2.2.4 Coastal Forests (Marine Riparian Vegetation)

Marine riparian zones occur at the interface between upland and marine aquatic systems (Culverwell and Brennan 2003; Brennan and Culverwell 2004, Brennan et al. 2009). Marine riparian zones occur above the area subject to tidal inundation, but may be in the area influenced by salt spray or storm waves. The type of marine riparian vegetation that occurs along the shoreline is influenced by a number of factors. The underlying geology, that influences the type of shoreform, whether feeder bluff, rocky shore, or beach backshore, will also influence the type of riparian vegetation present. In addition to underlying shoreform, the types of soils, steepness and height of the shoreline or bluff, annual precipitation, adjacent land uses, and surface and hillslope runoff processes, can all affect what type of vegetation is present. For example, adjacent land uses may result in presence of invasive species, or the replacement of forested riparian vegetation with ornamental landscaping, lawns, or impervious surfaces. Shorelines comprised of very steep or unstable slopes may not support

Table 3-2. Nearshore landforms, habitat components and biological communities in

Geomorphic System	Major Landforms	Habitat Components	Habitats / Biological Communities
Rocky shores Resistant bedrock with limited erosion	Platform Wave-eroded platform/ramp, but no beach Pocket Beaches Isolated beaches contained by rocky headlands	Cliff, ramp/platform Cliff, backshore, beach face, low tide terrace	Kelp – intertidal, subtidal (floating canopy) Kelp – non-floating canopy Rockweed – intertidal, subtidal Rockfish/Bottomfish
Beaches Shorelines consisting of loose sediment and influenced by wave action	Bluff-backed beaches Formed by landward retreat of the shoreline	Bluff face, berm, beach face, low tide terrace	Marine riparian vegetation (Coastal Forests) Coastal bluff

Table 3-2. Nearshore landforms, habitat components and biological communities in

Geomorphic System	Major Landforms	Habitat Components	Habitats / Biological Communities
Also referred to as accretion shoreforms (Johanessen and MacLennan 2007)	Barriers Formed where sediment accumulates seaward of earlier shoreline (spits, recurved spits, stream mouth spits, bay barriers, bay-mouth barriers, bay-head barriers, looped spits, tombolos, and cuspate forelands) Bars depositional features that are covered by high tides; transverse bars parallel to net shore-drift	Berm, beach face, low tide terrace	Forage fish spawning Sand/mud flats Shellfish aggregations Benthic macroinvertebrates Backshore (dunes, plant community?) Shorebird foraging
Small embayments: estuaries and lagoons Protected from wave action by small size and sheltered configuration	Open coastal Inlets Small inlets protected from wave action by their small size or shape, but not extensively enclosed by a barrier beach Barrier estuaries Tidal inlet largely isolated by a barrier beach and with a considerable input of freshwater from a stream or upland drainage Barrier lagoons Tidal inlet largely isolated by a barrier beach and with no significant input of freshwater Closed lagoons and marshes Back-barrier wetlands with no surface connection to the Sound	Stream delta, tide flats, salt marsh, tidal channels Stream delta, tide flats, salt marsh, channels, tidal delta Tide flats, salt marsh, channels, tidal delta Salt marsh, pond or lake, tidal channels Salt marsh	Eelgrass beds Salt marshes Shellfish aggregations Sand/mud flat Shorebirds
Deltas Long term deposition of fluvial sediment at river mouths	Tide-dominated deltas Deltas at heads of bays where tidal influence is much more significant than fluvial factors, typically with wedge-shaped estuary	Alluvial floodplain (freshwater tidal, brackish tidal marshes/wetlands), salt marsh, tide flats, subtidal flats, distributary channels, tidal channels	Tidal freshwater wetland (forest, shrub, emergent) Tidal brackish wetland (forest, shrub, emergent) Tidal salt marsh wetland

Table 3-2. Nearshore landforms, habitat components and biological communities in

Geomorphic System	Major Landforms	Habitat Components	Habitats / Biological Communities
			(emergent)
			Eelgrass beds
			Shellfish aggregations
			Sand/mud flats
			Riparian forests adjacent to stream channels
Artificial/Anthropogenic	Shoreline Modification:		
	Armoring	Bulkheads/seawalls	
		Revetments	
	Causeways	Tires	
		Roadways	
	Groins/jetties	Railroads	
		Groins	
	Overwater structures	Jetties	
		Docks	
	Fill	Piers	
		Marinas	
	Dredged Channels	Ferry terminals	
		Pilings	
	Aquaculture	Boat ramps	
		Log booms	
		Fill/structures in intertidal	
		Ports	

vegetation except at the very top of the slope. In contrast, small bluffs or shorelines may support dense riparian vegetation that overhangs into the upper beach zone.

Healthy marine riparian areas provide a range of essential functions, including water quality protection, sediment stabilization and control, wildlife habitat, nutrient retention, microclimate regulation, insect food sources for juvenile fish, shade/cover, and woody debris to provide complex habitat structure and stabilize beaches (Brennan and Culverwell 2004, Brennan et al. 2009). Areas with intact riparian vegetation can also help protect slopes and bluffs from erosion hazards, mitigate storm damage, and stabilize slopes. Plant root masses provide stability by holding the soil in place. In addition, evapotranspiration removes moisture from the soil and can prevent high soil moisture or saturated soil conditions, which can lead to landslides or erosion hazards (Brennan and Culverwell 2004). The extent to which riparian zones perform these functions is dependent on vegetation composition, vegetation density, and the area continuously covered with vegetation (e.g., width of buffer and length of shoreline with buffer) (Knutson and Naef 1997).

Brennan and Culverwell (2004) and Brennan et al. (2009) note the following characteristics of healthy nearshore riparian systems:

- 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 vegetation diversity;
- Composition of native vegetation differing from upland (inland) systems (e.g., different species composition, abundance, diversity, and structure), and
- Complex physical structure that provides support for terrestrial and aquatic biota.

Relatively intact marine riparian vegetation is found at the following locations: NAD Marine Park, western side of Madrona Point (east shore of Ostrich Bay), portions of Oyster Bay, portions (northern portion) of Mud Bay, portions of the eastern side of Rocky Point, portions of point to east of Phinney Bay, Port Washington Narrows west just north of Warren Ave. Bridge and a very narrow fringe around Manette Bridge, very small isolated patch east of Gorst on south side of Sinclair Inlet, most of the shoreline along Bremerton East UGA, Port Washington Narrows east to either side of Warren Avenue Bridge, and Port Washington Narrows opposite Rocky Point (but mostly separated from nearshore by roadway).

3.2.2.5 Eelgrass

Eelgrass (*Zostera marina*) is a native marine seagrass that forms extensive meadows or beds on gravel, fine sands or 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, adequate light, relatively high levels of organic matter and nutrients (Simenstad 2000). Typical eelgrass locations are shallow tideflats, along channels in tideflats or estuaries, and in the shallow subtidal fringe. The eelgrass zone in Puget Sound 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).

In undisturbed areas with optimal conditions, eelgrass can grow to a height of 2 meters, forming a tall, dense canopy. Eelgrass beds can be dense and continuous along a stretch of shoreline, or occur in small, discontinuous patches. On the shallow flats typical of the southern Puget Sound, eelgrass beds can form wide expanses. Eelgrass beds form narrow corridors along the shoreline in areas with steeper beaches, or where light penetration is limited by turbidity (Simenstad 2000).

Eelgrass ecosystems are highly productive, providing a source of organic matter to intertidal and shallow subtidal food webs. Eelgrass plants produce large amounts of organic carbon that is consumed directly by grazers, as well as forming the basis for complex detrital food webs (Williams and Thom 2001). Organic carbon produced by eelgrass is broken down by microbial decomposition. Particulate organic matter is also processed and consumed by a number of invertebrates, including harpaticoid copepods, gammarid amphipods and isopods, which in turn, are important prey items for juvenile salmon and other fish (Simenstad et al. 1991). Juvenile salmon, as well as a number of other animals depend on eelgrass habitat structure for refuge from predators. Eelgrass leaves provide physical attachment sites for epiphytic algae and other organisms, and physical structure which absorbs and dampens the energy of waves and currents, providing some buffering for adjacent habitats. Pacific herring use eelgrass for spawning substrate and for protection while eggs and juveniles mature (Williams and Thom 2001).

Eelgrass is found in patchy distribution north of Erlands Point, south of Elwood Point, in the southern point of Ostrich Bay and on the east shore of Ostrich Bay, in Oyster Bay near Madrona Point, in Mud Bay, along Port Washington Narrows at Lions Park, on both shores of Sinclair Inlet adjacent to Gorst Estuary, and north of the planning area near Illahee State

Park. Eelgrass is mapped in continuous distribution along the south and west shores of Phinney Bay (Map 8D).

3.2.2.6 Macroalgae/Kelp

Kelp and other macrophytic brown algae can form dense, highly productive undersea forests that support many species of fish and marine mammals. Juvenile salmon and forage fish may preferentially use kelp stands in nearshore habitats (Shaffer 2003). Dense kelp forests also dissipate wave energy and provide sheltered habitat for resting/rafting seabirds and other animals within the kelp forest or adjacent surface waters. Kelp forests are comprised primarily of bull kelp (*Nereocystis luetkean*a) and other large brown algae, including the introduced Sargassum (*Sargassum muticu*m). These plants are attached to the marine 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.

Continuous beds of non-floating kelp are mapped along both shores of Port Washington Narrows, and around Rocky Point. Patchy distribution of non-floating kelp is mapped along Bremerton East UGA shorelines north of Herron Point and opposite Rocky Point, Madrona Point, and Erlands Point. The non-native Sargassum is mapped as patchy distribution near Erlands Point, at Rocky Point, and along the Bremerton East UGA shoreline north of Herron Point. An area of continuous *Sargassum* is mapped around Herron Point (Map 8C).

No areas of floating kelp are mapped by WDNR, WDFW, or the EKNHA.

3.2.2.7 Beaches and Bluffs

Coastal bluffs are the primary source of beach sediments in the PNW, being particularly important in Puget Sound and along portions of the Washington and Oregon coasts. Natural erosion of coastal bluffs is essential for the maintenance of beaches and other associated nearshore habitats. Nearshore habitats and biological communities that are particularly dependent on the functioning of the bluff/beach system include coastal forests, dunes/dune systems, estuarine spits, lagoons and coastal marshes, forage fish (e.g., surf smelt, Pacific sand lance spawning beaches), juvenile salmon, shorebirds/waterfowl, and eelgrass beds.

Coastal bluffs are treated as a separate habitat unit here, but most bluff-backed beaches include the following sub-units or features:

- Backshore - includes bluff face, colluvium at toe of bluff, berms and beach scarp on the upper part of the beach generally above MHHW;
- High tide beach - steep beach face and transition to low tide terrace;
- Low tide terrace – the flatter portion of lower beach which can also contain troughs and longshore bars parallel to the shoreline.

Beach types include bluff-backed beaches, depositional beaches, barrier beaches and spits. The most common type of beach in Puget Sound are bluff-backed beaches - relatively narrow, thin beach deposits of sand and gravel underlain by a relatively flat erosional platform in most areas of the Sound. Along the Washington and Oregon coasts, beaches predominantly sand and gravel beaches and are one of the most shoreforms, particularly along the southern portion of Washington and Oregon coasts.

Ecological processes that affect beaches and bluffs include sediment erosion and delivery, sediment transport and deposition, tidal flows, freshwater input, and exchange of organisms. Beaches and bluffs contribute to numerous ecological functions, including energy dissipation, forage fish spawning, habitat formation, shellfish support, waterfowl foraging, eelgrass habitat, and juvenile salmon rearing and migration.

Forage Fish

In Puget Sound, forage fish species constitute a significant part of the marine food web, being particularly important as prey for fish species, including salmonids, and for marine mammals and seabirds (Fresh et al. 1981; Pentilla 1995; Bargmann 1998). Three species comprise the main forage fish species: surf smelt (*Hypomesius pretiosus*), Pacific herring (*Clupea harengus pallasi*), and Pacific sand lance (*Ammodytes hexapterus*). Forage fish species use a range of nearshore and estuarine habitats for feeding, rearing, and spawning,

Surf smelt and Pacific sand lance 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 (Pentilla 1978, 1995). Surf smelt spawn on coarse sand or pea gravel; gravels ranging in size from 1 to 7 millimeters. Surf smelt spawning occurs during high tides, most typically during afternoons or early evening (WDFW 2004). Pacific sand lance spawn over a wider range of substrate sizes than surf smelt, ranging from fine sand beaches to beaches with gravel up to 30 millimeters in size (Pentilla 1995; Lemberg et al. 1997). Pacific herring spawn in intertidal and shallow subtidal areas, depositing eggs on marine vegetation at elevations between 0 and -10 feet MLLW (WDFW 2000). Eelgrass beds are important spawning substrate for Pacific herring; adhesive eggs are deposited on leaf blades of eelgrass and to a lesser extent on a variety of marine algae (Lemberg et al. 1997; Pentilla 1995). Due to the spawning requirements of these species, suitable spawning habitat for forage fish is limited, and these species are particularly vulnerable to changes in beach morphology (relative depth, exposure), beach sediment characteristics (substrate size - sediment sources, transport, or deposition), and nearshore riparian vegetation cover (WDFW 2000, 2004).

Forage fish spawning areas in the study area include:

- A herring holding area off the tip of Bainbridge Island east of the Bremerton East UGA shoreline, but no mapped herring spawning in the study area.
- Sand lance spawning areas are mapped just west of the Warren Ave. Bridge on Port Washington Narrows, on Rocky Point, east side of Ostrich Bay near Madrona Point, near Elwood Point, and the south shore of Sinclair Inlet near Port Orchard.
- Surf smelt spawning habitat has been mapped on the north tip of Erlands Point, at Elwood Point, along Madrona Point and the east shore of Ostrich Bay, around Rocky Point, west Bremerton (small inlet near Taft Avenue), on either side of Port Washington Narrows near the Manette Bridge, Bremerton East UGA shoreline north of Herron Point, on the north side of Sinclair Inlet east of Gorst, and along the south side of Sinclair Inlet near Port Orchard (Map 7C).

3.2.2.8 Sand/Mud Flats

Tidal flats are gently sloping, intertidal or shallow subtidal areas with unconsolidated sandy or muddy substrates. Mud flats are predominantly silts and clays and are high in organic content, often experiencing anaerobic conditions below the surface (Simenstad et al. 1991). Sandflats are comprised of larger particles ranging from fine sands to gravels. Sand and mud flats are not necessarily featureless – they frequently contain a number of channels formed by hydrologic processes that transport and distribute water, sediments and organic material, and provide some refuge for fish and invertebrates, especially during low tides.

Sand and mud flats typically occur at mouths of rivers and streams where relatively large supplies of sediment are deposited as currents slow, also in embayments and depositional areas where wave and current energies are low. Because these are depositional areas where sediments are retained or build up over time, toxins (e.g., heavy metals) and/or pathogens associated with sediments also are retained and can build up over time.

The shallow flats and inlets of the study area, especially in Sinclair Inlet, Phinney, Ostrich, and Oyster bays, are highly productive habitats, supporting high primary productivity and a diverse assemblage of benthic invertebrates and fish (Redman et al. 2005). Algal production on the surface of tide flats is an important source of food for prey items of salmonids and other fish. Light levels increase earlier in shallow tidal flats than in some deeper water habitats, such as eelgrass, and algal production on tide flats is important in the production of prey items used by juvenile salmon entering the nearshore in early spring (Redman et al. 2005). The shallow flats in the Kitsap County nearshore become productive earlier in the season than flats further north, due to higher light levels and warmer temperatures.

Nutrient cycling on tidal flats and particularly the exchange of inorganic nutrients between benthic sediments/benthic infauna can be an important source of nutrients for algal growth and algal based food webs (Simenstad et al. 1991). Channels in tidal flats provide habitat and refuge for fish and invertebrates, including chironomids, amphipods (both important prey for juvenile salmon), polychaetes, clams, shorecrabs, tanaids, and mysids (Dethier 1990). Tidal flats also provide habitat and foraging areas for a number of fish, including juvenile Chinook and chum salmon, as well as English sole, starry flounder, sand sole, speckled sanddab, and staghorn sculpin (Simenstad et al. 1991).

Sand and mud flats are found in Sinclair Inlet, Chico Bay, Mud Bay, Ostrich Bay, Phinney Bay, and Oyster Bay. Mud flats are most extensive in Sinclair Inlet and Mud Bay (Map 4H).

Shellfish/Benthic Macroinvertebrates

Cobble to fine sand beaches and sand and mud flats are important habitat for many shellfish species. Intertidal and subtidal areas that support the native Dungeness crab (*Cancer magister*) occur more abundantly in the northern portions of Puget Sound, but also occur in the South Sound, often associated with estuaries and eelgrass beds (Stevens and Armstrong 1984). Geoducks (*Panopea abrupta*) occur offshore in fine substrates of mud or soft sand, and typically burrow up to 2-3 feet deep into the substrate. A number of hardshell clams, including butter clams (*Saxidomus gigantean*), native littleneck (*Protothaca staminea*), manila clams (*Venerupis philippinarum),* and horse clams *(Tresus capax* and *T. nutallii*) also inhabit the intertidal shorelines. Olympia oyster (*Ostreola conchaphila*) and non-native Pacific oysters (*Crassostrea gigas*) are common in the South Sound. Other nearshore shellfish include a number of filter feeders that remove plankton from the water column - cockles (*Clinocardium nutallii*), softshell clams (*Mya arenaria*) and detritivores that feed on organic detritus on the surface of sediments – clams (*Macoma* spp.). Shellfish resources in Kitsap County are important as the basis for commercial, recreational, and tribal harvesting, particularly for hardshell clams, oysters, and geoducks.

Shellfish beds perform a number of important ecological functions including nutrient cycling, stabilizing substrate, enhancing water quality (filtering and retention), creating and maintaining habitat structure (e.g., oyster reefs), and providing food for a wide variety of marine invertebrates, birds, fish and mammals. As filter feeders, shellfish consume large quantities of plankton and particulate organic matter, cleaning the water column of organic matter (and any pathogens or pollutants that are present). Shellfish species occupy a range of substrate types from mud to gravels, with each species having a preferred or optimal substrate size for larval settling and adult growth (Dethier 2006). Siltation can negatively impact larval shellfish by smothering, and adult shellfish through interfering with filter feeding. Shellfish are therefore sensitive to changes in sediment dynamics, especially increased erosion and inputs of fine sediments or changes in substrate type or size (Dethier 2006). Because shellfish filter the water column, they retain and concentrate pathogens and pollutants in the water – although this helps improve water quality, contaminated shellfish can negatively impact people and other animals that eat shellfish.

Mapped locations for shellfish concentrations occur in Phinney Bay and Port Washington Narrows (geoduck) and Port Washington Narrows from Phinney Bay to Herron Point (hardshell clams), the shoreline of Bremerton East UGA north of Herron Point (hardshell clams), and the south shore of Sinclair Inlet near Port Orchard (hardshell clams)(Map 6B).

3.2.2.9 Estuaries and Coastal Marshes

Estuaries

Estuaries are embayments (bays) or semi-enclosed inland waters with freshwater inputs that serve as transition zones between marine and freshwater environments. Estuaries include the zone at the mouth of a river or stream dominated by the discharge of freshwater, and generally extend from the head of tidal influence seaward to the point where fluvial influences no longer dominate. Within the larger Puget Sound estuary, there are many river estuaries (e.g., Skagit, Stillaguamish, Nisqually), numerous smaller estuaries associated with streams or bays (e.g., Chambers Bay, Rocky Bay), and localized small embayments that sometimes have freshwater discharge from either surface or groundwater sources (Beamer 2003). These smallest estuaries are sometimes referred to as 'pocket estuaries'. Pocket estuaries usually contain emergent marsh, sand or mudflats, a channel structure, uplands and open water in close proximity. They may or may not contain surface freshwater inputs.

Estuarine areas, and tidal channels in estuaries, can be particularly important for physiological adjustment for juvenile salmon transitioning from freshwater to saltwater (Pess et al. in Montgomery et al. 2003). Estuaries and large areas of habitat open to tidal exchange contain a wide variety of salinity levels and salinity gradients, which allow juvenile salmon to gradually adjust to saltwater. Complex tidal channel networks also provide a range of depths and velocities, which provide habitats suitable for a wide range of juvenile salmon sizes and life history types (Redman et al. 2005). Small, shallower tidal channels provide habitat suitable for fry which spend little time in freshwater and enter the estuary at small sizes, while deeper, larger channels provide habitat suitable for larger juveniles entering the estuary after some time rearing in freshwater or larger juveniles transitioning to pelagic habitats. Estuaries also provide large amounts of organic matter to support macro-detritus based food webs, which are particularly important for salmon prey items (Bottom et al. 1991). Estuaries in natal streams, such as Gorst or Chico Creeks, are critical habitats for juveniles originating in those rivers and can support large numbers of juvenile salmon. However, small estuaries, or pocket estuaries, in streams without salmon runs may also be critical to supporting juvenile salmon, especially when pocket estuaries occur in close proximity to larger estuaries (Beamer et al 2003).

The primary ecological functions of estuarine shorelines include:

- Flood attenuation;
- Tidal exchange/organic matter exchange;
- Stream base-flow and groundwater support;
- Water quality improvement (nutrient retention, nutrient cycling);
- Erosion/shoreline protection; and
- Biological support and wildlife habitat including:
    - Food web support
    - Habitat structure
    - Habitat connectivity
    - Salinity gradients
    - Refugia – from predators (i.e., turbid waters of tidal channels and salmon)

Estuarine wetlands are mapped in Chico Bay, the embayment south of Erlands Point, Ostrich and Oyster Bays, Mud Bay and Phinney Bay, and the Gorst Estuary (Map 3B). Pocket estuaries are mapped at Chico Bay (3), Ostrich Bay, the small inlet in West Bremerton near Taft Avenue, on the south shore of the Gorst Estuary, and at Anderson Creek (Map 4G).

Salt Marshes

Salt marshes and brackish marshes are habitats that occur in areas with tidal inundation. Salt marshes typically occur at elevations at and above 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 and marshes tend to grow outwards over time as sediments entering the delta from rivers are captured and retained by salt marsh vegetation. Marshes provide complex, branching networks of tidal channels where juvenile salmonids feed and take refuge from predators, as well as providing habitat connections to riverine and marine environments (Hood 2005).

Ecological processes that are important for creating and maintaining salt marsh habitat include sediment transport and deposition and tidal exchange. Sediment transport and deposition forms the coastal landforms subject to periodic tidal inundation and exposure, which support salt marsh vegetation. Tidal exchange provides the sediment required for building marsh surfaces that are substrate for saltmarsh vegetation, and in addition, provides twice daily flushing of organic matter, nutrients, and pollutants. Organic matter from salt marsh vegetation supports macro-detritus based food webs that provide food items for forage fish and salmonids in nearshore habitats adjacent to salt marshes. Maintenance of salt marsh habitats depends in part on the balance between marsh aggradation due to the buildup of organic matter and sediment trapped in the marsh and sea level rise (Bottom et al. 2005).

The ecological functions and biological resources of salt marshes include:

- Detrital based food webs;
- In-situ production of invertebrate prey items of importance to nearshore fish and birds (e.g., salmonid prey);
- Tidal channels provide refugia and foraging areas for fish and invertebrates; and
- Primary production– salt marshes are highly productive.

Mixed marsh areas are mapped as continuous distribution around Chico Bay, the embayment south of Erlands Point, southern end of Mud Bay and the eastern shore of Mud Bay south of Rocky Point, the barrier estuary in Phinney Bay, and the Gorst Estuary. Mixed marsh is patchy along Erlands Point, Oyster Bay, portions of Madrona Point, Phinney Bay south of Rocky Point, small area of Port Washington Narrows East to the west of Warren Ave. Bridge, and the south shore of Sinclair Inlet near Anderson Creek.

Salt marshes have been mapped Elwood Point, south end of Ostrich Bay, scattered in Oyster Bay, Mud Bay, a small area near Rocky Point and on the Port Washington Narrows shore opposite the point and near Lions Park, in Phinney Bay, and along the north and south shores of Sinclair Inlet east of the Gorst Estuary (Map 8A).

3.2.2.10 Marine Mammals, Bald Eagles, and Shorebirds

Marine Mammals

A number of marine mammals can occur in the nearshore and marine waters of the study area including harbor seals (*Phoca vitulina*), California sea lions (*Zalophus californianus*), and Southern Resident killer whales, or Orcas (*Orcinus orca*). Steller sea lions (*Eumatopias jubatus*) may also occasionally occur, although their occurrence in Puget Sound is transient. While sea lion rookeries typically occur on beaches along the outer coast, haulout areas are more diverse, including offshore islands, reefs, rocks, and buoys. Steller sea lions prefer relatively remote rookery and haulout areas, where human access and mammalian predation are difficult (NMFS 1992). Although, they are occasionally found on navigation buoys in Puget Sound, they are most frequently observed north of Admiralty Inlet (Jefferies 2006). There are no known Steller sea lion haulout sites within the study area. Although harbor seals and California sea lions are occasionally observed at haulout sites in Dyes Inlet (at the head end of Port Washington Narrows) and in Rich Passage (east of the project area), there are no known Steller sea lion haulout sites within the study area (Jeffries et al. 2000).

Southern Resident Killer Whales (SRKW) are infrequently observed in the Bremerton area. Resident killer whales occur at various locations in central Puget Sound each summer, typically for short periods of a few days, but they may remain in the area for more than a month. From late spring to fall, most whales can be found in the inland waters around the San Juan Islands, including Haro Strait, Boundary Passage, and the eastern portion of the Strait of Juan de Fuca (Ford et al. 2000; Krahn et al. 2004). Less time is generally spent elsewhere, including other sections of the Georgia Strait, the Strait of Juan de Fuca, the San Juan Islands, Admiralty Inlet west of Whidbey Island, Puget Sound, and the outer coast.

Southern resident killer whales differ from transient killer whales in that they rely exclusively on fish as a food source. Fish are the major dietary component of resident killer whales in the northeastern Pacific (Wiles 2004), with 22 species of fish and one species of squid (*Gonatopsis borealis*) known to be eaten (Ford et al. 1998, 2000; Saulitis et al. 2000). Observations from northern Puget Sound indicate that salmon are a preferred prey of killer whales, representing over 96 percent of the prey during the summer and fall (Ford and Ellis 2005). This study also indicated that Chinook salmon comprise over 70 percent of the identified salmonids taken in the summer and fall, although extensive feeding on chum salmon was also observed in the fall. Species such as rockfish (*Sebastes* spp.), Pacific halibut (*Hippoglossus stenolepis*), a number of flatfish, lingcod (*Ophiodon elongatus*), and greenling (*Hexagrammos* spp.) are also likely consumed regularly by SRKWs (Ford et al. 1998).

Although SRKWs have apparently never been abundant – estimated numbers ranged between 100 and 200 before 1960 – recent reviews identified a decline in the population of about 15.5 percent from 1996 to 2001. Although the factors limiting SRKW numbers have not been clearly defined by scientific investigations, likely causes include the capture and removal for display in aquaria, the bioaccumulation of toxic chemicals (e.g., organochlorine compounds), and declines of Chinook salmon stocks, which serve as the main food source for the SRKW (Krahn et al. 2004).

There has been at least one occurrence of members of one of the SRKW pods in the study area; the pod was identified entering Dyes Inlet in September 1997, presumably to feed on the chum salmon returning to Chico Creek (Kitsap Sun 2007; NMFS 2006b). This group of 19 killer whales remained in Dyes Inlet for about 2 months before returning to Puget Sound, and there was some speculation that they were being stressed by the extensive boat traffic of curious observers in the inlet. The whales also appeared to resist exiting the inlet through the Port Washington Narrows, making a number of excursions down to near the Warren Street Bridge before returning to the inlet. The whales apparently passed through the waterway relatively quickly on a strong outgoing tide on November 19, 1997. The only other recent observation of killer whales in the study area occurred in May 2004, when a pod of transient whales (not affiliated with the three SRKW pods) passed through Port Washington Narrows into Dyes Inlet, purportedly preying on seals.

Seabird and Waterfowl Concentration Areas

Both resident and migratory seabirds and waterfowl are associated with shorelines in the study area. Commonly occurring seabirds or waterfowl include loons (*Gavia* spp.), cormorants (*Phalacrocorax* spp.), mergansers (*Mergus* spp.), grebes (*Aechmophorus* spp.), herons and egrets (*Ardeidae*), geese (*Branta*), brants (*Branta bernicla*), gulls (Larinae), sandpipers (Scolopacidae), and ducks (dabbling and diving) (Buchanan 2006). In addition, a number of bird species identified as state priority wildlife species are associated with and forage along shorelines of the study area, including bald eagles (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), marbled murrelet, and great blue heron (*Ardea herodias*) (WDFW 2007).

Waterfowl concentration areas are mapped in the Gorst estuary and along the south shore of Sinclair Inlet from Gorst to Port Orchard, in Port Washington Narrows to the northwest of Point Herron and opposite Rocky Point, and on the northwest shore of Phinney Bay. Shorebird concentrations are mapped on the north shore of Sinclair Inlet just east of Gorst. Two seabird colonies are mapped on the north shore of Sinclair Inlet near the PSNS (Map 9 and Map 6A).

Numerous bald eagle nest sites and nest management areas are mapped by WDFW in the study area. Nest sites are mapped at Kitsap Lake, Ostrich Bay and Phinney Bay, Gorst Estuary and the Sinclair Inlet shoreline near Port Orchard, as well as several sites along the Bremerton East UGA shoreline north of Herron Point. Associated nest management areas extend along the shores of Kitsap Lake, most of Ostrich Bay, Mud Bay, Rocky Point and Phinney Bay, Port Washington Narrows, Bremerton East UGA, and Gorst Estuary and the southern shore of Sinclair Inlet (Map 6A).

3.2.2.11 Marine Fish (Rockfish)

The three species of Puget Sound rockfish are currently listed under the ESA. The Georgia Basin distinct population segment (DPS) of bocaccio (*Sebastes paucispinis*) is listed as endangered; yelloweye rockfish (*S. ruberrimus*), and canary rockfish (*S. pinniger*) are listed as threatened (http://www.nwr.noaa.gov/Publications/FR-Notices/2010/upload/75FR22276.pdf). All three species are rare and declining in Puget Sound. Rockfish are long-lived species with relatively slow population growth rates. These species are also typically associated with deeper habitats as adults and frequently with rocky substrates. Although little information exists on their occurrence in the vicinity, all three species could potentially occur in nearshore habitats within the shoreline planning area.

Boccacio are found from Baja California to Alaska but are most common from Oregon to northern Baja California, and are most frequently found at depths between 160 and 820 feet (Love et al. 2001, Orr et al., 2000). Larvae and juveniles are associated with floating kelp mats, while adults are found in deeper waters and most frequently associated with rocky reef habitats or hard substrates. Yelloweye rockfish also range from Baja California to Alaska, but are most common from northern California to Alaska. Yelloweye rockfish also are found in deep waters ranging from 50 feet to 1,560 feet and are associated with rocky habitats with high relief such as rocky reefs, crevices, and sponge gardens. Typical prey of adult yelloweye rockfishes include sand lance, gadids, flatfishes, shrimps, crabs, and gastropods (Love et al., 2002; Yamanaka et al., 2006). Predators of yelloweye rockfish include salmon and orcas (Ford et al., 1998; Love et al., 2002). Canary rockfish range between Punta Colnett, Baja California, and the Western Gulf of Alaska (Boehlert, 1980; Mecklenburg et al., 2002). Within this range, canary rockfish are most common off the coast of central Oregon

(Richardson and Laroche, 1979). Canary rockfish primarily inhabit waters 160 to 820 feet deep (Orr et al., 2000), but may be found up to 1,400 feet depth (Boehlert, 1980). They can live to be 84 years old (Drake et al., 2008). Canary rockfish were once considered fairly common in the greater Puget Sound area (Holmberg, 1967).

Nearshore habitat association of juvenile rockfish are associated largely with larval and juvenile stages. Nearshore vegetated habitats are particularly important for common species of rockfish and serve as nursery areas for juveniles and later provide connecting pathways for movement to adult habitats. (Palson 2009)

Threats to bocaccio include areas of low dissolved oxygen within their range, the potential for continued losses as by-catch in recreational and commercial harvest, and the reduction of kelp habitat necessary for juvenile recruitment. Yelloweye and canary rockfish, are threatened by low reproduction rates, and continuing threats from by-catch in commercial and recreational harvest, loss of nearshore habitat, chemical contamination, and areas of low dissolved oxygen.

4. ECOSYSTEM-WIDE CHARACTERIZATION

This chapter describes how ecosystem-wide processes affect the function of the City's shorelines as required under the shoreline guidelines outlined in WAC 173-26-210(3)(d). Information is presented at a watershed-scale and provides a basis for understanding shoreline management in relation to the broader landscape context. This watershed-scale overview is intended to provide context for the reach-scale discussions provided in Section 5. To conduct the landscape analysis we used existing approaches developed for the Puget Sound region, and adapted them for use with Bremerton's shorelines. For freshwater shorelines, the approach to understanding and analyzing watershed processes developed by Stanley et al. (2005) and Gersib et al. (2004) were the primary references used. For nearshore systems, the landscape analysis approach of Stanley et al. (2005) was adapted to marine environments using conceptual models and assessments developed for the Puget Sound nearshore by), Schlenger et al. (2010), Borde et al. (2009), Simenstad et al. (2009), Ruckelshaus and McClure (2007), Simenstad et al. (2006), Fresh et al. (2004), Williams et al. (2004), Williams et al. (2001).

Although many of the processes that affect ecological function in the City's shorelines occur outside the city and are outside the City's control, an understanding of their impact is important when considering the potential for management actions that may be undertaken by the City. For this reason, SMA guidelines require local jurisdictions to look beyond shorelines and 'assess the ecosystem-wide processes to determine their relationship to ecological functions present within the jurisdiction'.[17]

The following ecosystem characterization defines the area contributing to shoreline functions in the City, identifies the physical, biological, and chemical processes that occur, and characterizes changes to processes resulting from land-use. The ecosystem characterization includes the following:

- Define spatial scales for the ecosystem wide characterization – drift cells, basins or contributing watersheds (i.e., assessment areas and then assessment units – reaches)
- Identify key ecological processes occurring, key drivers of those processes
- Identify landscape areas most sensitive to process alteration
- Characterize the general ecological process condition within the selected spatial scales
- Describe the extent of process alteration and the potential for process maintenance/restoration

The remainder of this chapter first describes the general setting for the Bremerton SMP planning area, then discusses ecosystem-wide processes, process-important areas and alterations to processes, and then concludes with a general assessment of ecosystem conditions and process impairments within the planning area.

4.1 ECOSYSTEM-WIDE PROCESSES

The physical and biological processes that occur within the region's watersheds deliver, transport, store, and remove materials from the ecosystem, thereby affecting the structure and biological functions of marine nearshore, river, and lake shorelines. The movement of water,

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[17] WAC 173-26-201(3)(d)(i)

sediment, chemicals, organic material, and plants and animals, occurs throughout the landscape, and with varying intensities, depending on local geologic and climate conditions. The following section describes ecosystem processes, identifies areas most important for supporting those processes, and factors contributing to the alteration or impairment of processes. This section also summarizes conditions broadly across the entire study area.

4.1.1 Introduction

Ecosystem-wide processes are the physical, chemical and biological interactions that form and maintain landforms (or shoreforms) and ecosystems. Processes create the physical form of the landscape, and maintain the structures (e.g. habitats) and conditions (e.g., substrate, depth, flow velocities, water temperature, and salinity) that support biological communities. Ecosystem processes create a diversity of habitat types that support ecological functions important to the maintenance of ecosystem health, as well as providing benefits to people (Figure 4-1). For example, the diversity of habitats/biological communities created by ecosystem processes provide ecological functions such as primary production; carbon sequestration; local climate regulation (temperature and moisture); nutrient management; breeding, feeding, and refugia habitat for salmon and forage fishes; nursery habitat for a variety of fish and invertebrates (in eelgrass beds, salt marshes); and energy dissipation and flood storage in coastal marshes, floodplains, and wetlands.

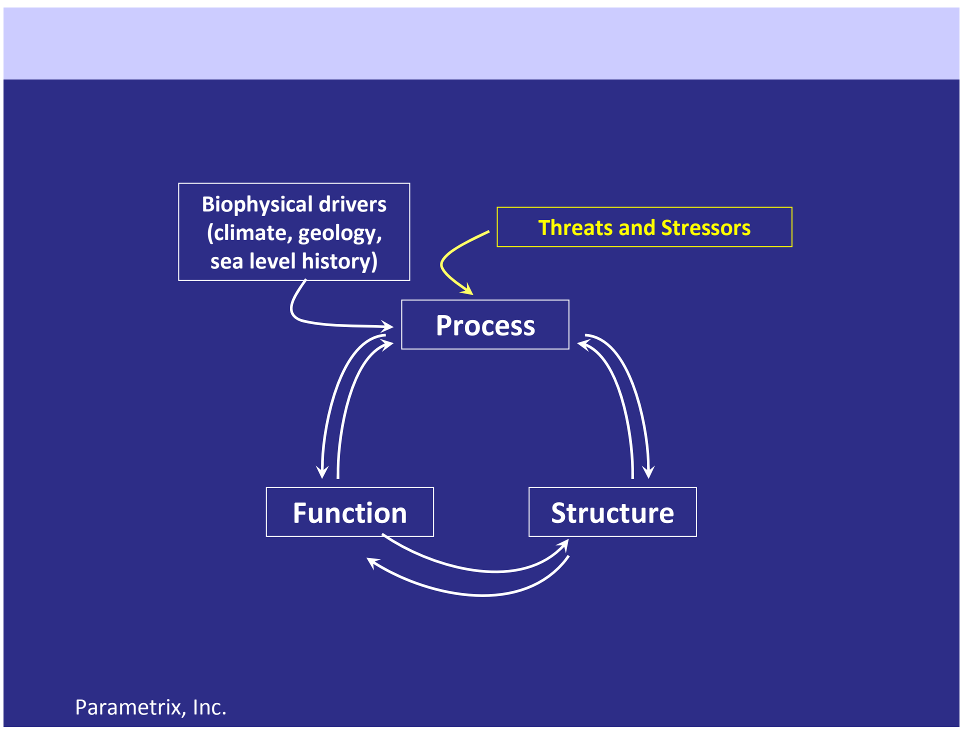

Figure 4-1. Relationship between biophysical drivers, processes, structures, and functions (adapted from Fuerstendberg 1998).

4.1.1.1 Processes Occur at Multiple Scales

Ecological structure and function in freshwater and marine shorelines are driven by physical and biological processes occurring at varying spatial scales across the entire ecosystem.

PSNERP (Simenstad et al. 2009), defines three broad scales that are important in nearshore processes (Figure 4-2):

- regional (large-scale and long-term);
- broad physiographic processes (landscape/seascape level in Figure 4-2); and
- local processes (site conditions in Figure 4-2)

Large-scale and long-term processes such as regional geology and tectonic activity, climate, sea level history, disturbance regime (e.g., episodic fires, landslides or flooding), and tidal regime can be thought of as providing the geoclimatic setting or drivers that create the physical structure within which ecosystem processes at lower scales operate (Figure 3-4). Biophysical drivers set the stage for, and determine the type of, processes, habitats and biological communities that occur in a particular region. For example, regional climate (e.g., amount and type of precipitation), topography (e.g., steep or low gradient), and geology/soils (e.g., permeable or impermeable deposits) act together to influence the hydrologic processes (e.g., surface and groundwater movement and storage) and type of vegetation within a watershed. In turn, hydrologic processes influence the natural variability of flows in rivers and streams in terms of the timing of high flows and floods, timing and extent of inundation in floodplains and associated wetlands, habitat features such as pools and riffles, substrate types and flow velocities. The flow regime in rivers and streams in turn influences habitat suitability and conditions for aquatic biota. The presence of species and biological communities is affected by these conditions – for example, flow regimes that are suitable for the specific life history requirements of Pacific salmonids for spawning, migration, and rearing.

Processes at the landscape and local level are important in determining the ecological functions that will be present along the City's shorelines. These scales are also most likely to be affected by disturbance and stressors associated with human actions, such as increases in impervious surfaces or shoreline armoring.

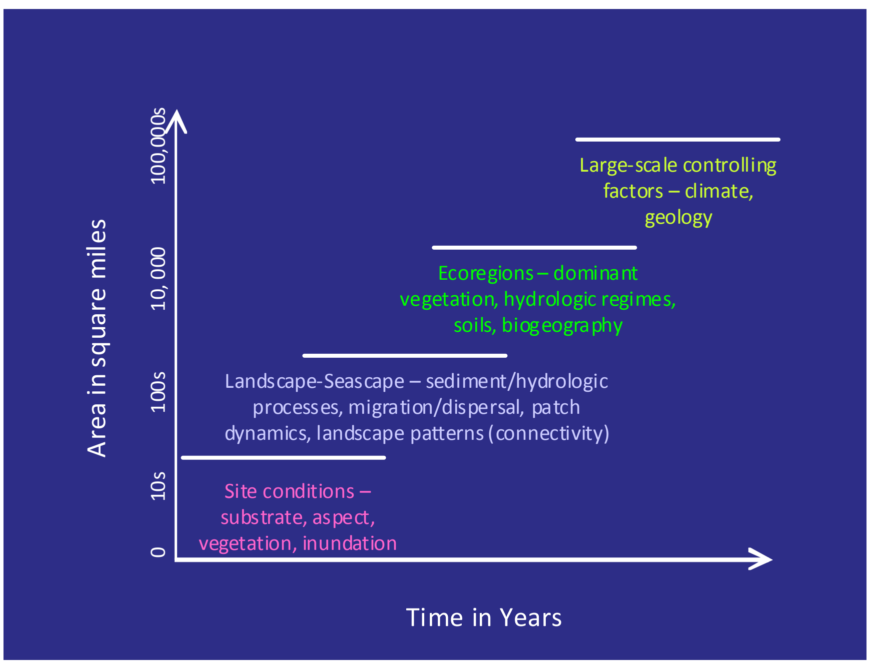

Figure 4-2. Processes affecting shorelines operate at a range of spatial and temporal scales; processes at higher levels create the conditions and structure that influence processes at lower scales.

4.1.1.2 Landscape Ecology

The complex mix of habitats found in the study area is formed and maintained by the dynamic interaction of physical, chemical, and biological processes occurring throughout watersheds and marine basins (Roni et al. 2002, Stanley et al. 2005, Simenstad et al. 2006). Habitats formed by these processes are dynamic and change over time in terms of their condition, size or area, and availability at a particular location. The cumulative result of multiple processes acting across broad areas is a complex landscape supporting a diverse set of habitats performing a wide variety of functions. Changes in a single process, such as sediment transport, can therefore affect numerous habitat types and impact more than one function.

In addition, the landscape pattern – the location, spatial extent, and connectivity of habitat elements – also affects the flow of energy, materials, and organisms through the landscape. Human actions frequently fragment habitats or create barriers to flows between habitats, for example by placing dams or shoreline armoring that interrupts sediment movement and impacts habitat forming processes. In addition, many organisms, but especially salmonids, need to be able to move freely among different parts of the landscape during different life stages. The entire 'landscape mosaic' – the distribution and connectivity of critical landscape features such as tidal freshwater areas, brackish or salt marsh rearing areas, tidal channel refugia, and eelgrass foraging areas – is important in providing opportunities for salmon (and other fish and wildlife) to find and use suitable habitat (Cederholm et al. 2000, Simenstad et al. 2000).

4.1.1.3 Process Impairments and Ecological Function

The functions performed by ecosystems provide many benefits, or ecosystem services, that people value, such as fish and wildlife populations, clean drinking water, flood mitigation, and aesthetic and spiritual values (Figure 4-3). Threats and stressors created by human actions, such as increases in nutrients, presence of dams, shoreline armoring, habitat alteration or fragmentation, changes in land use, harvest of fish or shellfish populations, or pollution, can also alter processes and structures. Threats and stressors can therefore impact ecological function and result in the loss of benefits or ecosystem services. Changes in land use patterns and development across the landscape, not solely at the water's edge, may affect these processes and change shoreline functions.

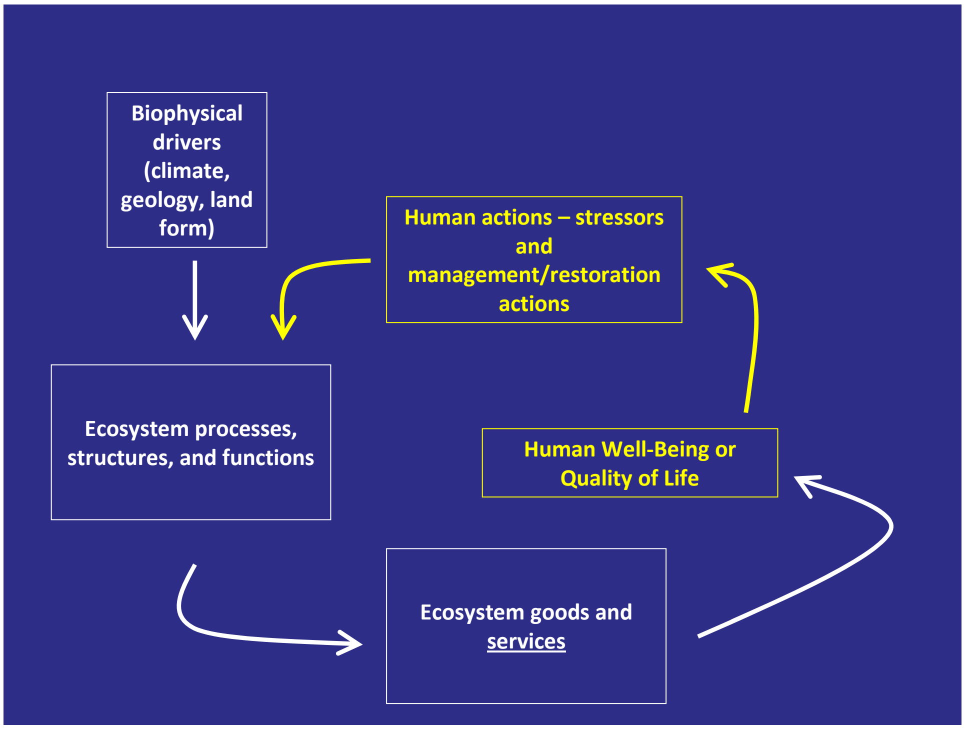

Figure 4-3. Conceptual model of relationship between biophysical drivers, ecosystem processes, structures, and functions, ecosystem services, human well-being, and human-produced stressors that affect ecosystem processes.

In summary, biophysical drivers or regional controlling factors establish the building blocks and environmental conditions that control local habitat structure (e.g., substrate, depth, vegetation density) and the composition of ecological communities (e.g., vegetation composition), including where habitat types occur and the amount of habitat that is present. Habitat structure and composition are linked to local ecological processes and functions that maintain biological communities and provide benefits to people. Actions that affect processes or controlling factors will change habitat structures and ultimately be reflected in changes to ecological functions. The actions that affect processes and controlling factors act as stressors to the system; cumulative stressors can affect the viability of healthy ecosystems, communities, and individual species populations (Figure 4-4).

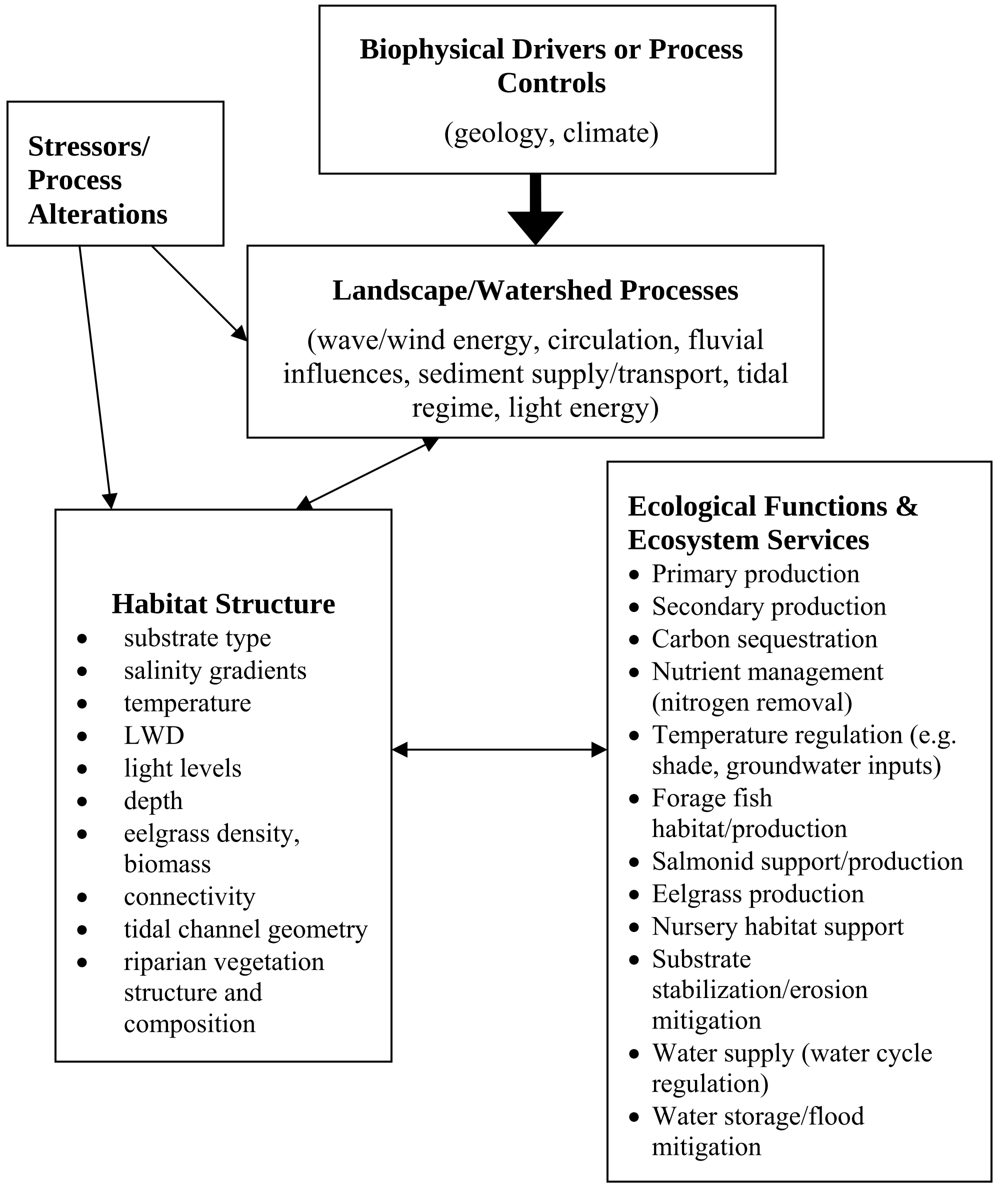

Figure 4-4. Biophysical drivers, processes, habitat structures, ecological functions and ecosystem services (adapted from Williams et al. 2001, Simenstad et al. 2006, Ruckelshaus and McClure 2007).

4.1.2 Regional Processes/Biophysical Drivers

Processes acting at large scales constitute regional influences or controlling factors that determine the physical and biological conditions for ecosystems across wide regions. Regional scale processes in Puget Sound such as climate, geology, plate tectonics, volcanism, establish large-scale controls on other processes and set the stage for, and affect, processes acting at landscape and local scales. Changes to regional influences – such as changes in overall precipitation patterns – will affect a suite of processes over wide geographic scales (see Figure 4-2). Regional influences are rarely affected by management or restoration actions, but they can constrain the effectiveness or feasibility of particular management or restoration actions. Regional climate will be affected by global climate change, and in turn will change some of the regional and landscape processes that influence habitats and ecological functions. Climate change will potentially affect some of the key regional influences that affect Puget Sound shorelines – energy inputs (air and water temperatures) and winds, precipitation patterns and intensity.

Large scale, regional processes that are important in the study area include:

- Regional Climate – winds and atmospheric circulation patterns, precipitation patterns – seasonality, intensity, and duration of storms, and multi-year weather cycles (Pacific Decadal Oscillation - PDO, El Nino Southern Oscillation – ENSO);
- Geology/Tectonic – movement of tectonic plates and earthquakes, inherited topography or bathymetry, and surficial geology from glacial processes;
- Tidal, Current, and Wave Energy – tidal regime, dominant wind driven currents, estuarine circulation and mixing, and wave energy;
- Freshwater Flows/Flow Regime – driven largely by precipitation patterns, regional geology, and land cover, freshwater flows influence the hydrologic regime and movement of water, as well as salinity patterns and circulation in Puget Sound;
- Historic Sea-level Change – history of relative sea level in response to melting of glaciers and rebound of the land surface after the last glaciation, as well as tectonic activity that may affect relative sea level; and
- Biogeography[18] – geographic patterns in the distribution of biological communities (dominant vegetation and characteristic animals).

Regional climate, geology, and hydrology were described above in Section 3.1). Additional regional controlling factors are described briefly in this section.

4.1.2.1 Tidal Regime

Tides in Puget Sound occur twice each day, with significantly higher and lower tides occurring about each fortnight (Mofjeld and Larsen 1984). These are classified as mixed semi-diurnal tides, with one of the daily tides having a greater range than the other. Puget Sound intertidal shorelines are therefore exposed to two cycles of alternating inundation and exposure to sun, rain or air during each 24 hour period. The mean tidal range in the study area is about 7.66 feet and tends to be higher at the ends of inlets (e.g., Sinclair Inlet) (Mofjeld et al. 2002, Finlayson 2006). Kitsap bays and inlets are characterized moderate tidal ranges (Shipman 2008).

4.1.2.2 Estuarine Circulation and Currents

Circulation and mixing of marine waters in the study area are driven primarily by estuarine circulation. The dense and saline waters of the Pacific Ocean flow into Puget Sound and towards the land along the bottom or deeper waters of the Sound. The less dense, freshwater inputs from the region's rivers flow out of the Sound along the surface. A number of shallow sills in the Sound that separate the deeper basins (e.g., Admiralty Inlet and Tacoma Narrows) disrupt the movement of water and promote mixing of the water layers.

4.1.2.3 Wind and Wave Energy

The Kitsap bays and inlets of the study area are relatively sheltered from the region's predominant winds and are characterized by limited wave action (Shipman (2008). In Puget

[18] Biogeography – large scale patterns in the geographic distribution of plants and animals based on ecological conditions and evolutionary history; ecoregions have characteristic biological communities, such as boreal forests, temperate grasslands, temperate coastal rainforests, or temperate salt marshes.

Sound, wave energy is primarily limited by fetch, or the distance over water that the wind blows (Downing 1983). Prevailing winter winds are from the southwest, with the strongest winds being from the south during winter storms (Mass 2002). The large land masses to the southwest of the study area, including the Olympic Mountains and the Kitsap peninsula provide some shelter from prevailing winter winds. This results in waves with small to moderate wave heights and short periods, and the study area has a relatively low wave-energy environment.

4.1.2.4 Natural Flow Regime

Compared to the large rivers of Puget Sound, the small, low gradient streams within the study area contribute relatively small amounts of freshwater to the Sound and move small to moderate amounts of sediment. These are rain-driven streams that experience prolonged periods of high flows during the rainy winter months, with gradually receding flows during late spring and low summer and early fall flows (Booth 2002). The characteristic flow regimes of these small streams are important in determining the physical structure and habitat features of channels, floodplains, and deltas. The natural variation in flow regimes also influences the characteristic aquatic animals that occur in the study area as salmonid and aquatic invertebrate life histories are adapted to the seasonal and annual variations in flow regimes. Freshwater flows from streams and groundwater seepage also locally influence salinity regimes in the nearshore.

4.1.2.5 History of Sea Level Rise

Historical sea level rise is the result of two general and opposing forces: the melting of glaciers since the end of the last glaciation and the uplift of the land surface as the weight of the glaciers was removed (isostatic rebound). In some areas, sea levels have risen faster than the land surface, resulting in an increase in sea level relative to the land. In other areas, the land surface has risen fast enough to keep pace with or outpace the rise in sea level, resulting in a stable or lower sea level relative to the land surface. In the mid-Sound region near Bremerton, the vertical land movement is near zero and historic sea level rise has been about 0.08 inches per year.

These historic rates of sea level rise can be modified by climate change, which is expected to accelerate sea level rise in Puget Sound. In addition, some land use actions, such as draining estuarine wetlands, can result in land subsidence or the sinking of the land elevation relative to sea level, also resulting in greater rates of sea level rise.

4.1.2.6 Biogeography

The characteristic plants and animals in a region form distinct biological communities – the composition of species (e.g., eelgrass communities, coastal forests) is likely determined by the past evolutionary history and presence of a distinct suite of climatic, oceanographic or topographic features. The study area occurs within the Cold Temperate Northeast Pacific/Puget Trough-Georgia Basin marine ecoregion and the Temperate Coniferous Forests/Puget Lowland Forests terrestrial ecoregion (Ricketts et al. 1999, Spalding et al. 2007).

4.1.3 Broad Physiographic or Landscape Processes

Landscape processes, or broad physiographic processes of importance in the region include the following categories:

- Hydrology (freshwater flows and tidal flows)
- Sediment Processes

- Geomorphic Processes (Habitat Formation and Connectivity)
- Light Energy
- Biogeochemical Processes
- Movement/Exchange of Organisms
- Disturbance Regime
- Native Vegetation Establishment
- Invasive Species Colonization/Establishment

Component processes within these categories are defined in Table 3-1 and discussed in more detail in the following sections.

4.1.3.1 Hydrology and Tidal Flows (Delivery, Movement, Storage, and Loss of Water)

Hydrologic processes include elements of the hydrologic cycle that result in the delivery and movement of water across the landscape. Hydrologic processes influence freshwater flow regimes, or the natural variability in the magnitude, timing, frequency, duration, and rate of change of flow in the region's rivers and streams; as well as local and regional groundwater flows. Water processes in the marine environment include circulation patterns and mixing at the basin scale within the Sound, local tidal flows and currents, and wind-driven currents. Movement of water forms channels and floodplains, moves sediment and wood, and affects the circulation and mixing of marine waters and seasonally modifies salinity regimes in Puget Sound.

Hydrologic Processes in Freshwater Environments

The cycling of water through the ecosystem is dependent on geologic and climate controls such as slope, elevation, precipitation type and amount, soil permeability, storage potential on the surface (landform), and underground (soil porosity). Water is input to the watershed in the study area predominantly as rain. At elevations below 1,500 feet, precipitation occurs mostly in the form of frequent but low intensity rainfall that infiltrates the soil to recharge groundwater, or is delivered to surface water bodies via shallow subsurface flow.[19]

During intense winter storms that cause flooding, storm flow can be attenuated through temporary storage in floodplains, coastal marshes, freshwater wetlands, lakes, and in-channel features that add roughness and decrease flow velocities. Typically, storage areas occur near low gradient streams and in lowland areas where physical relief is very low, coarse glacial outwash stores high volumes of water, and subsurface flow velocities are rapid. Water can be

[19] Rainfall rates can also exceed soil infiltration capacity, causing overland flow, which combined with shallow subsurface flow and groundwater discharges augments streamflows and sometimes causes flooding.

Table 4-1. Ecosystem process definitions.

Ecosystem Process	Important System[20]: Freshwater, Upland, Nearshore	Process Description
Hydrology		**Delivery, movement, storage, and loss of water from a watershed or drift cell.**
Water Supply and Delivery	F, U	Process by which water (in form of rain, snow, or fog) reaches the watershed. Controlled by regional climate (type, quantity, and timing of precipitation) and vegetation (interception, infiltration).
Freshwater Input (Delivery of Water to Nearshore)	N	Freshwater inflow from surface (streams, rivers) and groundwater (seepage) to nearshore (bluffs, beaches, estuaries and embayments). Timing and amount of input; influences water chemistry (salinity, oxygen), temperature of water and substrates, and moisture content of substrates.
Water Movement (Freshwater)	F, U	Movement of water once precipitation sinks into or infiltrates the soil. Includes, infiltration, overland flow, shallow subsurface flow, deep subsurface flows (recharge), return flow (groundwater discharge).
Tidal Flow (Water Movement Nearshore)	N	Localized tidal effects on currents, depth and duration of inundation, or elevation of water surface (beaches, estuaries, embayments, tidally influenced freshwater). Rise and fall of tides regularly floods and wets and dries the beach face, transports and repositions living organisms and organic material and sediments, influences sediment porewater and water table fluctuations within the beach, and creates complex salinity gradients where there is freshwater input. Regionally, tidal flows drive some larger currents (e.g., Port Washington Narrows, Rich Passage, Agate Passage).
Water Storage	F, N, U	Short or long-term storage of water on the surface (interception by forest canopy, lakes, streams, wetlands, floodplains, side or distributary channels) or subsurface (soils/substrate, hyporheic zones, shallow and deep groundwater).
Water Loss	All	Water is lost from a watershed by flowing out of the basin as surface or groundwater (into another basin or marine waters), or through evapotranspiration.
Sediment/ Geomorphic		**Delivery, transport, and deposition/storage of sediment and geomorphic processes**

[20] Important system(s) includes those systems (freshwater, upland, or nearshore) that are important for the process. For example, water supply and delivery is influenced by all three systems through precipitation (all), tidal flow (nearshore), infiltration (upland), and recharge (freshwater).

Table 4-1. Ecosystem process definitions.

Ecosystem Process	Important System[20]: Freshwater, Upland, Nearshore	Process Description
		influenced by sediment movement.
Sediment Supply and Delivery (Erosion) / Sediment Input	All	Delivery or erosion of sediment from coastal bluffs and shorelines, beaches, steep slopes, and stream banks; depending on the location or landscape setting, delivery can occur in rare, large events (mass wasting, bluff failures, landslides), to more common, moderate or small events such as erosion of stream banks, erosion and retreat of coastal bluffs, or movement of gravel in rivers.
Sediment Transport	F, N	Movement of sediment as bedload or suspended sediment by water (primarily) and wind; in rivers movement can be downstream or by overbank/channel migration; in nearshore movement can be along (parallel or longshore transport) or across (perpendicular or cross-shore) the shoreline. Types of sediment transport: Fluvial – by streamflow to downstream stream segments or to shorelines and across beaches; Tidal – rise and fall of tides and tidal currents that transport and reposition sediment; Longshore – redistribution of sediment along and parallel to a coastline (shore drift or littoral drift); Cross-shore – transport perpendicular to shoreline by wave action that moves sediment towards and away from shoreline.
Accretion, Deposition, and Storage of Sediments (including organic sediments)	F, N	Deposition and storage occurs with settling of bedload (non-suspended sediments) in channel bars, channel meanders, floodplains, deltas or alluvial fans, beach dunes, offshore spits, etc., after being moved by wind or water. Accretion and storage occurs with the settling of fine particles from suspended sediment (typically in vegetation) and/or the accumulation of organic matter in riparian areas, wetlands, coastal marshes, and submerged aquatic vegetation (eelgrass). Creates barrier beaches, tidal wetlands, floodplains, and off-channel wetlands. Builds marsh surfaces relative to sea level; long-term burial of organic matter/carbon sequestration in sediments and soils.
Distributary Channel Migration	N	Geomorphic processes that create and maintain dynamic distributary channel form and location by combined freshwater and tidal flows. Distributes alluvial material across stream deltas.
Tidal Channel Formation and Maintenance	N	Geomorphic processes that form and maintain tidal channel morphology and natural levee formation.
Channel Migration	F	Geomorphic processes that create and maintain dynamic river/stream channel form, location, and movement within the channel migration zone.

Table 4-1. Ecosystem process definitions.

Ecosystem Process	Important System[20]: Freshwater, Upland, Nearshore	Process Description
Floodplain/ Hyporheic Connectivity	F	Geomorphic processes that maintain flows of water, sediment, nutrients, and organisms between river channels and hyporheic zones and river channels and floodplains. Important sites for processing/cycling nutrients, maintaining chemical balances in surface and groundwater.
Habitat Connectivity	All	Geomorphic and biological processes that maintain the connectivity between areas of similar habitat on the landscape.
Nearshore Connectivity	F, N	Geomorphic and biological processes that maintain the connectivity between fresh and marine waters in tidal systems, and along shoreline segments within drift cells and larger landscape units (e.g., basins and sub-basins of Puget Sound).
Biogeochemical (Water Quality)		**Input, movement, retention/cycling, and loss of nutrients, pollutants/toxins, and pathogens in a watershed.**
Nitrogen Delivery	All	Sources of dissolved or adsorbed inorganic N and organic N (from plants and animals); via atmospheric deposition or transport with water and sediments from stormwater runoff, agricultural fertilizers, septic/wastewater. Salmon carcasses were significant natural source historically.
Nitrogen Cycling/Retention	All	Uptake, removal, and/or transformation of nitrogen from one form to another by plants and microbial communities in soils and sediments; alternating aerobic and anaerobic sediment conditions facilitate nitrogen cycling.
Phosphorous Delivery	F, U	Chemical weathering of soil and bedrock; transport of sediments/soil into surface waters. Natural sources from weathering of rocks and erosion; anthropogenic sources from stormwater runoff, agricultural/residential fertilizers, septic/wastewater.
Phosphorous Cycling/Retention	F, U	Retention and/or long term adsorption or burial with sediments. Facilitated by soil retention and stabilization from vegetation cover, rootbiomass.
Pathogens and Toxins	All	Inputs and processing of toxins (heavy metals, petroleum products, PCBs) and pathogens (E. coli, vibrio) that enter shorelines from atmospheric deposition, stormwater runoff, septic/wastewater.
Carbon Cycle	All	Regulation of carbon and sequestration in coastal marshes and submerged aquatic vegetation; forests; terrestrial soils.
Other Processes		**Interacting biological and physical processes that influence habitat structure and**

Table 4-1. Ecosystem process definitions.

Ecosystem Process	Important System[20]: Freshwater, Upland, Nearshore	Process Description
		condition.
Large Woody Debris (LWD)	F, N	Delivery, movement, and storage of large wood in rivers/streams, lake shores, and the nearshore. LWD provides flow obstructions in rivers that store sediment, provide flow refugia and cover for fish and aquatic invertebrates, create hydraulic heterogeneity and moderate flow disturbances, and create habitat (e.g., bar and island formation, establishment of vegetation).
Organic Matter Import and Export	All	Processes that contribute to soil formation (accumulation of organic matter); export, import and deposition of organic matter (export of detritus from eelgrass beds or salt marsh; export of detritus from riparian areas into streams); recruitment and export of large wood from riparian forests to streams/rivers and nearshore habitats. Influences detritus based food webs, forms habitat, provides refugia, and stabilizes substrates.
Exchange of Organisms	All	Passive transport (plankton, larvae, eggs) and movement (spawning migrations, movement from juvenile to adult habitats) of organisms, predominantly by water (tides, rivers/streams) and habitat connectivity. Includes processes by which invasive species colonize and become established in new areas.
Disturbance Regime	All	Maintenance of habitat structure and biological communities by the natural or typical physical disturbance regime. Important disturbance agents in Pacific Northwest forests, streams, and nearshore include: wildfire, windthrow, landslides, bluff erosion from wind/wave energy during storms, movement of large wood/large wood jams, and scour and movement of sediment during winter high flow in rivers and winter storms on beaches. Typical or ‘natural’ disturbance regimes maintain habitat and biota.
Native Vegetation Establishment	All	Processes of colonization, growth, reproduction, and competition resulting in the distribution, abundance, and community composition of native plant communities across the landscape. Influences the physical structure of vegetation that creates habitat for wildlife, and the performance of numerous functions such as substrate stabilization, sediment retention, infiltration and runoff regulation, shade/temperature regulation, productivity, organic matter production and LWD sources, and nutrient management.
Invasive Species Establishment	All	Processes of colonization, growth, reproduction, and competition resulting in the establishment and spread of non-native invasive species across the landscape, and the displacement of native species. Establishment of invasive species can affect native plant and animal communities from competition, changes in food web dynamics, and predator-prey interactions, and can affect the performance of functions such as productivity and production of organic matter.

Table 4-1. Ecosystem process definitions.

Ecosystem Process	Important System[20]: Freshwater, Upland, Nearshore	Process Description
Solar Incidence/Light Energy	All	The exposure, absorption, and reflectance of solar radiation (light and radiant heat). Influences numerous local processes such as photosynthesis and plant growth, soil/water/air temperatures, microbial processes and nutrient cycling, humidity/water content of air and soil/substrates, as well as movement and behavior of animals.

transported to storage areas via hyporheic (i.e., flow through streambeds and soils near stream channels) and overbank flow.

Alternatively, precipitation can infiltrate the soil to recharge groundwater. Areas with coarse outwash, deposited by receding glaciers, are important areas for groundwater recharge. Where coarse outwash overlays fine-grained till and creates a soil with a high infiltration rate, there is a very high potential to recharge groundwater. However, till underlying coarse deposits can also act as an aquitard, preventing infiltrated water from percolating to recharge deep, underlying aquifers. Instead, water is confined and creates wetlands or moves laterally above confining till layers to discharge to streams. Deeper aquifers are also confined by layers of till interspersed with coarse deposits. Groundwater moves laterally and eventually discharges in lowland areas to support baseflow in lakes and rivers.

Vegetation has a critical role in the hydrologic cycle by affecting the rate at which water reaches the surface by providing a physical barrier that reduces the force of raindrops hitting the surface and also by intercepting, storing, and releasing water at a reduced rate. Intercepted precipitation may be stored on leaves, branches, or stems, and may evaporate back into the atmosphere, largely depending on seasonal temperatures. The amount that is intercepted depends on the water storage capacity of the vegetation, which depends on leaf size and shape, and the surface area of the canopy, which varies with tree age and density of stems. Some precipitation that passes through the tree canopy drips from the canopy and reaches the ground at a reduced rate, which facilitates infiltration into the soil. An additional component runs down stems. This stemflow is influenced by a number of factors including canopy shape that is related to the species mix. Stemflow tends to deposit water deeper into the soil than does throughfall. Thus, vegetation is extremely important for protecting and restoring aquatic resources. The ability of vegetation to perform these functions varies with vegetation type (forest, meadow, shrub wetland). Urban mowed grass landcover has runoff rates generally 68 to 90 percent of impervious areas depending partially on soils. Unmowed grass meadow areas and pasture have runoff in the range of 38 to 85 percent of impervious areas. (USDA 1986) In addition

Toxins from fertilizers, pesticides, and herbicides can be washed into surface waters by rainfall. If applied in a volatized form, fertilizers may drift into the water during application (May 1997). The National Marine Fisheries Service (NMFS2009) has determined that carbaryl and carbofuran, common chemicals in lawn care products jeopardize salmon due to effects on the central nervous system (NMFS 2009). Location of lawns or ornamental vegetation adjacent to the shoreline also limits the potential for native vegetation to provide shade, cover, and food resources for aquatic species (Collins 1995).

Water is lost by flowing out of the watershed into the adjacent watershed or marine waters, and through evapotranspiration. Water directly evaporates from the surface of lakes and marine waters. Plants pull water up from the soil through their roots and transpire large amounts of water vapor back into the atmosphere during photosynthesis.

Tidal Flows in Nearshore Environments

Tidal flow processes are the twice daily ebb/flood of tidal currents that moves water, sediments, organisms/propagules, nutrients, and organic matter between the seaward limit of low tides and the landward limit of high tides. Tidal flows contribute to habitat formation, nutrient cycling, organic matter export, dispersal of organisms, species support (e.g., maintenance of salinity gradients) and connectivity. Local tidal flows are influenced by the regional tidal regime, local topography, and connectivity between marine/nearshore waters and shoreline or inland habitats.

Tidal exchange/hydrology is a vital process structuring estuarine and nearshore communities (physically and biogeochemically), and influences the formation of habitat structure in tidally influenced wetlands, estuaries, mudflats, and beaches. Tidal currents transport and rework sediment in estuaries and nearshore habitats (mudflats, eelgrass) forming complex channel networks that provide a range of flow conditions, temperature regimes, and refuge from predators. Tidal exchange maintains the balance of freshwater and saltwater in estuaries and tidal marshes, which is critical to the distribution of plant species and communities within marshes, as well as utilization of habitats by animals. Tidal mixing and freshwater inflows in estuaries are critical for maintaining a wide range of salinities supporting a diversity of species, including eelgrass, shellfish, and juvenile salmonids.

Local tidal flows, in combination with local topography, also influence the depth of inundation during high tides, the extent of intertidal habitat, and the amount of habitat exposed to high temperatures and desiccation during low tides. These tidal inundation patterns in turn determine the suitability of intertidal areas for foraging fish spawning, eelgrass growth, shellfish communities, and rearing areas for juvenile salmonids.

Tidal flows can be altered by barriers to water movement (e.g., tide gates, fill, culverts or road crossings) and loss of connectivity. Maintenance of connectivity allows water movement throughout a tidal channel network without impediments to longitudinal (freshwater to saltwater), horizontal (overbank; between channel and marsh surface or off-channel sloughs, wetlands), and/or vertical (e.g., groundwater connectivity in closed lagoon systems) connectivity.

4.1.3.2 Sediment Dynamics (Delivery, Transport, and Storage/Deposition of Sediment)

The cycling of sediment through an ecosystem is dependent on geologic features such as slope, land cover, soil or substrate cohesion, and storage potential determined by landform, and climate features such as wind and wave energy, precipitation duration and intensity. Also important are interactions (including impairments) with the hydrologic process, which is a vehicle for sediment delivery and transport. Therefore, many of the alterations to hydrologic processes also directly and indirectly affect the sediment processes.

Freshwater Systems

The primary mechanisms for sediment delivery to aquatic systems are mass wasting and soil erosion. Mass wasting in the form of shallow landslides typically occurs on steep slopes. The vast majority of moderate landslide hazard areas occur in the steeper, higher elevation areas to the south and west of the Gorst area. These areas are underlain by volcanic deposits, which contribute valuable gravel and cobble to streams. Landslides occur along the steep slopes and in the ravines of tributary streams as they cut through these deposits.

Soil erosion is a function of soil erosivity, slope, and vegetation cover. Steep slopes with erosive soils also contribute fine sediment to water bodies, not high quality gravel and cobble substrate. Erosive soils are most commonly associated with alluvium and outwash. Erosivity is low or moderate in most of the study area, with some areas of moderate erosion hazard in the higher elevations around the Union Reservoir west of Gorst.

Important areas for sediment storage are the same as those described for water. Depressional areas such as lakes, wetlands, and floodplains allow for the settling out of suspended sediment in slack water. Additionally, larger streams with low gradients, such as the lower portion of Gorst Creek, cycle sediment through periods of transport and storage as they migrate laterally across the floodplain. Therefore, alluvial deposits in floodplains are an important sediment storage area. Processes for sediment delivery to lakes include the delivery of sediment via tributaries and bank erosion. Inputs remain localized, and mechanisms for transport are limited.

Nearshore Sediment Processes

Sediment processes in the nearshore are comprised of sediment delivery, transport, and deposition or accretion components. Sediment processes are dynamic, but the consistent and long-term net movement of sediment in the nearshore occurs in generally well-defined littoral or drift cells that include a sediment source, active transport zone, and zone of deposition.

Erosion and Sediment Delivery

Coastal bluffs are the primary source of sediment for most Puget Sound beaches (Downing 1983). Mass wasting (landslides) and more gradual erosion and retreat of these bluffs deliver sediment to the beach in large quantities. A secondary sediment source is rivers and streams, but these are thought to contribute only on the order of 10% of beach sediment (Downing 1983).

The majority of coastal landslides occur during and following prolonged high precipitation periods in the winter (Gerstel et al. 1997, Shipman 2004). Landslides typical occur on bluffs with a combination of characteristics that make the bluff more vulnerable to slope failure. These characteristics include the underlying geology of a bluff or bank, its level of exposure to wave energy (fetch), and the local hydrology (groundwater and surface water). As a result, the exposed high gradient bluffs and banks of the Port Washington Narrows and east Bremerton are more susceptible to coastal landslides compared to lower banks and protected embayments in Sinclair Inlet and Dyes Inlet.

Landslides are more likely to occur in areas where there is a history of landslides or where the lower bluff strata is comprised of an unconsolidated, permeable layer (sand), overlain by a (more) consolidated 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 pattern of permeable layers above impermeable is a typical initiator of mass movement throughout the Puget Sound. Bluff failures also occur when wind-generated wave action gradually erodes beaches and the toe of coastal bluffs, leading to collapse of the bluff. 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).

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 will 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 mixed coarse sands and gravels, with some areas of cobble and silts/mud (EKNHA 2009, WDNR 2001, Ecology 1979).

These same materials dominate sediment found on the beaches, with the exception of silt (and clay), that is winnowed from the beachface and deposited in deeper water.

Sediment Transport and Deposition

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 to deposition along a portion of coast. Each drift cell acts as a system consisting of three components: a sediment source (erosive feature) and origin of a drift cell; a transport zone where materials are moved alongshore by wave action with minimal sediment input; and an area of deposition that acts as the drift cell terminus. Deposition of sediment occurs where wave energy is no longer sufficient to transport the sediment in the drift cell. Drift cells in the Puget Sound region range in length from 5 or more miles to just a few hundred feet.

Drift cells in the study area have been mapped in the late 1970s as part of the Coastal Zone Atlas of Washington (Ecology 1974). Drift cells were most recently revised as part of the East Kitsap Nearshore Inventory (EKNHA); drift cell boundaries used in this inventory and characterization are those as defined in the EKNHA report (Borde et al. 2009; Johannessen and MacLennan 2007). Most drift cells in the study area are between 1,000 and 3,500 feet in length (Map 4E). Much smaller drift cells occur in areas where the shoreline orientation changes rapidly. One large area with no appreciable net shore-drift is in the enclosed and protected waters at the head of Sinclair Inlet.

The general pattern of littoral transport in the region largely reflects the shore orientation relative to the predominant (strongest) wind and wave conditions. Shores that are exposed to the south typically have northward net shore-drift due to predominant southerly winds. Shores exposed only to the north are within the wind and wave shadow of strong southerly wind conditions, but are exposed to lighter northerly winds, resulting in southward transport. Shores oriented east and west are similarly influenced by their shore orientation relative to direction from which the greatest fetch is derived. No appreciable net shore-drift occurs along rocky shores or in enclosed shorelines such as the inner shores of lagoons and small estuaries.

4.1.3.3 Nutrients, Pathogens, and Toxins

The delivery of elements and compounds to water bodies is highly dependent on water and sediment processes that provide a vehicle for dissolved and adsorbed materials transportation. Estuarine circulation, vegetation, and the atmosphere also play a role in the delivery of certain compounds/elements.

Nutrients, Pathogens, and Toxins in Freshwater

Storage of materials that affect water quality is similar to those for sediment, where adsorbed compounds, including phosphorus, nitrogen, and toxins can be deposited and potentially removed via biotic uptake. Wetlands with mineral soils are important areas where dissolved phosphorus can undergo adsorption and storage. Toxin storage, however, is better facilitated by wetlands with clay or organic soils where adsorption and biotic uptake is better catalyzed (Stanley et al. 2005). Nitrogen cycling is augmented by wetlands with non-organic soils (denitrification) and pH-neutral or alkaline soils (nitrification; Stanley et al. 2005).

Areas with flatter topography and peat or clay soils have concentrations of wetlands (Map 3B and Map 4D). These are important areas for toxin storage, denitrification, and adsorption and deposition of dissolved contaminants. Lowland wetlands are more likely to be either fine grained, where floodplain deposition has occurred, or mineral, where coarse-grained alluvium is present. These depositional areas also support deposition of adsorbed contaminants.

Like wetlands, lakes are depositional areas that have a high potential for storage of adsorbed materials. Streams, deltas, shallow water areas, and lacustrine wetlands, such as the wetlands around Kitsap Lake and the Union Reservoir, are all depositional areas near lakeshores where contaminants may be stored. If nutrient/contaminant loading increases, sediment quality can be impaired. Destruction or disturbance of these sinks can render a lake more susceptible to eutrophication (a state of high algal productivity that decreases dissolved oxygen [DO] levels) or ecological responses to water quality impairment.

Nutrients, Pathogens, and Toxins in Marine Waters

The nearshore and marine waters of the study area receive inputs of nutrients and organic matter from deeper ocean waters via estuarine circulation and mixing, from nearshore bottom sediments, and from adjacent uplands, streams, rivers, and groundwater seeps. In general, inputs from natural sources of nitrogen and phosphorus in Puget Sound are several orders of magnitude greater than anthropogenic sources (Harrison et al. 1994). However, a number of factors that characterize the study area can lead to a greater contribution from terrestrial and anthropogenic sources of nutrients compared to oceanic influences. These include numerous shallow, enclosed bays with low flushing rates, high shoreline to volume ratio, and high impervious surface area in contributing watersheds, and numerous outfalls on the shoreline, which result in a relatively high sensitivity to eutrophication and low dissolved oxygen related to anthropogenic sources of increased nutrient inputs (Newton and Reynolds 2002, in Albertson et al. 2002).

The study area is characterized by areas of protected bays and narrow inlets, relatively shallow depths, stratification of the water column, slow flushing times, and a high shoreline to water surface-area ratio. Under these conditions, nutrients entering the nearshore from adjacent uplands, rivers, and streams are not diluted by mixing or flushing. The shallow nature of the bays and inlets results in high productivity – given abundant nutrients and light, plankton and other algae have high growth rates. Excess nutrients entering these areas can lead to water quality problems associated with eutrophication – algal blooms and low levels of dissolved oxygen (hypoxia), which can be detrimental to marine organisms. Eutrophication can also lead to contamination of shellfish beds from the harmful bacteria associated with some nutrient sources, and from harmful algal blooms, which are thought to contribute to Paralytic Shellfish Poisoning (PSP) and Amnesiac Shellfish Poisoning (ASP) (WADOH 2005). Nutrient loads from streams and rivers are affected by the magnitude of river discharge and by watershed land uses. Major human sources of nutrients from upland areas include agricultural operations (animal manure, fertilizers), wastewater treatment plants, septic systems, and stormwater runoff from residential/urban landscapes (Embrey and Inkpen 1998).

4.1.3.4 Organic Matter and Carbon Cycling

Organic materials include living organisms and the carbon-based material they leave behind after dying, including coarse woody debris, finer woody debris, and detritus. Organic matter import and export provides the basis for detrital food webs, which are important elements of both freshwater and marine food webs (Simenstad et al. 2006).

Detrital food webs are particularly important to salmonids in both fresh and saltwater, because detrital food webs support many of the prey items salmonids rely on. In addition, riparian forests, estuaries and coastal wetlands, and submerged aquatic vegetation (e.g., eelgrass) are important sinks for carbon and perform important climate regulation functions by sequestering carbon in vegetation and/or soils.

Large woody debris (LWD) is generally recognized as an important element of the natural marine and freshwater shorelines of Puget Sound. These elements are important for the cycles of energy and nutrients in aquatic ecosystems, including storage, transport, and chemical transformation (Naiman 2001). Downed trees play a significant role in the aquatic ecosystems of the Pacific Northwest. Large woody debris (LWD) significantly influences the geomorphic form and ecological functioning of riverine ecosystems (Maser et al. 1988; Nakamura and Swanson 1993; Collins and Montgomery 2002; Abbe and Montgomery 1996; Collins et al. 2002; Montgomery et al. 2003a; Montgomery et al. 2003b).

In a natural system, LWD provides organic material to aquatic ecosystems and is considered a principal factor in forming stream structure and associated habitat characteristics (e.g., pools and riffles). Riparian vegetation is the key source of LWD. LWD is primarily delivered to rivers, streams, or wetlands by mass wasting (landslide events that carry trees and vegetation along with sediment), windthrow (trees, branches, or vegetation blown into a stream or river), and bank erosion (Stanley et al. 2005). Thus, riparian areas, steep forested slopes adjacent to streams, and channel migration zones are important areas for LWD recruitment.

Although best understood in freshwater systems such as large rivers, large woody debris (LWD) is an important habitat forming element and source of organic material in nearshore environments (Maser 1987). Under natural conditions it provides shoreline complexity that may have a role in providing refuge area for juvenile salmon and other species. It is also an important organic input and is important to the overall function of the food chain. Sustaining different individual functions (e.g., water quality vs. habitat structure) requires different widths, densities, and compositions of riparian vegetation. The importance of the different functions varies with the character of shoreline setting.

Factors affecting the ecological functions provided by LWD include whether there is a source of LWD (i.e., primarily from riparian forests), hydrological connectivity affecting the transport and movement of large wood, and water and sediment transport processes that influence erosion and inputs of LWD into aquatic systems (e.g., bluff landslides, storm surges, river floods). In the marine environment, major sources of LWD are non-accretion shoreforms (Shipman 2004) and large river estuaries (Naiman et al. 1992). Bluff landslides in areas with trees and shrubs adjacent to the shoreline provide LWD inputs to the nearshore and accretion shoreforms (e.g., lagoons, spits, small embayments, marshes) are areas of LWD storage. Removal of riparian vegetation and shoreline armoring are the major factors altering the delivery and accumulation of LWD in the nearshore.

Sources of LWD to the nearshore in the study area include eroding bluffs, and shoreline areas with intact coastal forests in the riparian zone. Areas with the potential to accumulate or store LWD include estuaries and pocket estuaries.

4.1.3.5 Light Energy

Light entering both freshwater and marine nearshore environments is a key factor controlling biological processes such as primary production, the growth of plants, reproductive cycles of aquatic animals, and migratory movements and predator-prey interactions of aquatic animals (Carrasquero 2001, Nightingale and Simenstad 2001). For example, the growth of eelgrass is highly dependent on adequate light levels, and the foraging success of juvenile fish (or their predators) depends on adequate light levels for locating and capturing prey. Juvenile salmonid movements are affected by areas of deep shade and this in turn may affect vulnerability to predators and timing of migration from the nearshore to deeper waters (Simenstad et al.1999, Thom and Albright 1990). Light levels also affect water temperatures in ways that directly affect the growth and productivity of aquatic plants. For example, light levels influence the rate at which water temperatures warm during the spring and the timing of plankton blooms. Finally, light levels affect temperatures and therefore the degree of desiccation and heat stress in upper beach areas which are important habitats for forage fish spawning.

Three types of light alteration are particularly important in aquatic systems – a decrease in daytime light levels due to artificial shading; an increase in daytime light levels (and heat/desiccation stress) due to loss of natural shade (i.e., removal of riparian vegetation and/or shoreline armoring); and an increase in nighttime light levels due to artificial lighting from buildings, docks, marinas, or roadways.

4.1.3.6 Other Processes

In addition to the processes detailed above, a number of other processes are closely linked with water, sediment, organic matter, and nutrient processes and strongly affect ecological function. These include connectivity processes, disturbance regime processes, exchange and movement of organisms, and native vegetation establishment processes. Habitat connectivity and disturbance regimes strongly influence the composition and location of biological communities by influencing habitat quality, migration and access to habitats, and determining which species and biological communities can occur in a particular area. Habitat connectivity, which may be limited by natural barriers such as waterfalls, can also limit community or population productivity by limiting availability to valuable habitat. Disturbance regimes are closely associated with movement of water, sediment and wood and in the study area important disturbance regimes include coastal bluff landslides and erosion, debris flows and landslides on steep slopes and higher gradient streams, windthrow which contributes woody debris to streams and nearshore, and to a lesser extent wildlife. The introduction of invasive plants and animals can have a significant influence on community productivity through competition, food web dynamics, and predator-prey interactions, among others.

Processes contributing to the establishment of native vegetation are difficult to capture. These processes are very important in influencing other key ecological processes because of the central role that vegetation plays in creating habitat structure for animals; affecting the delivery, movement, and storage of water and sediment; providing the source of LWD; influencing organic matter production and import/export processes; contributing to water quality through sediment retention and nutrient management; and strongly influencing local temperature and moisture regimes. Figure 4-5 provides an illustration of the functions of riparian vegetation in an urban setting.

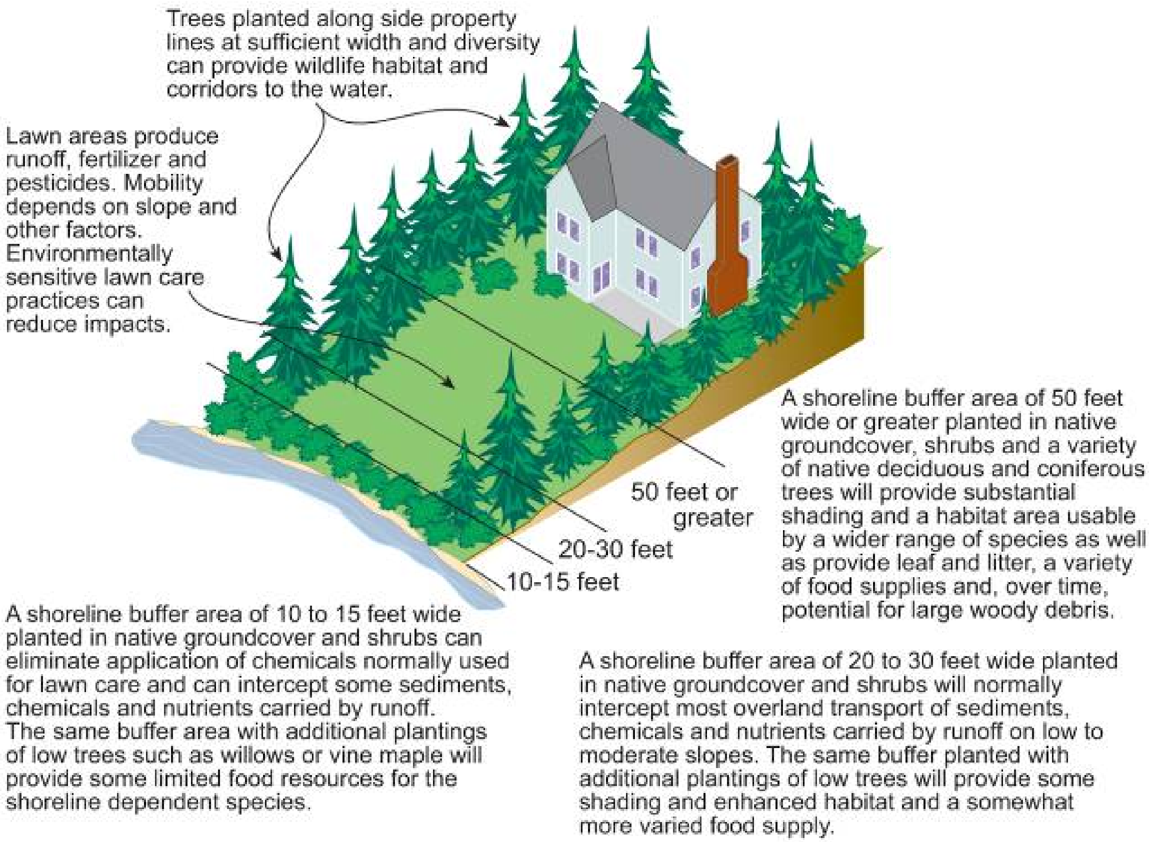

Figure 4-5. Riparian Vegetation Function in an Urban Setting

4.2 PROCESS IMPAIRMENTS

Activities or factors that alter important ecosystem processes or habitat structure can act as stressors that impair the performance of ecological functions and lead to the loss of species and ecosystem benefits to people. Important stressors that have been identified for the Puget Sound region and apply to the study area include (Williams et al. 2003, Schlenger et al. 2010; Clancy et al. 2009; Stanley et al. 2005):

- Loss of Forests
- Land Cover Changes/Alteration
- Impervious Surfaces
- Dams
- Stream Crossings
- Culverts
- Channel Confinement/Disconnection of Floodplains
- Water Quality – increased inputs of nutrients, pollutants, pathogens
- Fill – filling of wetlands/floodplains/estuaries/marshes/beaches/nearshore
- Tidal barriers
- Shoreline Armoring
- Overwater structures

- Marinas
- Jetties/Breakwaters/Groins
- Water Diversions/Withdrawals
- Roads (esp. nearshore and adjacent to rivers/streams)
- Railroad
- Invasive Species

Ecosystem functioning is not evenly distributed throughout watersheds, leading to the concept of 'Important Areas' where greater storage and/or flux of water, nutrients, sediment, and/or pathogens occurs. When stressors affect areas that are particularly important for ecosystem processes, impacts to ecological processes, habitat structures, and ecological functions can be significant.

4.2.1 Nearshore Process Important Areas

Process important areas were identified using the linkages and relationships identified in conceptual models of nearshore function, and process alterations were identified by evaluating which stressors influence key processes and functions (Williams et al. 2001, Williams et al. 2004, Simenstad et al. 2006, Ruckelshaus and McClure 2007). Following the identification of key nearshore processes (described above in Section 3.2), we used the following steps in evaluating process intensive areas and process alterations for the nearshore:

- Identify important areas on the landscape (both in contributing upland watersheds and the nearshore environment itself) for each process,
- Identify important alterations affecting key processes,
- Select appropriate indicators of process alterations developed for East Kitsap, and
- Identify key locations in the study area for these process alterations.

Many of the process alterations that are important in the nearshore affect more than one process; process important areas and process alterations are listed in Table 4-2. The primary process alterations affecting the nearshore environment are discussed in the next sections.

Table 4-2. Nearshore Processes, Process Important Areas, and Process Alterations

Process	Process Important Areas	Alterations

Table 4-2. Nearshore Processes, Process Important Areas, and Process Alterations

Process	Process Important Areas	Alterations
Freshwater Inputs	Streams and estuaries Contributing watershed for stream or shoreline Seepage zones in bluffs or banks	Changes in flow regime from dams, diversions, withdrawals, increased impervious areas (changed magnitudes, timing, frequency, duration) Increase in impervious area in watershed (increased peak flows, change in timing of peak flows) Stormwater outfalls in nearshore Constrictions of river flows or encroachment into estuary/delta (e.g., road crossings/culverts at river mouths, filling of floodplains and estuarine wetlands) Armoring or fill in nearshore that cuts off movement of groundwater into beach sediments
Tidal Flows	Rocky shores Beaches Stream deltas Estuaries and pocket estuaries (barrier estuaries) Barrier lagoons/marshes Open coastal inlets	Shoreline armoring/alteration of beach profile Tidal constrictions – tide gates, culverts, bridges, weirs Tidal encroachment – filling of tidal wetlands, dikes/levees, roads within tidal wetlands Increased impervious surfaces in watershed – increased flashiness/peak flows, higher river flows during winter (changes extent of tidal salt wedge intrusion into estuarine habitats and distribution of salt, brackish, and freshwater habitats)
Water Storage	Tidal and distributary channels Estuaries Coastal marshes	Tidal encroachment – filling of tidal wetlands, dikes/levees, loss of tidal channels, roads within tidal wetlands Shoreline armoring/alteration of estuarine/marsh profile Tidal constrictions – tide gates, culverts, bridges, weirs
Sediment Supply	Coastal bluffs Streams	Armoring of shorelines Dams Filling of estuaries, floodplains Tidal restrictions – dikes, tide gates, roads
Sediment Transport	Beaches in transport zones Estuaries (tidal and distributary channels)	Armoring, jetties/groins Fill in intertidal or upper shoreline Overwater structures (associated piers, pilings, seawalls) Tidal restrictions – dikes, tide gates, roads
Sediment Accretion & Deposition	Barrier beaches Stream deltas Estuaries and coastal marshes	Armoring
Habitat Formation – distributary and tidal channels	Estuaries Barrier lagoons/marshes Open Coastal inlets	Shoreline armoring/alteration of beach profile Tidal constrictions – tide gates, culverts, bridges, weirs Tidal encroachment – filling of tidal wetlands, dikes/levees, roads within tidal wetlands
Habitat Connectivity and Movement/Exchange of Organisms	Estuaries Beaches/bluffs Marine riparian vegetation	Fill in intertidal, estuaries, coastal marshes Shoreline armoring, jetties, groins Overwater structures, piers, pilings Impervious surfaces on bluffs; removal of riparian vegetation Tidal restrictions – tide gates, dikes/levees, culverts, road/railroad fill
Water Quality (nutrients, pathogens, toxins)	Land uses/land cover adjacent to surface waters discharging to marine shorelines Wetlands adjacent to marine shorelines	Removal of forest cover in contributing watershed Agricultural land uses – dairy, pasture, feed lots, manure sources Impervious surfaces and stormwater runoff from roads, residential lawns

Table 4-2. Nearshore Processes, Process Important Areas, and Process Alterations

Process	Process Important Areas	Alterations
	Semi-enclosed bays/heads of bays with low flushing rates Marine riparian vegetation	Wildlife/domestic animal concentrations Failing septic systems Filling of wetlands adjacent to surface waters discharging to marine environment; Filling of wetlands adjacent to marine shorelines Removal of riparian vegetation Contaminated sediments; point discharges of toxins
Light Energy	Marine riparian Upper beach/shallow intertidal areas Eelgrass beds	Removal of riparian vegetation Shoreline armoring Overwater structures (docks, marinas) Nighttime lighting adjacent to shore (marinas, terminals, roadways)
Organic Imports/Exports, Carbon Cycling, LWD	Marine riparian Feeder bluffs Accretion shoreforms Estuaries and coastal marshes	Removal of riparian vegetation Removal of marsh vegetation Fill in coastal wetlands Shoreline armoring Constrictions in estuaries or pocket estuaries – presence of culverts, tide gates, bridges, or piers

4.2.2 Freshwater Process Important areas and Alterations

Important areas for several freshwater processes or process groups are often collocated, and occur at junctions between upland and aquatic habitats, and along streams and rivers. Table 4-3 lists typically associated processes, important areas, and alterations.

Table 4-3. Freshwater process important areas and alterations.

Process	Important Areas	Alterations
Water Delivery	Forested uplands Vegetated uplands	Removal forest cover Impervious surfaces
Water Movement (infiltration/recharge, surface runoff, peak flows, groundwater flow/discharge)	Forested/vegetated uplands Channel migration zones Floodplains Aquifer recharge areas	Impervious surfaces Removal of forest cover Channel confinement Filling of floodplains Levees
Water Storage	Floodplains Wetlands Lakes	Levees Channel confinement Filling or draining wetlands, floodplains, or lakes
Water Loss	Lakes Vegetated areas/forest cover Deep groundwater flows	Removal of vegetation Impervious surfaces
Sediment Supply/Delivery	Steep slopes Bare ground/early seral stage vegetation Channel migration zones	Removal of vegetation cover/loss of forest vegetation Impervious surfaces Bank armoring

Sediment Transport	River/stream channels Floodplains Channel migration zones	Bank Armoring Dams
Sediment Storage	Floodplains Channel migration zones Lakes Wetlands	Filling of floodplains and wetlands
Channel Migration	Channel Migration Zone Floodplain	Channel confinement Bank armoring Fill in floodplain Altered flow regime (water diversion, dams, impervious surface)
Floodplain/hyporheic Connectivity	Floodplain Channel Migration Zone Forested Contributing Watershed	Channel incision Channel confinement Bank armoring Fill in floodplain Altered flow regime (water diversion, dams, impervious surface)
Habitat Connectivity and Movement/Exchange of Organisms	Streams/floodplains Riparian zones Channel migration zones	Dams Roads Culverts Channel confinement/levees Removal of vegetation/loss of native vegetation cover
Nutrient Management/Nitrogen and Phosphorous Retention and Cycling	Hyporheic zones/floodplains Lakes Wetlands Riparian zones	Removal of forest cover/riparian vegetation Channel confinement Filling or draining of wetlands
Pathogen and Toxin Removal/Processing	Hyporheic zones/floodplains Wetlands	
Carbon Cycling/Sequestration	Forested/vegetated uplands Vegetated riparian zones Soils/organic soils	
Organic Matter Export and Import/LWD	Steep slopes/landslide prone areas Riparian forests Floodplains/hyporheic zones Wetlands	Removal of vegetation/loss forest cover Channel confinement/levees Fill in floodplains and wetlands Bank armoring
Solar Incidence/Light Energy	Riparian forests Lakes Wetlands River channels	Removal of vegetation/loss of forests Loss of LWD Overwater structures Artificial nighttime light sources
Disturbance Regime	Steep slopes Channel migration zones Floodplains Forested contributing watersheds Riparian forests Wetlands	Removal of vegetation/loss forest cover Channel confinement/levees Bank armoring Fill in floodplains Alteration in flow regimes – water diversion, dams, impervious surfaces
Establishment Native Vegetation	Upland, wetland, and aquatic habitats Riparian zones	Alteration of water processes Alteration of sediment processes Removal of native vegetation Introduction of non-native

		vegetation
		Impervious surfaces
		Habitat fragmentation/loss of connectivity
		Increased inputs of nutrients, toxins
Establishment of Invasive Species	Disturbed or bare ground	Removal of vegetation cover/loss of forests
		Increased nutrient inputs
		Altered flow regimes
		Filling or draining wetlands
		Impervious surfaces

4.2.2.1 Tidal Barriers

Tidal barriers are structures that impede tidal flows and can include dikes and levees, tide gates, and roads or railroads constructed across tidal wetlands. Tidal barriers are used to prevent saltwater flows into diked agricultural lands, facilitate drainage and conversion of tidal wetlands for development or agriculture, and to support infrastructure in tidal wetlands (e.g., roads, railroads, buildings).

Tidal barriers alter processes associated with the movement of water, sediment, organic matter, and organisms and result in significant changes to habitat conditions and biotic communities (Thom 1992, Hood 2004). A lack of tidal flow prevents water and sediment from reaching tidally influenced wetlands – salt, brackish, and freshwater marshes. Restriction of water and sediment movement changes habitat structure by eliminating tidal channels, and habitat conditions by changing the freshwater/saltwater balance typical of estuaries and coastal marshes. Changes to sediment transport processes from stream deltas or tidal wetlands can affect the sediment supply and substrate quality for eelgrass beds that occur adjacent to estuaries and tidal marshes (Mumford 2007). Salt-tolerant vegetation is replaced by freshwater or upland vegetation on the landward side of tidal barriers. Former marsh elevations subside as sediment and organic matter no longer build up with tidal flows and inundation. On the seaward side of dikes or tide gates, channel complexity is typically reduced, impacting the amount and quality of habitat for juvenile salmon and other tidal marsh invertebrates and fish (Hood 2004). Tidal barriers reduce the overall extent of tidal marshes and channel networks, reducing foraging and refuge areas for fish, invertebrates, and birds. In addition, organic matter and nutrients that are exported from coastal marshes to nearby marine waters and support productive, detritus based food webs are no longer transported out of the marsh once tidal barriers prevent or reduce tidal flows (Williams and Thom, 2000; Simenstad et al. 2000; Fresh 2006).

Tidal wetlands are important areas for carbon sequestration and nutrient cycling, performing important functions for mitigation of GHG emissions and climate change. Tidal wetlands also influence water quality in adjacent nearshore areas through prevention of eutrophication by nitrogen removal, and retention of pathogens and pollutants. Tidal wetlands also store large amounts of water from floods and storm surges, dissipate energy and slow movement of water – hazard mitigation that is lost when tidal flows are restricted.

In addition tidal wetlands support:

- Access to a mosaic of habitats for feeding, refuge, physiological/ontogenetic transitions, rearing, and/or reproduction is critical for species that use different habitats at different life stages or that have a diversity of life history strategies. For example, access to marsh areas and tidal channels during high tides for juvenile salmon and access to freshwater spawning reaches for adult salmonids (Simenstad et al. 2000; Fresh 2006).

- Nutrient and material cycles depend on movement of matter and nutrients among habitats and transformation from one form to another.
- Biological processes that support reproduction and population viability depend on the movement of individual organisms – migration of anadromous fish, seed dispersal by biological dispersal agents, pollination, emigration/immigration that supports metapopulations (source/sink dynamics) and gene flow, dispersal of juveniles from nursery to adult habitats, or ontogenetic habitat shifts between different life history stages.
- Export/transport of nutrients and organic matter between habitats supports secondary production and biological diversity – e.g., salmon transporting marine-derived C, N, and P to freshwater streams and riparian forests; benthic filter feeders (shellfish) that move carbon/nutrients from water column to support diverse benthic faunas.

Tidal barriers alter the following processes:

- Tidal flow
- Sediment transport
- Movement of LWD
- Erosion/accretion of sediment and organic matter
- Tidal channel formation and maintenance
- Distributary channel migration
- Nutrient cycling
- Carbon cycling
- Organic matter import and export
- Exchange/movement of aquatic organisms

The effects of tidal barriers on ecological processes results in impacts to the following functions:

- Foraging, refugia, physiological adjustment, and rearing habitat support for juvenile salmonids
- Access to estuarine areas by juvenile salmonids
- Support for detritus based food webs in marshes and adjacent nearshore
- Nursery habitat for native fish, shellfish and other invertebrates (Dethier 2006)
- Foraging habitat for shorebirds (e.g., dunlin) (Buchanan 2006)
- Maintenance of suitable substrates for eelgrass
- Carbon sequestration in marsh soils (accumulation and burial of organic matter)
- Productivity of eelgrass and marsh areas (reduced prey availability for forage fish, juvenile salmonids)
- Maintenance of water quality (temperature reduction, nutrient inputs, toxin/pathogen retention) in adjacent nearshore

4.2.2.2 Dredging and Filling

Dredging and filling result in the direct loss of habitat, loss of connectivity and fragmentation of habitat, changes in water movement, sediment transport, LWD movement, and loss of shade/organic matter inputs from riparian vegetation.

Dredging and filling are primarily conducted to maintain boat access and create channels for mooring and navigation, and to create new upland areas for development. Dredging has the potential to redistribute and resuspend contaminated sediments and is regulated through both Federal and State permits. Dredging results in direct physical disturbance to benthic organisms and loss of habitat, although re-colonization may occur within a few years of disturbance (Williams et al. 2001). Temporary impacts from dredging include an increase in turbidity and potential resuspension of contaminants. Some of the same impacts occur as a result of boat scour in areas where propeller wash or high boat traffic disturbs benthic sediments.

Filling also directly impacts upland and wetland habitats adjacent to the shoreline and has been responsible for much of the loss of freshwater and estuarine wetlands in the study area, particularly in the Gorst estuary (Redman et al. 2005). Direct burial of wetlands or intertidal areas by filling results in a loss of habitat area for wetland or intertidal associated vegetation, fish, and wildlife (Dethier 2006, Fresh 2006, Pentilla 2007). Fill that is associated with shoreline armoring will also reduce inputs of sediment and LWD to streams and nearshore areas, as well as reducing freshwater inputs to beaches. Sediment transport can also be disrupted by fill in channels, floodplains or nearshore areas. In nearshore areas where fill occurs along bluff-backed beaches or barrier beaches, fill can trap sediment, prevent further transport and resulting in loss of sediment supply to down-drift habitats. Fill that extends into the intertidal can also result in the loss of nearshore habitats, including forage fish spawning and eelgrass beds through changing elevations, water depths, current patterns, and substrate size and type (Williams et al. 2001, Buchanan 2006, Eissinger 2007).

Fill in tidally influenced shorelines reduces the volume of water flowing in and out of an area during each tidal cycle, and also reduces mixing, salinity patterns, organic matter exchange, sediment transport, movement of organisms, and habitat formation processes. Alteration of these processes results in the loss or reduced area of tidal channels, loss of tidal marsh vegetation, reduced accretion of sediments and organic matter, reduced carbon sequestration, and a lowering of marsh elevations relative to sea level. Because fill is frequently associated with development and impervious surfaces, fill adjacent to streams, wetlands, or nearshore areas can result in increased nutrient, pathogen, and toxin inputs from stormwater runoff or septic system. These changes affect nutrient processing, access to habitat, habitat area and quality for fish and wildlife, resilience to sea level rise, and connectivity between habitats.

4.2.2.3 Shoreline/Bank Armoring

Freshwater – channel confinement, downstream flooding, loss of connectivity between channel and floodplain, altered sediment processes, reduction in habitat complexity, loss of LWD recruitment, usually associated with some loss of riparian vegetation (see below).

Nearshore – primarily associated with bluffs and barrier beaches, but can also impact other areas (embayments, marshes, estuaries) where armoring is associated with fill below OHWM/MHHW). Impacts are greater where structures extend below MHHW. Impacts sediment supply (Canning and Shipman 1995) and sediment available for down-drift beaches (Johannesen and MacClennan 2007), reduces accumulation of beach wrack and LWD on upper beaches or berms Tonnes 2008), reduces or eliminates input of LWD and freshwater into beach/nearshore areas. Usually associated with loss of wetland and riparian vegetation (increased light, temperatures, desiccation of beach/nearshore, loss of shoreline stabilization, decreased retention of sediment and nutrients/toxins, decreased inputs of organic matter). Also results in increased wave energy (wave reflection) and increased erosion waterward of structures (MacDonald et al. 1994), leading to a coarsening of substrate which impacts suitability for forage fish spawning, increases desiccation, etc. Also, reduces sediment transport and deposition processes in tidal marshes and deltas, reducing tidal channel formation and maintenance, migration of distributary channels, reduced or eliminated marsh accretion and resistance to sea level rise and degraded habitat quality and access for fish and wildlife. Armoring can function as a tidal barrier or change tidal flows in ways that increase erosion and/or restrict movement of LWD.

Impacts to sediment processes will affect beach, sand/mud flat, shellfish, shorebirds, eelgrass, and tidal marsh habitats (Griggs 2005, Buchanan 2006, Dethier 2006, Mumford 2007). Forage fish spawning beaches, eelgrass, shellfish, and shorebird foraging areas, can be directly impacted by elimination of upper intertidal areas and indirectly impacted by changes in depth, wave energy, substrate composition, substrate moisture, riparian shade and organic matter inputs. Changes in sediment processes and habitat structure will also indirectly affect quality of nearshore migration corridors and rearing habitat for juvenile salmonids by effects of armoring on shallow intertidal, eelgrass and forage fish spawning habitats, as well as increased wave energy, loss of shallow intertidal areas, and loss of overhanging riparian vegetation.

4.2.2.4 Overwater Structures/Marinas

Overwater structures occur on lakes, along streams/wetlands, and in the nearshore. They can include larger areas of overwater structure from marinas and ports, but also individual docks, piers, floats/buoys, and bridges. Overwater structures (esp. marinas) frequently are associated with pilings, armoring, breakwaters or jetties, and/or shoreline structures such as buildings and parking lots. Effects of overwater structures include the following:

- Decreased light and reduced productivity, growth, and survival of aquatic vegetation (eelgrass, kelp, freshwater macrophytes, plankton),
- Indirect effects on food webs, substrate stabilization, nutrient management, energy dissipation, and fish and wildlife populations from impacts on native vegetation,
- Changes in sediment supply and transport (deepening of beach profiles, changes in channel migration, changes in substrate composition),
- Fill in lake, stream, or nearshore habitat and direct impacts to habitat,
- Removal of riparian vegetation and reduced or eliminated shade, organic matter inputs, sediment retention, and nutrient management functions,
- Armoring and associated impacts,
- Increase in pathogens, toxins, and nutrients from stormwater runoff, boats, septic systems, creosote pilings or anti-fouling compounds,
- Altered wave and current energy around support structures (pilings) which can alter sediment transport and increase deposition under or near the structure; sediment supplies down stream or down-drift are reduced leading to coarsening of substrates,

- Changes in movement and behavior of fish, especially juveniles, when encountering areas of deeper shade (changes in migration patterns, greater exposure to predators, increased expenditure of energy),
- Changes in movement and behavior of fish and wildlife from artificial lighting at night.

4.2.2.5 Breakwaters and Jetties

Breakwaters and jetties are usually associated with marinas and harbors. Effects on processes and structures include:

- Reducing wave energy, which also reduces erosion and sediment supply from bluffs, which affects habitat forming processes,
- Reducing or altering sediment transport and reducing sediment availability to downstream or down-drift reaches, leading to a coarsening and steepening of beaches with loss of intertidal habitat (impacting shorebirds, shellfish, forage fish, eelgrass, and kelp),
- Altering sediment deposition patterns and location and extent of beach habitat, and
- Disrupting connectivity along shorelines by physically blocking the movement of organic matter and organisms, resulting in impacts on detrital food webs, loss of access to the mosaic of shoreline habitats needed by aquatic organisms (e.g., movement of juvenile salmon between estuaries or salt marsh edges to eelgrass or movement along nearshore between sheltered areas such as pocket estuaries) and fragmentation and isolation of habitat and populations.

4.2.2.6 Roads/Railroads

Roads and railroads are examples of stressors that affect multiple processes and therefore can change multiple habitat structures and affect many ecological functions. Effects of roads and railroads include:

- Fill and direct loss of habitat,
- Loss of connectivity (between habitats, nearshore and adjacent terrestrial systems, freshwater and adjacent terrestrial systems),
- Loss of riparian vegetation associated with clearing for road corridors,
- Interruption of bluff or bank sediment and transport processes,
- Barriers to tidal flows (movement of sediment, organic matter, water, LWD, organisms),
- Interruption of distributary channel migration and tidal channel formation,
- Barriers to surface/groundwater flows in wetlands or floodplains;
- Barriers to freshwater inputs from upland to nearshore areas,
- Passage barriers in streams (barriers to sediment, LWD, organic matter, water movement and organisms),
- Habitat fragmentation,

- Armoring and impacts to sediment processes,
- Overwater structures – increased shade, artificial light,
- Increase in pollutants (aerial deposition and stormwater runoff,
- Increase in impervious surfaces and changes to flow regimes…..

Stream Crossings and Culverts

Stream crossings are typically associated with roads and the density of stream crossings in a watershed has been correlated with impairment to aquatic ecosystem health (May et al. 1998, Booth et al. 2002). Effects of stream crossings are similar to culverts and include:

- Loss of connectivity and reducing the movement of water, wood, organic detritus, sediment, and organisms downstream of the crossing or culvert,
- Flow restrictions and associated flooding upstream of culverts, or reduced freshwater inputs to nearshore areas,
- Altered water flows and sediment transport,
- Shade and reductions in light available for plant growth and primary productivity,
- Passage barriers to fish migration,
- Increased inputs of nutrients and toxins from stormwater runoff, and
- Restriction of tidal flows, reduction in tidal prism (timing and volume of inundation), changes in sediment transport and loss or reduction in tidal and distributary channel habitat.

4.2.2.7 Dams

Dams create barriers that block the flow of water in stream or river. Impacts depend on the type and operation of the dam, whether for water supply (irrigation or drinking water), flood control, or generation of hydroelectric power. Flood control and hydroelectric dams can dramatically alter the flow regime of rivers and streams, changing the natural timing, magnitude, frequency, duration, and rate of change of flows that characterize a particular river. Aquatic organisms are adapted to the typical or natural flow regime of rivers in a particular area (Poff et al. 1996). Altering the flow regime can therefore disrupt critical life history stages, such as seed dispersal and recruitment for plants; migration, spawning, and egg incubation for fish; and adult emergence for macroinvertebrates. Flood control or water storage dams can eliminate high seasonal flows that are important in maintaining sediment movement, channel migration, floodplain connectivity, and habitat formation in channels.

Dams also create barriers to the movement of water, sediment, organisms, organic matter, and LWD. River reaches below dams lack a supply of sediment and LWD, affecting the formation of habitat in lower reaches and nearshore areas, as well as resulting in changes in substrate composition (coarsening). Nearshore habitat formation in stream deltas and estuaries can be significantly reduced over time by the trapping of sediment behind dams. Dams create passage barriers to fish and invertebrates, eliminating access to large areas of habitat upstream of dams for anadromous species and isolating populations of resident species. Releases of water from dams can alter the temperature in downstream areas, by either releasing very cold bottom water or warm surface water from reservoirs. Finally, dams directly impact stream and associated wetland and riparian habitat when these areas are flooded by reservoirs; flowing water, wetland, and terrestrial habitats are converted to lake and lakeshore habitats. Impacts of dams will depend on the proportion of the drainage basin that is impounded, the size of the dam, and operation of the dam.

4.2.2.8 Impervious Surfaces (and Loss of Forest Cover)

Loss of forest vegetation and the creation of impervious surfaces is one of the most important stressors with the greatest number of effects on freshwater and nearshore environments. Multiple processes and most habitat types are affected by impervious surfaces. Effects include:

- Altered flow regimes – increased magnitude and frequency of peak flows, decreased base flows (Booth et al. 2002), reduced recharge of groundwater,
- Decreased base flows and reduced recharge of groundwater can reduce freshwater inputs to nearshore via seeps and small streams,
- Increased stream channel erosion and sediment transport to downstream or nearshore areas, resulting in siltation, smothering of downstream habitats and biota such as spawning gravels, shellfish beds, and eelgrass beds,
- Scouring of spawning gravels and alteration of channel morphology by high flows,
- Channel incision and disconnection from floodplains and off-channel wetlands,
- Impervious surfaces can concentrate runoff and result in higher volumes of freshwater reaching nearshore, changing salinity gradients in estuaries,
- Impervious surfaces increase and concentrate contaminants from runoff reaching streams, lakes, and nearshore waters, resulting in altered nutrient, toxin and pathogen inputs,
- Increased nutrient inputs can result in eutrophication, harmful algal blooms and increased incidence of paralytic shellfish poisoning (PSP), greater incidence of low dissolved oxygen, and reduced light available for eelgrass and other submerged aquatic vegetation,
- Vegetation (including riparian) is removed for impervious surfaces, eliminating or reducing infiltration, sediment retention, shade, organic matter inputs, substrate stabilization, carbon sequestration, nutrient and pollutant retention, and LWD supplies to adjacent waters, and
- Large areas of impervious surface and removal of vegetation increase the amount of light reaching the ground and increases air temperatures, as well as creating warmer temperatures in water running off the surface, which can alter temperatures in receiving waters.

4.2.2.9 Removal of Riparian Vegetation

The marine riparian zone is an important area for several nearshore processes, including water quality processes, light energy, sediment processes, and as a source of LWD and organic matter. Removal of riparian vegetation occurs as a result of shoreline armoring, construction of overwater structures, construction of roads or railroads adjacent to the shoreline, and commercial or residential development. Removal of riparian vegetation results in the following process alterations and impacts to nearshore functions (Pentilla 2001, Williams et al. 2004, Brennan and Culverwell 2004):

- Loss of sediment retention and bank stabilization functions provided by vegetation (particularly root masses), increased sediment inputs and/or erosion, and higher rates of bank or bluff failure;
- Loss of nutrient cycling and pollutant retention functions and increased nutrient and pollutant inputs to the nearshore;
- Replacement of riparian vegetation with impervious surfaces (e.g., including residential lawns) results in increased stormwater runoff, and inputs of pollutants (including metals, pesticides, and fertilizers);
- Loss of wildlife habitat;
- Loss of inputs of LWD and other organic matter (e.g., leaf litter, insects) that are important components of nearshore food webs;
- Increased heat and drying stresses in the upper beach/intertidal area due to loss of riparian shade, decreased suitability for forage fish spawning, changes in beach faunal communities;

Increases in light levels, and the associated desiccation and temperature stress, is most commonly associated with the removal of riparian vegetation from the shoreline and the loss of shade to the beach from overhanging vegetation (Brennan and Culverwell 2004, Brennan et al. 2009). The upper limit of many intertidal animals is controlled by temperature and moisture/desiccation stress associated with exposure during low tides. Removal of riparian vegetation can result in a loss of these animals from upper beach areas that are no longer shaded. The success of forage fish spawning and egg survival is also tied to suitable temperature and moisture conditions within sands and gravels in the upper beach – these conditions are negatively affected by higher light levels and reduced shade following removal of riparian vegetation (WDFW 2000).

4.2.2.10 Land Cover Development

Land cover is the type of dominant feature present on the surface at any particular area, and includes categories such as open water, deciduous forest, coniferous forest, grassland, developed low intensity, developed high intensity, pasture, cultivated crops, and woody wetlands (National Land Cover Data – MRLC 2001). Development occurs when one type of land cover is replaced by another. Because each land cover has different kinds of effects on ecosystem processes, changes in land cover can alter processes and impact ecological functions. For example, replacing an evergreen forest with developed, low intensity land cover will increase impervious surface, alter hydrologic and sediment processes, affect temperatures and light levels and change local climate, change the species composition of vegetation, affect habitat quality of the area for wildlife (e.g., by removing nest trees or food plants), fragment habitat, and change nutrient and pollutant inputs. Process alterations and effects of developed land cover types are very similar to those for impervious surfaces, and removal of forest and/or riparian vegetation (See Sections 3.3.2.9 and 3.3.2.9).

4.2.2.11 Increased Nutrient, Pathogen, Toxin Inputs

Increased inputs of nutrients result in increased plant production which can lead to increased biological oxygen demand, increased turbidity and lower light levels, and low or extremely low levels of dissolved oxygen (DO). Low DO levels impact fish and benthic macroinvertebrates in both fresh and marine waters. High levels of nutrients can result in harmful algal blooms which impact water quality in terms of appearance and odors, as well as contributing to toxins that affect human and animal health. Paralytic shellfish poisoning (PSP) is linked to harmful algal blooms. Increased inputs of pathogens/toxins adversely impact shellfish populations and recreational/commercial harvests. Pollution, thermal stress, and desiccation increase mortality of forage fish on beaches (egg and larval) (Emmett et al. 1991).

Low energy, semi-enclosed habitats with significant inputs from upland areas such as river or stream deltas, and sand and mud flats are particularly vulnerable to alterations that affect water quality. Inputs may be higher in these areas, and excess nutrients, pathogens, and toxins tend to accumulate or have longer residence times in these areas. Particularly during periods of increased water stratification, nutrients or pollutants can increase to levels that impact marine organisms. Because they are sedentary and filter feeders, shellfish are particularly vulnerable to deteriorating water quality and excess nutrients or pollutants. Shellfish contaminated with fecal coliforms and/or algal toxins can pose problems for people, as well as for other animals that feed on shellfish.

5. WATERSHED ANALYSES

5.1.1 South Central Puget Sound Action Area (as defined by PSNERP)

The regional context for the Bremerton SMP study area includes South Central Puget Sound (see Figure 3-1). Existing conditions in the study area for Bremerton's shorelines are influenced by process alterations and the health of ecological functions in the larger region. South Central Puget Sound has a relatively high level of development, with moderate to large urban centers, including Tacoma, Seattle, and Bremerton. As a result, this area of the Sound has relatively high levels of impervious surface in contributing watersheds and high levels of modification (e.g., armoring, fill, removal of riparian vegetation) along both freshwater and nearshore shorelines (Table 4-1). Results of PSNERP studies (Schlenger et al. 2010, Simenstad et al. in review) indicate that this basin has lost significant areas of tidal wetlands and coastal shoreforms compared to historic conditions, including:

- 42% of barrier estuaries;
- 78% of barrier lagoons;
- 89% of closed lagoon/marsh; 52% of open coastal inlet; and
- 45% of tidal wetlands within embayments.

Table 5-1. Nearshore Stressors Affecting Major Shoreforms in the South Central Puget Sound Basin[21]

	Percent of Current Shoreforms Affected by Stressor							
Stressors	**Bluff-backed beach**	**Barrier beach**	**Barrier estuary**	**Barrier lagoon**	**Open coastal inlet**	**Rocky platform**	**Pocket beach**	**Artificial**
Armoring	98%	48%	21%	19%	49%	49%	53%	86%
Overwater structures	4%	4%	5%	10%	10%	2%	4%	44%
Fill	8%	14%	8%	0%	4%	0%	0%	11%
Roads/ railroads	10%	11%	37%	2%	8%	29%	7%	38%
Tidal barriers	0%	0%	45%	3%	3%	0%	0%	0%

[21] Regional stressors compiled from Schlenger et al. 2010, Borde et al. 2009, PSP 2009, Kitsap County GIS 2010.

5.1.2 Sinclair Inlet Watersheds and Shorelines

The Sinclair Inlet watershed drains an area of 27,492 acres, including the creeks that flow into Sinclair Inlet (primarily along the southern shore) and the Beaver Creek watershed to the east. The watershed includes 57 miles of saltwater frontage, approximately 46 lakes with 9.7 miles of shoreline, and >62 miles of streams. The watershed is characterized by many small streams that drain relatively small areas. Gorst and Blackjack creeks are the main dischargers of freshwater into the Inlet (WADNR 2009, Ecology 2009). Estimates of freshwater runoff into Sinclair Inlet have ranged from 335 cfs in January to 5 cfs in August. The contribution of groundwater flow to the inlet is unknown but thought to be substantial (Lincoln and Collias 1975, as cited in PSCRBT 1990).

Sinclair Inlet and Rich Passage have a combined surface area of 4,668 acres and about 36 miles of marine shoreline in the study area (Table 5-2). The main basin of Sinclair Inlet is deepest near the eastern end (130 feet) south of Point Herron, but the head of the bay is <10 feet deep. Tideflats present at the head of the inlet are exposed during low tides. The currents of Sinclair Inlet are relatively weak, at only 0.8 knots (Determan 1980, as cited in PSCRBT 1990). The estimated total flushing time is approximately 14 days for Sinclair Inlet (Lincoln and Collias 1975, as cited in PSCRBT 1990), assuming that none of the waters leaving the inlet on ebb tides returns on flood tides. In reality, some waters do return and waters from Sinclair and Dyes inlets mix in an area off Annapolis. The volume that mixes and returns on flood tides to Sinclair Inlet is unknown (TetraTech 1988, as cited in PSCRBT 1990).

Table 5-2. Sinclair Inlet Watershed Characteristics

Shoreline Area Name/ID[22]	Upland Drainage Area in Acres (square miles)	Nearshore Zone Area in Acres (square miles)[23]	Shoreline Length in Miles
Blackjack Creek (4044)	10,374 (16.2)	494 (0.8)	4.9
Gorst Estuary to Phinney Bay (4046)[24]	12,844 (20)	1,729 (2.7)	16.7
Port Washington Narrows East (4061)	3,705 (5.8)	494 (0.8)	8.3
Point Herron (4062)	494 (0.8)	49 (0.07)	1
Bremerton East UGA (4062)	988 (1.5)	454 (0.7)	4.9

Forest land covers 7,626 acres or about 28% of the watershed (20% is in public ownership, 68% in private woodlots, 12% in commercial forest land) (PSCRBT 1990). Rural/agricultural areas cover 10,627 acres, or about 37% of the watershed (35% covered with grass/shrubs, 65% covered with trees). Most of the watershed consists of low, rolling hill topography.

[22] PSNERP Process Unit Number.

[23] Based on PSNERP and EKNHA nearshore assessment areas.

[24] Includes Port Washington Narrows West

Slopes in the upper watershed are moderate, with some steep slopes (>50%) occurring in the City of Bremerton watershed. Bremerton and Port Orchard are the major urban areas with additional retail centers at Gorst, Manchester, and Annapolis. Kitsap County designates approximately 6,658 acres (24%) of this watershed as urban. The remainder of the watershed is characterized by large parcels of pasture, forest, single-family homes, small farms, and low-intensity commercial uses. Impervious areas are moderate to high in the urban centers, most of the watershed is in developed land cover, but in some areas much of the contributing watershed is still forested (Table 5-3). Most of the land is in private ownership.

Table 5-3. Watershed Conditions in Sinclair Inlet Shorelines

	Land Cover (% area)		Impervious Surface (% area)				Ownership Status (% area)			
Reach[25]	**Dev**[26]	**Natural**	**0-10%**	**10-30%**	**30-50%**	**50-100%**	**Public**	**Private**	**Tribal**	**Prot**[27]
Black-jack - SPU	49	51	55	13	10	22	2	98	0	0
Black-jack DPU	41	59	70	16	7	6	3	97	0	0
Gorst to Phinney Bay SPU	78	22	28	18	13	41	17	83	0	16
Gorst to Phinney Bay DPU	37	64	71	10	6	14	33	67	27	0
Port Washington Narrows East SPU	65	35	46	26	12	16	3	97	0	0
Port Washington Narrows East DPU	66	34	46	23	14	17	14	86	0	2
Point Herron SPU	63	37	44	28	10	18	3	97	0	<1
Point Herron DPU	66	34	40	32	15	15	2	98	0	0
Bremerton East UGA SPU	51	49	59	21	13	7	5	95	0	0
Bremerton East DPU	62	38	49	24	17	10	9	91	0	<1

[25] SPU = Shoreline Process Unit or Nearshore Zone; DPU = Drainage Process Unit for Upland contributing area.

[26] Dev = Developed land cover.

[27] P= Protected land status.

At a watershed level, a number of stressors are present that impair freshwater ecosystem processes, including a small number of dams, large number of road crossings of streams, and the existence of barriers in streams (Table 5-4). The most important stressors in the nearshore are shoreline armoring, roads, and fill, although some important estuarine areas have a high level of construction and barriers affecting tidal flows (Table 5-5).

Table 5-4. Existing stressors in upland drainage are in Sinclair Inlet shorelines.

Reach	Number Dams	Number Stream Crossings	Fish Passage Barriers	Roads (% area)
Blackjack Creek (4044)	0	90	6	6
Gorst Estuary to Phinney Bay (4046)	4	136	25	8
Port Washington Narrows East (4061)	0	37	7	8
Point Herron (4062)	0	0	0	8
Bremerton East UGA (4062)	0	9	0	6

Table 5-5. Existing stressors in nearshore zone.

Reach	Tidal Barriers (% length)	Armoring (% length)	Roads/ Railroads (% area)	Overwater Structures (% area)	Nearshore Fill (% area)
Blackjack Creek (4044)	26	85	21	14	8
Gorst Estuary to Phinney Bay (4046)	6	88	18	4	20
Port Washington Narrows East (4061)	6	80	12	<1	2
Point Herron (4062)	0	77	5	2	2
Bremerton East UGA (4062)	0	54	6	<1	<1

Estimates by PSNERP suggest that a significant amount of nearshore habitat has been lost through filling or conversion to artificial shoreforms (Table 5-6).

Table 5-6. Estimated percent loss of historic shoreforms in the nearshore zone of Sinclair Inlet shorelines

Reach	Bluff-backed Beach	Barrier Beach	Barrier Estuary	Barrier Lagoon	Closed Lagoon Marsh	Open Coastal Inlet	Rocky Shore	Pocket Beach
Blackjack Creek (4044)	77	74	100	-	100	-	-	-
Gorst Estuary to Phinney Bay (4046)	45	100	100	-	-	65	82	9
Port Washington Narrows East (4061)	12	36	41	44	10	-	22	-
Point Herron (4062)	9	10	-	-	-	-	-	-
Bremerton East UGA (4062)	10	10	57	-	100	-	-	-

The USFWS has classified 5,012 acres of wetlands in the Sinclair Inlet watershed, with 17% being freshwater, and 83% being marine; an additional 57 acres of freshwater wetlands (ponded water and hydrophytic vegetation) were identified using aerial photography, and an additional 1,560 acres of hydric soils using soils interpretation (PSBRT 1990). Although estimates of the loss of freshwater wetlands in the study area are not available, loss of wetlands in most areas of Puget Sound has been significant (e.g., >50% loss; Bortleson 1980).

Water quality impairment in the watershed is the result of both water and sediment contamination (Table 5-7). Pollution in Sinclair Inlet is the result of a combination of agricultural, urban, and industrial sources. The Naval Shipyard has been a major contributor to water and sediment quality in Bremerton. Category 5 listings include dissolved oxygen, phosphorus, temperature, mercury, fecal coliform, and PCBs (Table 4-2). Category 2 listings include fecal coliform, dissolved oxygen, pH, 31 temperature, PAHs, zinc, and pesticides (TCDD, or Agent Orange).

Table 5-7. 303(d) Water and Sediment Quality Impairments in Sinclair Inlet Waterbodies

		Sites	
Compound	**Medium**	**Impaired (Catebory 5)**	**Area of Concern (Category 2)**
Fecal Coliform	Water	Parish Creek Sinclair Inlet	Wright Creek Anderson Creek
Temperature	Water		Sinclair Inlet
Dissolved Oxygen	Water	Union River Sinclair Inlet Gorst Creek Enetai Creek	Sinclair Inlet Anderson Creek
pH	Water		Sinclair Inlet Union River Enetai Creek
Sediment Bioassay	Sediment		Sinclair Inlet
Polycyclic Aromatic Hydrocarbons (PAHs)	Sediment		Sinclair Inlet
PCBs	Sediment	Sinclair Inlet	
Zinc	Sediment		Sinclair Inlet
Bioassessment	Other		Anderson Creek

5.1.3 Dyes Inlet Watershed

The Dyes Inlet watersheds drain an area of 30,289 acres, including the creeks that flow into Dyes Inlet and Port Washington Narrows. Approximately 40% of the watershed is within the urban area (12,231 acres) designated by Kitsap County. Within the study area, about 16 miles of marine shoreline with contributing drainage areas occur in Dyes Inlet (Table 5-8). Bremerton and Silverdale are the major urban areas, with smaller retail centers at Chico, Tracyton, and Kitsap Lake. The Jackson Park Navel Reservation, Camp Wesley Harris, and parts of the Bangor Naval Reservation are located within the watershed. The remainder of the watershed is characterized by large parcels of land used for pasture, forest, wetlands, single-family homes, small farms, and low-intensity commercial uses.

Table 5-8. Dyes Inlet Watershed Characteristics

Shoreline Area Name/ID[28]	Upland Drainage Area in Acres (square miles)	Nearshore Zone Area in Acres (square miles)	Shoreline Length in Miles
Phinney Bay (4047	741 (1.2)	247 (0.4)	2.5
Rocky Point & Mud Bay (4048)	494 (0.8)	494 (0.8)	3
Ostrich Bay Peninsula (4049/4050)	247 (0.4)	247 (0.4)	2
East Shore Ostrich Bay (4051)	247 (0.4)	247 (0.4)	1
Oyster Bay (4052-4054)	988 (1.5)	494 (0.8)	5
Ostrich Bay (4055)	1,235 (2)	247 (0.4)	2.5
Ostrich Bay North (4056/4057)	494 (0.8)	247 (0.4)	2
Chico Bay (4058)	11,609 (18)	494 (0.8)	2.5

Most of the watershed consists of low, rolling-hill topography. Slopes in the upper watershed are moderate, with the steepest slopes (>60%) occurring in the Lost Creek drainage. The highest point in the watershed is on Green Mountain (1,500 feet). Agricultural areas in the Clear Creek drainage are nearly flat. Steep, sloping sea cliffs and bluffs dominate the Port Washington Narrows shoreline. The Dyes Inlet watershed is characterized by many small streams that drain relatively small areas. Clear, Barker, and Chico creeks are the main dischargers of freshwater into Dyes Inlet. Freshwater runoff into Dyes Inlet varies considerably throughout the year. The contribution of groundwater flow to the inlet is unknown, but thought to be substantial (Lincoln and Collias 1975, as cited in PSCRBT 1990).

The Dyes Inlet watershed contains a diverse array of land uses. Land use in the watershed was estimated to be 25% forested, 29% rural/agricultural, 40% urban, and 6% other (lakes, wetlands, military, parks, etc.) (PSCRBT 1989). There has been extensive conversion of rural/agricultural/forest land to urban (residential and commercial) area since 1989, particularly in the Clear Creek and Barker Creek watersheds. Shorelines and contributing basins have moderate to high levels of impervious surfaces, are mostly in developed land cover, and in private ownership (Table 5-9). The USFWS classified 5,785 acres of wetlands in the Dyes Inlet watershed, with 20% freshwater, and 80% saltwater. Because of inventory methods, this does not constitute a complete list of existing wetlands. The PSCRBT identified and additional 78 acres of freshwater wetlands, and an additional 1,207 acres of hydric soils.

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[28] PSNERP Process Unit Number.

Table 5-9. Watershed land cover, impervious surface, and ownership status

	Land Cover (% area)		Impervious Surface (% area)				Ownership Status (% area)			
Reach[29]	**Dev[30]**	**Natural**	**0-10%**	**10-30%**	**30-50%**	**50-100%**	**Public**	**Private**	**Tribal**	**Prot[31]**
Phinney Bay (4047)	49	51	55	13	10	22	2	98	0	0
Rocky Point & Mud Bay (4048) SPU	41	59	70	16	7	6	3	97	0	0
Rocky Point & Mud Bay (4048) DPU	58	42	49	29	17	4	<1	99	0	0
Ostrich Bay Peninsula (4049/4050) SPU	42	58	60	22	14	5	0	100	0	0
Ostrich Bay Peninsula (4049/4050) DPU	48	55	57	22	17	6	0	100	0	0
East Shore Ostrich Bay (4051) SPU	36	64	65	25	8	2	<1	99	0	0
East Shore Ostrich Bay (4051) DPU	37	64	65	25	8	2	<1	99	0	0
Oyster Bay (4052-4054) SPU	58	41	43	21	14	23	5	95	0	0
Oyster Bay (4052-4054) DPU	70	30	32	25	19	25	4	96	0	0
Ostrich Bay (4055) SPU	66	34	41	25	19	15	35	65	0	29
Ostrich Bay (4055) DPU	80	20	35	27	18	20	26	74	0	20
Ostrich Bay North (4056, 4057) SPU	47	54	56	28	13	5	7	94	0	7
Ostrich Bay North (4056, 4057) DPU	52	49	57	25	13	6	6	93	0	6
Chico Bay	73	27	39	38	18	6	0	100	0	0

29 SPU = Shoreline Process Unit or Nearshore Zone; DPU = Drainage Process Unit for Upland contributing area.

30 Dev = Developed land cover.

31 P= Protected land status.

Table 5-9. Watershed land cover, impervious surface, and ownership status

	Land Cover (% area)		Impervious Surface (% area)				Ownership Status (% area)			
(4058) SPU										
Chico Bay (4058) DPU	14	86	89	7	3	2	31	69	0	7

Stressors affecting freshwater shorelines are primarily stream crossings, barriers, and roads associated with the more developed areas (Table 5-10).

Table 5-10. Existing stressors in upland drainage area of Dyes Inlet shorelines.

Reach	Number Dams	Number Stream Crossings	Fish Passage Barriers	Roads (% area)
Phinney Bay (4047	0	0	0	11
Rocky Point & Mud Bay (4048)	0	0	0	9
Ostrich Bay Peninsula (4049/4050)	0	0	0	11
East Shore Ostrich Bay (4051)	0	0	0	9
Oyster Bay (4052-4054)	0	0	0	12
Ostrich Bay (4055)	0	26	14	14
Ostrich Bay North (4056/4057)	0	1	0	8
Chico Bay (4058)	1	135	46	4

Dyes Inlet and the Port Washington Narrows have a surface area of 4,642 acres. The main basin of Dyes Inlet is deepest near the center (150 feet), but the adjacent bays are typically <35 feet deep (PSCRBT 1989). Tideflats present in the small bays and at the head of the inlet are exposed during low tides. The currents of Dyes inlet are relatively weak, but those of Port Washington Narrows are strong (4 knots)(NOAA 1988, as cited in PSCRBT 1989). The estimated total flushing time is approximately four days for Dyes Inlet (Lincoln and Colias 1975, as cited in PSCRBT 1989), assuming none of the waters leaving the Inlet on ebb tides returns on flood tides. In reality, some waters do return and waters from Sinclair and Dyes inlets mix in an area off Annapolis. The volume that mixes and returns on flood tides to Dyes Inlet is unknown (Tetra Tech 1988, as cited in PSCRBT 1989).

Stressors in the nearshore are primarily the extent of shoreline armoring, tidal barriers, and roads affecting the nearshore (Table 5-11). Although there are numerous small overwater structures and areas of fill, these affect a small percentage of shoreline due to their small size, with the exception of a few reaches (e.g., Phinney Bay; Table 5-11). PSNERP has estimates a significant amount of habitat loss in the nearshore, associated with the history of development (Table 5-12).

Table 5-11. Existing stressors in nearshore zone of Dyes Inlet.

Reach	Tidal Barriers (% length)	Armoring (% length)	Roads/ Railroads (% area)	Overwater Structures (% area)	Nearshore Fill (% area)
Phinney Bay (4047	0	64	8	5	<1
Rocky Point & Mud Bay (4048)	2	41	8	<1	<1
Ostrich Bay Peninsula (4049/4050)	<1	65	5	<1	<1
East Shore Ostrich Bay (4051)	<1	63	9	<1	<1
Oyster Bay (4052-4054)	11	50	13	<1	<1
Ostrich Bay (4055)	3	57	13	<1	2
Ostrich Bay North (4056/4057)	5	50	10	<1	<1
Chico Bay (4058)	2	35	14	<1	<1

Table 5-12. Estimated percent loss of historic shoreforms in the nearshore zone of

Reach	Bluff-backed Beach	Barrier Beach	Barrier Estuary	Barrier Lagoon	Closed Lagoon Marsh	Open Coastal Inlet	Rocky Shore	Pocket Beach
Phinney Bay (4047	8	9	-	-	100	24	-	-
Rocky Point & Mud Bay (4048)	5	28	-	100	100	13	24	20
Ostrich Bay Peninsula (4049/ 4050)	8	13	-	100	-	13	-	-
East Shore Ostrich Bay (4051)	6	13	-	100	-	-	-	-
Oyster Bay (4052-4054)	4	9	-	-	100	14	-	-
Ostrich	10	47	100	-	100	11	-	-

Table 5-12. Estimated percent loss of historic shoreforms in the nearshore zone of

Reach	Bluff-backed Beach	Barrier Beach	Barrier Estuary	Barrier Lagoon	Closed Lagoon Marsh	Open Coastal Inlet	Rocky Shore	Pocket Beach
Bay (4055)								
Ostrich Bay North (4056/ 4057)	6	94	-	100	-	15	-	-
Chico Bay (4058)	13	-	-	-	-	27	-	-

Water quality impairments in Dyes Inlet are associated primarily with agricultural, urban/commercial and some industrial runoff (Table 5-13). Fecal coliform levels are impaired in numerous streams and nearshore areas. Ostrich Bay, Oyster Bay and Phinney Bay are classified as 'Prohibited' for shellfish growing areas (Map 12).

Table 5-13. Water and Sediment Quality Impairments in Dyes Inlet[32]

Compound	Medium	Number of Sites: Impaired (Category 5)	Number of Sites: Area of Concern (Category 2)
Phosphorous	Water	Kitsap Lake	
Fecal Colifom	Water	Kitsap Lake Dyes Inlet/Port Washington Narrows Ostrich Bay Creek Tributary to Kitsap Lake Phinney Creek Chico Creek Kitsap Creek	
Mercury	Water	Dyes Inlet/Port Washington Narrows Ostrich Bay	
Dissolved Oxygen	Water	Chico Creek Ostrich Bay Creek Kitsap Creek	Dyes Inlet/Port Washington Narrows
Temperature	Water	Chico Creek Kitsap Creek	Dyes Inlet/Port Washington Narrows
PCB	Tissue	Kitsap Lake	
2,3,7,8-TCDD TEQ	Tissue		Kitsap Lake
Bioassessment	Other		Chico Creek
Sediment Bioassay	Sediment	Dyes Inlet/Port Washington Narrows	Dyes Inlet/Port Washington Narrows

21 2008 303(d) listing from

Table 5-13. Water and Sediment Quality Impairments in Dyes Inlet[32]

		Number of Sites	
Compound	Medium	Impaired (Category 5)	Area of Concern (Category 2)

Ecology

6. SHORELINE INVENTORY AND ANALYSIS

The detailed inventory in this section will include only those reaches within the City's shoreline planning area (see Map 1 and Map 4F).

6.1 KITSAP LAKE

The Kitsap Lake is approximately 238 acres in size and the shoreline includes land currently within the city of Bremerton, as well as land within unincorporated Kitsap County. A large wetland is mapped at the south end of Kitsap Lake and is associated with the shoreline of the lake. Most of the lake shoreline is developed residential, with numerous docks, large areas of modified shoreline, and very little riparian vegetation (see Appendix C; Reach Maps).

The lake supports resident cutthroat, coho, steelhead, and pink salmon, with stock status mapped as unknown upstream and in the lake (WDFW 2009, Map 7A and Map 7B). The lake is associated with at least one bald eagle nest and foraging area along the shoreline (Map 6A). An extensive wetland at the sound end of the lake along inlet streams supports forested, scrub-shrub, and emergent wetland vegetation.

Land cover around the lake is predominantly urban grasses, high intensity residential, and low intensity residential on the north and eastern sides of the lake (Reach 1) (Map 10). The western and southern shores are less developed but still dominated by low intensity residential and mixed forest and grasslands (Reach 2). Impervious surfaces are relatively low around the west and south sides of the lake but greater than 50% with some areas above 80% on the eastern and northern shores (Map 11). About 90% of the lake shoreline is affected by shoreline armoring, overwater structures, removal of riparian vegetation, and impervious surfaces within 200 feet of the lake shore.

Kitsap Lake is on the 303(d) list as a Category 5 for phosphorous, fecal coliform, and PCBs (see Table 4-8, Map 12). Stormwater runoff from adjacent impervious surfaces, including residential lawns and landscaping contribute to water quality impairment in the lake (Ecology 2009).

The lake shoreline is mostly in private ownership. Kitsap Lake Park is on the south shore within City of Bremerton jurisdiction, and an open space corridor designated to the south connecting the lake shore wetlands with the City's watershed lands (Map 13).

6.2 UNION RESERVOIR AND UNION RIVER

The Union Rive reservoir has a surface area of about 40 acres. Shoreline reaches include the entire lake shoreline, as well as the Union River below the reservoir from McKenna Falls to the lake. The combined lake and river shoreline area is approximately 98 acres. The reservoir lies behind the Casad Dam and provides drinking water for the City of Bremerton. The upper watershed and the reservoir are within the City's protected watershed area with deciduous, evergreen and mixed forest as the predominant land cover.

The Union River system supports chinook, pink, coho, fall-winter chum, summer chum, steelhead, and cutthroat. The Union River is the only basin on the Kitsap Peninsula to currently have a viable native population of summer chum salmon. The lake and river reaches within shoreline jurisdiction support resident cutthroat, although coho, and steelhead could be present (WDFW 2009, Map 7A). The Kitsap Refugia report rated the instream habitat and riparian conditions are generally fair to good (May and Peterson 2003). Riparian conditions in the lake and river reaches within shoreline jurisdiction are in good condition, with forested riparian zones on both sides of the river and around the lakeshore. The upper watershed has numerous headwater wetland complexes, providing extensive rearing habitat for salmonids. McKenna Falls is a natural barrier to fish passage upstream, and is located just downstream of the Union Reservoir dam. Stock status is ‘unknown’ or ‘healthy’ in the reservoir and reaches just downstream (WDFW 2009, Map 7B).

Water quality impairments include low dissolved oxygen and pH in the shoreline reaches downstream of the reservoir (see Table 4-2 and Map 12).

The reservoir and river reach within shoreline jurisdiction are surrounded by the City’s 3,000 acre protected watershed area where only water supply and forest management activities are allowed (Map 14, http://www.ci.bremerton.wa.us/forms/publicworks/waterresources/CCR_annualreport10.pdf). Just to the east of the reservoir, land is zoned as Utility and Low Density Residential. Land cover is predominantly forested, with deciduous and mixed forest, and some areas of grasslands and shrublands. Impervious surface is less than 10%. The shoreline of Union Reservoir is currently designated as Urban Conservancy (Map 15).

6.3 TWIN LAKES

Twin Lakes together are approximately 21.7 acres in size and lie within the City’s utility area. Twin Lakes, which are on the hydrologic boundary between the Union River and Gorst Creek watersheds, and there are no surface drainage channels out of the Twin Lakes. Studies by the City of Bremerton indicate that approximately half of the groundwater flow out of the Twin Lakes is to the Union River watershed and half to the Gorst Creek watershed (Kuttel 2003, Haring 2000). Twin Lakes is located towards the western end of the Gorst Creek Aquifer Recharge area (Map 5). There are no identified water quality issues.

The area around Twin Lakes is zoned primarily as utility lands, with some area of low density residential zoning immediately to the east, and the industrially zoned South Kitsap Industrial Area is immediately to the south (Map 14). Twin Lakes shorelines are currently designated as Urban Conservancy (Map 15).

6.4 GORST CREEK UPSTREAM OF ESTUARY

The conditions in the upper Gorst Creek watershed are largely undeveloped, with low levels of impervious surfaces, and wetland complexes in the headwaters that provide moderate to high functions and values, including floodwater retention, water quality, and habitat functions. Floodwater retention is a critical function, due to the history of flooding within the Gorst Creek Drainage Basin (Parametrix 2006). The watershed covers approximately 7,000 acres in the southwestern portion of Kitsap County. Approximately 3,000 acres are forest resource land owned by the City of Bremerton, and approximately three percent of the remaining 4,000 acres include commercial, industrial and residential zoned land developed with buildings and other impervious surfaces.

Gorst Creek supports Chinook, chum, coho, steelhead and cutthroat (WDFW 2009, Map 7A). Gorst Creek is classified by Kitsap County as a Type F (fish-bearing) stream (WDNR 2009). Thirteen Type F tributary streams including Parish Creek, Heins Creek, and an unnamed stream (LMK 122) are located within the watershed. The upper reaches of these tributaries are of high ecological function and generally undisturbed by development; with the exception of one major tributary immediately south of Highway 3. This stream channel was destroyed in the 1960’s when the stream was put in a culvert and the area over the culvert was filled as a landfill. The lower reaches of Gorst are significantly altered by development and highways, with fill in the lower channel, estuary and nearshore, impervious surfaces, water and soil contamination, channel confinement, and tidal restrictions. The floodplain in lower Gorst Creek is mostly hardened and confined (although there are on-going restoration projects in the estuary). The lower reaches lack of riparian vegetation and LWD. A number of culverts/passage barriers affect the lower reaches – including under SR3 and Old Belfair Highway. Above SR 3, the channel may have no flow during summer months. Navy railroad crossing of Jarstad Creek is passage barrier.

The City's Gorst Creek Salmon Rearing Facility, jointly operated with the Suquamish Tribe, WDFW, and Kitsap Poggie Club, is located in the watershed. The facility includes two Chinook rearing ponds and two yearling fall Chinook raceways about 0.75 miles upstream from the mouth. All returning adult Chinook are thought to be hatchery fish and not the result of natural production. Gorst Creek is currently one of the largest producers of salmon in Kitsap streams. The facility releases two million Chinook salmon smolts into Gorst Creek, and raises 300,000 Coho salmon smolts for release into Agate Pass annually.

Gorst Creek is on the 303(d) list for dissolved oxygen and fecal coliform (Ecology 2009, Map 12). The lower reach of the stream is within the Gorst Creek Aquifer Recharge Area (Map 5).

Land cover is forested in the upper watershed, but mixed forest, grasslands, urban residential, or commercial industrial in the lower reaches. Impervious surfaces are high near the lower reaches and mouth of Gorst Creek – mostly greater than 80 to 90% impervious (Map 11). The area is currently zoned low density residential and utility lands around the western end of the jurisdictional reach (Map 14). However, the area within the Gorst UGA is not yet zoned by the City.

6.5 PUGET SOUND SHORELINES

6.5.1 Gorst estuary

Gorst Estuary is the largest estuary in the planning area and provides significant shoreline functions to Sinclair Inlet and Puget Sound. The estuary receives freshwater flows from Gorst Creek, as well as several small independent drainages nearby. Wright Creek is about 1.2 miles long and enters Sinclair Inlet between Gorst and Bremerton. The stream supports summer chum spawning in the intertidal, and cutthroat to a dam at RM 0.8. A small unnamed stream just east of Gorst enters Sinclair Inlet through a steep ravine, with a passage barrier at SR 16 (Kuttel 2003). This stream supports coho and may be associated with a small pocket estuary (Map 7A, Map 4G).

Anderson Creek enters Sinclair Inlet just east of the planning area boundary (Map 1) and supports coho, chum, cutthroat, and steelhead (Kuttel 2003, May and Peterson 2003, WDFW 2009). About half of the drainage area for Anderson Creek lies within the City's water supply protected area, which is managed primarily for municipal water supply and commercial forestry. A culvert at SR 16 may be passage barrier at low and high flows. Channel and floodplain constriction results from the 300-foot long concrete flume and pump station about ¼ mile upstream from SR 16. Upstream of the flume, the channel is moderately confined with moderate sinuosity, with marginal pool habitat, optimal riffle habitat, and sub-optimal LWD (May and Peterson 2003). Riparian zones are in relatively good condition along Anderson with most being rated in a natural condition and more than 30 meters wide (May and Peterson 2003). The estuary has been impacted by fill and tidal restrictions associated with SR 16/166 and culverts under the roadways, with virtually no saltwater influence upstream of the highway. Highway culverts may be passage barriers during times of receding tides.

Gorst estuary itself is shallow, with fringing marshes and mud flats that provide excellent production of prey for salmonids (May and Peterson 2003). Estuarine area upstream of the highway has been virtually eliminated through fill and development in the estuary. Good estuarine conditions occur at the mouth, but north of mouth, the shoreline is heavily modified and armored (highway and railroad, then PSNS). To the east of the mouth, the estuary has been filled with commercial and industrial buildings.

Figure 6-1. Gorst Estuary at the mouth of Gorst Creek (Ecology Coastal Atlas Photo 060624-1275)

Biological resources in the estuary include waterfowl concentrations at the mouth and along the north and south shorelines of Sinclair Inlet, and shorebird concentrations along the north shore (Map 9). Continuous mixed marsh and patchy salt marsh occurs along the inner estuary and north and south shorelines of Sinclair Inlet (Map 8A). Patchy eelgrass occurs between the edge of the marsh vegetation and adjacent mud and sand flats (Map 8D). Surf smelt spawning areas are mapped along the north and south shore if Sinclair Inlet just east of the estuary (map 7C). Bald eagle nests are associated with the estuary along the south shore of Sinclair Inlet with nest management and foraging areas within the entire estuary (Map 6A).

Shoreline modifications include significant alteration to tidal processes, with tidal barriers affecting 6% of shoreline length. Shoreline armoring affects 88% of shoreline length, road density is high (18% shoreline area), overwater structures affect 4% of shoreline area, and nearshore fill affects 20% of shoreline area. These modifications are reflected in the loss of habitats. Estimates of the loss of historic shoreforms include 100% of former barrier estuaries, 65% of coastal inlets, and more than 80% of tidal wetlands (Schlenger et al, in review).

Although public access is limited, urban trails (part of the Mosquito Fleet trail) and a shellfish beach are located along the shores of the estuary (Map 13).

6.5.2 Puget Sound Naval Shipyard

This reach is heavily modified by the development of the Naval Shipyard. Impervious surface along shoreline is more than 80% and frequently more than 90% along the entire shoreline (Map 11). More than 90% of the shoreline length is armored and overwater structures affect approximately 50% of the shoreline area (Map 16A).

6.5.3 Port Washington Narrows West

Port Washington Narrows provide the connection between Dyes and Sinclair Inlets and are characterized by a relatively narrow, deep channel with strong currents and bluff-backed beaches. All small streams north of Wright Creek have been covered and are contained in culverts (11 miles shoreline without natural streams).

A few locations for surf smelt spawning are mapped along this reach (Map 7C). Most of the shoreline is mapped with continuous non-floating kelp, but no eelgrass or marsh vegetation is mapped here (Map 8A, Map 8B, Map 8C, and Map 8D). Hardshell clam areas occur along the Narrows, but mostly associated with the eastern shore (Map 6B). Waterfowl concentrations occur at the entrance to the Narrows, between the ferry docks and Evergreen Park (Map 9).

Shoreline modifications include heavily armored shorelines (80% shoreline length), numerous roads (12% of shoreline area), and fill within the nearshore (2% of the area) (see Table 4-6). In addition, numerous overhanging structures; piers, docks, and floats; and old pilings occur along the Narrows shoreline (Map 16B and Map 16C).

Impervious surfaces along shoreline are mostly above 50% and mostly 90-100% at some locations including along the Bremerton waterfront, where the Warren Avenue Bridge crosses the Narrows, and just east of Anderson Cove (Map 11). Land cover is predominantly high intensity residential or commercial industrial, with small areas of low intensity residential (Map 10).

6.5.4 Phinney Bay

Phinney Bay is a large embayment at the western end of Port Washington Narrows and eastern end of Dyes Inlet.

Phinney Bay has some high bank areas on the eastern shore, but is mostly low bank and/or marsh lagoon shoreforms, with mud, sand, and gravel substrates dominating (Map 4G and Map 4H). One surf smelt spawning location is mapped on the northeast side of Phinney Bay. Non-floating kelp occurs along the northeastern side, with continuous eelgrass along most of the Bay shoreline, and patchy salt marsh at the southern end and in the lagoon in the western side of the Bay (Map 8B, Map 8D, and Map 8A).

Some oyster beds occur at the north end of the Bay, although Phinney Bay is currently classified as a Prohibited Shellfish Growing area (Map 12). Water quality issues include fecal coliform, and possibly dissolved oxygen (see Table 4-8, Map 12). Phinney Bay has a large number of outfalls, especially on the western side of the Bay, as well as a highly developed shoreline (Map 12).

About 30% of the drainage area contributing to Phinney Bay has impervious surfaces greater than 50%, but a relatively large portion of the drainage area (55%) is covered by less than 10% impervious surface (Map 11 and see Table 4-12). This is due to the mostly natural land cover (see Table 4-12) and cover is mostly low intensity residential but with some mixed forest (Map 10). Phinney Bay is currently zoned low density residential or not currently zoned in the Bremerton West UGA (Map 14).

Shoreline modifications include moderately high levels of shoreline armoring (64% of shoreline length), roads affecting the shoreline (8% of shoreline area), and overwater structures (5% of shoreline area) (see Table 4-12, Map 16A and Map 16B). Most of the overwater structure area is contributed by the single large marina (Map 16B).

6.5.5 Rocky Point/Mud Bay

Rocky Point and Mud Bay reaches are less intensively developed than the Bremerton waterfront and portions of the Narrows shorelines. Contributing drainage area is predominantly mixed forest, grasses, or low intensity residential (Map 10). Natural land cover is about 58%, with 42% classified as developed. Most of the contributing drainage is less than 30% impervious surface, but there are small areas with more than 50% impervious (see Table 4-13, Map 11). Within 200 feet of the marine shoreline, impervious surface is approximately 8% (EKNHA 2009). Rocky Point/Mud Bay is currently not zoned (Bremerton West UGA), although adjacent areas are zoned low density residential.

Non-floating kelp is continuous around Rocky Point, with areas of mixed marsh and salt marsh concentrated in Mud Bay (Map 8B and Map 8A). Oyster beds occur off Rocky Point, although this is in a Prohibited Shellfish Growing area (Map 6B). Surf smelt spawning areas occur on both sides of Rocky Point (Map 7C). A bald eagle nest is mapped south of Rocky Point, and foraging areas cover most of the Rocky Point/Mud Bay reach (Map 6A). In addition, a waterfowl concentration area occurs just south of Rocky Point (Map 9).

Shoreline modifications include a moderate to high amount of shoreline armoring (55% of shoreline length), some barriers to tidal flow (2% of shoreline length), and roads (8% shoreline area) (see Table 4-12). In addition, numerous overhanging docks and piers, and pilings are scattered along the shoreline (Map 16B and Map 16C). However, this reach lacks large overwater structures and the low energy areas in Mud Bay are generally not armored. Riparian vegetation is lacking for most of the shoreline, but areas along the eastern shore of Mud Bay and some areas along Rocky Point have intact riparian vegetation.

6.5.6 Ostrich Bay Peninsula and East Ostrich Bay

The Ostrich Bay Peninsula and East Ostrich Bay are similar to Rocky Point/Mud Bay in overall level of development patterns along the shoreline and adjacent uplands. Drainage unit land cover is about 40 to 48% natural and 60 to 55% developed, with some mixed forest, deciduous forest, and urban grasses (Map 10). Impervious surfaces are mostly below 30% in the contributing drainage (Map 11). Percent total impervious surface within 200 feet of the shoreline is less than 10% (EKNHA 2009).

Shoreline vegetation is patchy salt marsh on the shores of Mud Bay, with mixed marsh and patch eelgrass (Map 8A and Map 8D). The peninsula and the eastern shore of Ostrich Bay include a concentration of surf smelt and Pacific sand lance spawning areas (Map 7C)

Shoreline modifications include relatively high levels of armoring (63 to 65% shoreline length), roads (5 to 9% shoreline area), and low levels of tidal barrier, overwater structure, and nearshore fill (all less than 1% of shoreline area) (see Table 4-12, Map 16A and Map 16B).

6.5.7 Oyster Bay

Oyster Bay is a shallow protected embayment with a relatively narrow opening to Ostrich Bay. Surrounding land cover is mostly developed (about 70% developed and 30% natural), with most of the contributing area with high levels of impervious surface (>50% impervious surface) (Map 10, Map 11). The south shore of Oyster Bay has the highest level of development and impervious surface (Map 10).

Shoreline modifications include significant alteration to tidal action (11% of shoreline length with tidal barriers), moderate to high levels of armoring (50% of shoreline length), roads affecting the shoreline (13% of shoreline area), and relatively low levels of nearshore fill and overwater structures (less than 1% shoreline area) (see Table 4-12, Map 16A and Map 16B). Oyster Bay is classified as a Prohibited Shellfish Growing Area (Map 12).

6.5.8 Ostrich Bay

Ostrich Bay is a large embayment in Dyes Inlet with one small stream mapped entering the Bay at its south end. This small independent drainage (Ostrich Bay Creek or Unnamed Creek 15.0226) enters the south end of Ostrich Bay and is associated with a pocket estuary (Map 4G).

Ostrich Bay Creek supports coho, chum, and cutthroat; stock status unknown (Map 7A, Map 7B). The stream is in a ravine from about Shorewood Drive to SR 3 and has a fair (about 50 feet) riparian buffer. Upstream of SR 3 riparian condition is poor to fair. Fish passage barriers occur at Kitsap Way, SR 3, and Price Road. Seal and sea lion haulout area is mapped at Elwood Point (Map 6B). A concentration of surf smelt spawning areas is mapped around Elwood Point. Patchy eelgrass and salt marsh occur at a few scattered locations in Ostrich Bay (Map 8D and Map 8A). Bald eagle nests and foraging areas are associated with much of the Ostrich Bay shoreline (Map 6A).

Land cover surrounding Ostrich Bay is a mix of high intensity residential, low intensity residential, mixed forest, evergreen and deciduous forest, urban grasses, and small areas of commercial/industrial (Map 10). Land cover is mostly developed (66 to 80% developed) and impervious surface is relatively high; impervious surface is 30% or above over most of the contributing area (see Table 4-13 and Map 11).

Shoreline modifications include tidal barriers (3% of shoreline length), armoring (57% of shoreline area, roads (13% of shoreline area), and nearshore fill (2% of shoreline area) (see Table 4-12 and Map 16A). Overwater structures are concentrated in a few locations and cover less than 1% of shoreline area (Map 16B).

Water quality impairments include fecal coliform, mercury, and dissolved oxygen listings for 303(d) list Category 5 (Ecology 2009, Map 12). In addition, all of Ostrich Bay is a Prohibited Shellfish Growing Area.

6.5.9 Ostrich Bay North

Ostrich Bay North includes the small embayment north of Elwood Point and the east and north side of Erlands Point, just into Chico Bay. The southern half of the embayment is the limit of the City's planning area, but the entire reach is described here.

A small stream less than one mile long (Unnamed Creek 15.0226 and 15.0227) enters the west side of Ostrich Bay in the embayment to the south of Erlands Point. This stream is not known to support salmonids but provides estuarine habitat and marsh vegetation. The embayment contains continuous mixed marsh, with patchy mixed marsh, salt marsh, and eelgrass north of the embayment (Map 8A and Map 8D).

Surrounding land cover is predominantly urban grasses, low intensity residential, and some deciduous forest, mixed forest, and grasses (Map 10). Impervious surfaces are generally low, most of the area is less than 10% impervious, but the south shore of the embayment has area with more than 80% impervious surface (see Table 4-13, Map 11).

Shoreline modifications include significant tidal barriers (5% of shoreline length), armoring (50% of shoreline length), roads (10% of shoreline area), and numerous small boat ramps, overhanging docks, piers, floats, and areas of pilings (see Table 4-12, Map 16A, Map 16B, and Map 16C).

The U.S. Navy owns a large area of the western shoreline of Ostrich Bay and much of this shoreline is undeveloped, with relatively intact riparian vegetation.

6.5.10 Port Washington Narrows East

Port Washington Narrows provide the connection between Dyes and Sinclair Inlets and are characterized by a relatively narrow, deep channel with strong currents and bluff-backed beaches. Some small streams have been covered and are contained in culverts, however, some small streams still have relatively good riparian areas (Map 10).

A few locations for surf smelt spawning are mapped along this reach (Map 7C). Most of the shoreline is mapped with continuous non-floating kelp, but no eelgrass or marsh vegetation is mapped here (Map 8A, Map 8B, and Map 8D). Hardshell clam areas occur along the Narrows, but mostly associated with the eastern shore (Map 6B). Waterfowl concentrations occur at the entrance to the Narrows (Map 9). Sheridan Park, Lyons Park, and East Park occur along this reach.

Shoreline modifications include heavily armored shorelines (80% shoreline length), numerous roads (12% of shoreline area), and fill within the nearshore (2% of the area) (see Table 4-6, Map 16A). In addition, numerous overhanging structures; piers, docks, and floats; and old pilings occur along the Narrows shoreline (Map 16B and Map 16C).

Impervious surfaces along shoreline are mostly above 50% and mostly 90-100% at some locations including where the Warren Avenue Bridge crosses the Narrows (Map 11). Land cover is predominantly high intensity residential or commercial industrial, with small areas of low intensity residential (Map 10).

6.5.11 Point Herron

Point Herron is characterized by predominantly developed land cover, both in the drainage basins contributing to the shoreline reach and within the shoreline reach itself. Impervious area in the drainage unit and along the shoreline is generally greater than 10% and in some areas greater than 50%. Forest cover within the 200 foot shoreline area is less than 4%.

Nearshore stressors are primarily shoreline armoring, with more than 70% of the shoreline armored. In addition, 5% of the shoreline reach is affected by roads, with 2% affected by overwater structures and fill.

6.5.12 Bremerton East UGA

Land cover in reach 56B (Bremerton East UGA) is predominantly developed in the contributing drainage basins and along the shoreline, with a little more than 40% of the area having greater than 10% impervious surface. In addition to removal of forest cover, stream crossings/culverts and roads affect the upland drainage areas. Percent impervious within 200 feet of the marine shoreline ranges from 8% to 17%, while forest cover within the 200 foot shoreline area averages less than 2%. Over 50% of the shoreline is armored, with 6% of the shoreline affected by roads.

A small independent creek (Dee Enetai) enters Port Orchard Bay approximately 1.0 mile northeast of Point Heron. The creek currently supports chum, coho, and cutthroat in the lower reaches. There are a number of fish passage barriers in this watershed (Dorn). Anadromous salmonids are currently able to pass upstream to the second culvert under Enetai Beach/Jacobsen Boulevard, which is a total fish passage barrier. Additional culverts under Trenton Avenue and Helm Street are also identified as fish passage barriers. These culverts should be removed and replaced with small bridges.

The natural floodplain of Dee Creek is constrained at several culvert crossings. Most of the culverts are undersized, creating sediment deposition areas upstream. From the mouth to Trenton Avenue, the channel is located in a steep ravine with good LWD presence. Upstream of Trenton Avenue, channel conditions are considered to be poor. The upper watershed is intensely developed with no stormwater protection. Habitat upstream of Trenton Avenue is generally poor, and the primary identified concern downstream of Trenton Avenue is gravel scour, likely resulting from altered creek hydrology in the headwaters. Riparian condition upstream of Trenton Avenue is poor, with little remaining riparian vegetation due to intense development in the headwaters. Riparian condition in the steep ravine reach downstream of Trenton Avenue is considered to be generally good.

Flows in Dee Creek are very flashy, likely the result of the intense development in the watershed with no stormwater controls. This increases surface flows during storm events, decreases base flows, and contributes to poor water quality conditions in the stream. The Bremerton-Kitsap Health District has been collecting water quality information at one location in Dee Creek since 1996. Identified water quality concerns include consistent high fecal coliform counts (Mean=183 fc/100ml, three observations of 1600 fc/100ml). Although not identified as a water quality concern, there were some observations of dissolved oxygen levels <10 mg/l., and two observations of elevated turbidity. Dee Creek has a small estuary; both banks are armored. Effects of bank armoring to estuarine function should be evaluated.

6.6 SUMMARY OF REACHES

Shoreline modifications affecting nearshore processes are summarized in Table 6-1 for all shoreline reaches in the planning area. Table 6-1 shows a standardized number for stressors for all reaches to allow comparison of the reaches – the number of stressors present per 100 feet of shoreline is used to standard the stressor measure.

Table 6-1. Summary of Shoreline Modifications by Reach

Reach Name	Reach	Stairs / Unit[1]	Outfalls / Unit	Non-Culvert Outfalls /Unit	Culverts / Unit	Boat Launches / Unit	Groins / Unit	Overhanging Structures / Unit	Piers/Docks and Floats Number/ Unit	Floats/ Unit	Pilings / Unit
Kitsap Lake 1	K1	0	10	5	1	3	2	12	18	6	34
Kitsap Lake 2	K2	0	6	2	1	1	1	10	14	4	28
Twin Lakes	TL3	0	0	0	1	0	0	0	0	0	0
Union Reservoir	URES 4	0	0	0	0	0	0	0	0	0	0
Union River	UR5	0	0	0	0	0	0	0	0	0	0
Gorst Creek	GC6										
Puget Sound Navel Shipyard	34A	0	3	3	0	0	0	0	0	0	95
Gorst Estuary	34B	4	10	2	6	5	0	1	2	2	100
Blackjack Creek	34C	7	27	9	12	3	1	20	6	3	429
Port Washington Narrows West	35	5	5	5	0	3	0	1	2	1	34
	36	4	10	8	3	0	0	2	2	0	91
	149	9	6	6	0	3	2	1	3	1	20
	150	6	0	0	0	2	0	1	4	4	56
	151	3	5	4	1	0	0	0	1	0	59
Phinney Bay	37	11	3	3	0	3	1	1	4	4	38
	38	6	4	3	1	1	0	0	5	5	21

Table 6-1. Summary of Shoreline Modifications by Reach

Reach Name	Reach	Stairs / Unit[1]	Outfalls / Unit	Non-Culvert Outfalls /Unit	Culverts / Unit	Boat Launches / Unit	Groins / Unit	Overhanging Structures / Unit	Piers/Docks and Floats Number/ Unit	Floats/ Unit	Pilings / Unit
	39	0	0	0	0	3	0	0	1	1	14
	85	5	0	0	0	2	0	0	2	1	19
Rocky Point	40	1	0	0	0	1	0	0	1	1	0
	41	42	4	4	0	13	1	1	8	6	43
Mud Bay	42	12	6	6	0	5	1	3	7	6	9
	43	3	0	0	0	0	0	0	5	5	30
Ostrich Bay Peninsula	44	7	0	0	0	9	7	0	10	8	11
	86	9	3	3	0	2	0	1	1	1	11
East Shore Ostrich Bay	87	31	1	1	0	10	4	1	12	12	17
Oyster Bay	48	6	0	0	0	0	0	0	0	0	1
	49	48	11	11	0	13	0	4	26	23	47
	50	43	2	2	0	8	5	5	5	5	2
	88	8	1	1	0	5	1	2	4	4	18
Ostrich Bay	140	11	14	12	1	1	0	1	2	1	53
Ostrich Bay North	51	3	0	0	0	1	2	0	1	1	1
	52	13	1	1	0	5	1	0	6	4	24
	53	8	0	0	0	3	0	2	4	4	3
	89	8	1	1	0	4	0	1	1	1	42
Chico Bay	90	25	1	0	1	1	8	3	1	1	13
	138	1	0	0	0	0	0	0	0	0	36

Table 6-1. Summary of Shoreline Modifications by Reach

Reach Name	Reach	Stairs / Unit[1]	Outfalls / Unit	Non-Culvert Outfalls /Unit	Culverts / Unit	Boat Launches / Unit	Groins / Unit	Overhanging Structures / Unit	Piers/Docks and Floats Number/ Unit	Floats/ Unit	Pilings / Unit
Port Washington Narrows East	107	13	19	16	4	3	1	2	8	3	184
	108	2	2	0	2	0	1	0	1	1	28
	135	0	0	0	0	0	0	0	0	0	0
	137	77	18	17	1	19	7	6	29	25	212
Point Herron	55	9	2	2	0	1	2	1	1	0	16
	56A	15	1	1	0	10	0	0	3	2	12
Bremerton East UGA	56B	32	6	6	0	10	4	3	6	4	155

7. ECOLOGIC MANAGEMENT AND PROTECTION TOOLS

7.1 OVERVIEW

A wide range of options are available for management and protection of ecological functions in shorelines. The discussion below covers several topics including:

Designation, rating and classification systems

Functional assessment options

Classification based buffers

No harm regulations

7.2 DESIGNATION, RATING, AND CLASSIFICATION

There is no universally accepted method for classifying rivers, streams, and lakes or related habitat areas for regulatory purposes. In the State of Washington, there are a variety of classification systems used by different agencies based on specific regulatory needs. For example, Ecology classifies water types for the purposes of meeting water quality standards and employs a system that emphasizes the use of the water and the requirements of the Federal Clean Water Act, while DNR employs a system based on forest practices needs.

7.2.1 Washington DNR Stream Typing System

The DNR classification system was developed for forest practices and generally is based on the presence or absence of fish. The designation of shorelines of the state as a separate classification is based primarily on the statutory limitations on forest practices within shorelines of statewide significance in RCW 90.58.150 which allows only selective timber cutting. In general, the designation of streams over 20 csf as a separate category may be relevant because of the wider range of processes provided in streams with higher flows, but the DNR designation is not based on the presence or absence of particular geomorphic processes or ecological functions.

7.2.2 Fish Species and Lifestage Stream Classification System

The specific biological and ecological functions provided by individual streams differ substantially. Therefore, one potential classification system classifies stream reaches according to the fish species and lifestages present within the reach. The presence of salmonids in various life stages within a stream or river reach can indicate or infer information on the habitat quality and quantity of that specific reach. For example, if a headwater stream reach supports bull trout, it may indicate that riparian buffer conditions within that reach are relatively intact, and the buffers are of adequate size to provide for adequate moderation of water temperature and sediment filtration capability, because spawning bull trout require cool water and clean gravel. Likewise, a reach known to be occupied by spawning chum salmon can be assumed to be accessible to all other salmon species, because chum salmon are the least powerful swimmer of the salmon species.

This approach would use the WDFW Priority Habitat Species (PHS) database to assign fish presence or life stage information. The database covers streams in the Bremerton study area that have been identified as having anadromous species and classifies stream reaches as spawning, rearing, or migration habitat for each individual salmonid species. Other reaches of stream, where site-specific information is lacking, could be classified based on current knowledge as presumed or historical habitat for a species with the option that more detailed analysis could be done at the project review stage to confirm or change the presumption.

The primary advantages of this system are in its biological and ecological relevance, coupled with a relatively complete, easily accessible database. However, there are several potential drawbacks to such a classification system. First, the link between fish presence and the quality or type of aquatic habitat is not complete. Dams, for example, can completely block anadromous fish access to high-quality, productive, instream habitat, which may not be occupied for these reasons. Second, the quality of fish presence/life stage information is currently incomplete, and may be biased toward easily accessed valley-bottom reaches as compared to more isolated headwater tributary reaches.

In Bremerton, this option is not particularly valuable because most streams and lakes provide habitat for a variety of fish species, however specific reaches vary greatly in the character of the stream and adjacent uplands and the ecological functions provided.

7.2.3 Aquatic Habitat Quality Based Classification System

A third type of classification system is based on ecological functions using known differences in habitat quality and limiting factors to classify streams. The relative quality and quantity of individual geophysical or habitat parameters have direct correlation to the ecological functions that a particular stream reach or subbasin provides. The presence of particular species in various life stages within a stream or river reach can indicate or imply information on the habitat quality and quantity of that specific reach. For example, if a headwater stream reach supports bull trout, it may indicate that riparian buffer conditions within that reach are relatively intact, and the buffers are of adequate size to provide for adequate moderation of water temperature and sediment filtration capability, because spawning bull trout require cool water and clean gravel. Likewise, a reach known to be occupied by spawning chum salmon can be assumed to be accessible to all other salmon species, because chum salmon are the least powerful swimmer of the salmon species.

This approach would rely on review of available reports on habitat conditions and limiting factors (e.g., LCFRB 2002) to assign a classification system based on the relative ecological condition of a stream reach or subbasin. The primary advantage of such a classification system is that ecological relevance is built into the system. However, several major disadvantages are also present. For example, detailed, high-quality information on habitat quality is not available for many stream and lake reaches within the Bremerton study area, and because different sources of information have used different methods for habitat evaluation. Available information, therefore, is not directly comparable. Furthermore, in many cases this approach would require reliance on best professional judgment to combine information on multiple ecological functions in order to classify a particular stream or subbasin. Most likely, the approach would be most practical to apply at a larger spatial scale, such as the subbasin or subwatershed level, which could potentially negate the benefits by blending ecological function.

7.2.4 Functional Assessment Options

The current practice in assessing ecological functions provided by streams and other aquatic systems is to use a classification and rating system. Such systems focus on identifiable features and use rating systems to characterize factors such as sensitivity, significance, rarity, functions, and opportunities for replacement.

While the use of the current WDFW/DNR stream rating system is understood as common practice, it presents limitations that an ecosystem perspective can remedy. The current rating system focuses on discrete identifiable features of streams that are roughly related to functions important to aquatic species.

An alternative approach is to focus on the variety of functions provided by the landscape. The rationale for focusing on functions rather than the stream classification is to shift emphasis from a discrete element of the ecosystem, such as a stream, to a system of indicators that are integrated with other aquatic resource and habitat evaluations. Further, the current methodology relies on discrete stream evaluations. The alternative functional analysis would utilize structural components rather than particular features, such as streams, as the basis for units within sites. This also allows for a broader view of stream values that provides opportunities for including other functions, such as flood management functions, and evaluating water supply functions such as seeps and springs that have an integral part in aquatic ecological functions.

This functional approach allows for a detailed understanding of the ecosystem services provided by a natural or impacted site. Quantitative values can be developed for existing conditions in a natural or altered state, and alternatives can be compared in both restoration and impact scenarios. These values, or scores, allow for a clearer understanding of tradeoffs under site selection, design, or mitigation analysis.

The analysis of specific stream reaches in this report provides a qualitative assessment of these factors. It is not converted into a rating or other system because that intermediate step is not necessary in an area as small as the City. The approach used in the Draft SMP Policies and Regulations is to use all the relevant information about each reach in developing regulations that specify the application of the Shoreline Management Act’s competing priorities for water dependent use, public access and preserving or enhancing ecological functions.

7.3 BUFFER OPTIONS

For protection of ecological functions in streams and lakes, wetlands and habitat areas, a relatively narrow range of options have been used in Washington State. Most of the regulations developed in Washington State have been related to Growth Management Act (GMA) requirements to protect Critical Areas.

The predominant means of regulating uplands adjacent to water bodies and areas adjacent to wetlands and critical wildlife habitat has been through buffers. The Shoreline Management Act makes reference to buffers in RCW 90.58(2)(f)(ii) which allows inclusion of buffers for critical areas in SMP jurisdiction

References to buffers in the Shoreline Master Program Guidelines (WAC 173-36) are numerous and include the following:

> WAC 173-26-186(2)(c)(i)(D) Buffers. Master programs shall contain requirements for buffer zones around wetlands. Buffer requirements shall be adequate to ensure that wetland functions are protected and maintained in the long term. Requirements for buffer zone widths and management shall take into account the ecological functions of the wetland, the characteristics and setting of the buffer, the potential impacts associated with the adjacent land use, and other relevant factors.
>
> WAC 173-26-186(2)(5)(b) Local governments may implement these objectives through a variety of measures, where consistent with Shoreline Management Act policy, including clearing and grading regulations, setback and buffer standards, critical area regulations, conditional use requirements for specific uses or areas, mitigation requirements, incentives and nonregulatory programs.

> WAC 173-26-211(4)(f)(ii)(A) Standards for density or minimum frontage width, setbacks, lot coverage limitations, buffers, shoreline stabilization, vegetation conservation, critical area protection, and water quality shall be set to assure no net loss of shoreline ecological functions, taking into account the environmental limitations and sensitivity of the shoreline area, the level of infrastructure and services available, and other comprehensive planning considerations.
>
> WAC 173-241(3)(j) Standards for density or minimum frontage width, setbacks, lot coverage limitations, buffers, shoreline stabilization, vegetation conservation, critical area protection, and water quality shall be set to assure no net loss of shoreline ecological functions, taking into account the environmental limitations and sensitivity of the shoreline area, the level of infrastructure and services available, and other comprehensive planning considerations.

A wide range of buffer widths have been analyzed for a variety of functions. Variation in recommendations or buffer effectiveness is frequently due to variation in site conditions such as side-slope angle, stream type, geology, climate, etc. Design of riparian buffers must consider the ecological, cultural, and economic values of the resource, land use characteristics, and existing riparian quality throughout watersheds in order to address the cumulative impacts on stream functions and the resources being protected (Johnson and Ryba 1992; Castelle et al. 1994; 2000; Wenger 1999).

Appropriate buffer sizes will depend on the area necessary to maintain the desired riparian or stream functions for the given suite of land-use activities. A wider buffer may be desired to protect streams from impacts resulting from high-intensity land use while narrower buffers may suffice in areas of low-intensity land use (May 2000). It should be noted though that opportunities for protection or improvement of buffer conditions in areas of high-intensity land use are often effectively foreclosed by existing development, or the existing habitat conditions are already highly altered. Under such conditions, establishing buffers wide enough to provide an effective full-range of riparian functions is likely unattainable; other actions may be required to improve habitat conditions beyond what riparian buffers are able to provide. In addition, buffer vegetation type, diversity, condition, and maturity are equally as important as buffer width, and the best approach to providing high-quality buffers is to strive for establishing and maintaining mature native vegetation communities (May 2000).

Potential riparian, lake wetland and habitat buffer frameworks include the following types, which are discussed in greater detail below:

1. **Standard Single-Zone Buffers** – Fixed-distance stream buffers based on the maintenance of individual aquatic functions. The buffer widths may be further divided by land use (e.g., urban versus rural) or by other variables.
2. **Dual-Zone Buffers** – This approach employs two smaller adjacent buffer zones, which, when combined, make up the overall riparian buffer. An inner "core" zone, directly adjacent to the aquatic feature, consisting of an area where uses are prohibited or severely restricted, and an outer riparian zone, adjacent to the core zone, where uses are still restricted, but to a lesser degree.
3. R**each Based Buffers –** This approach is most relevant to streams and lakes that have been altered by human use. The approach focuses on "no net loss" of existing functions as they currently exist.

All of the above approaches could potentially incorporate buffer averaging techniques, in cases where the overall buffer area will be equal to un-averaged conditions, and it can be clearly demonstrated that averaging will result in no net loss of aquatic functions.

7.3.1.1 Standard Single-Zone Stream Buffers

Single-zone buffers are the most common type of riparian buffer, with a designated minimum buffer for each class or type of stream/habitat as defined by the applicable stream classification scheme.

The advantages of single-zone stream buffers are that they

- are the most common buffer type and have had extensive best available science (BAS) and legal review;
- are relatively simple to understand from a public standpoint and lend themselves to straightforward and efficient administrative processing; and
- allow for buffer averaging.

One disadvantage of such a system is that riparian buffers are not uniform in the functions they provide relative to the width of the buffer, as discussed further below.

Table 7-1 developed by Parametrix scientists summarizes this information in relation to the specific aquatic functions that are of greatest importance in maintaining conditions suitable to support fish and other aquatic life (e.g., LWD recruitment, stream temperature, sediment filtration). For each buffer width, the suitability of the buffer is rated by its ability to maintain these aquatic functions. Although this evaluation is qualitative, it is firmly based on BAS regarding ecological functions.

An example of a buffer recommendation based on a choice of a critical factor is the recommendation by Pollack and Kennard (1998) of a minimum buffer width of 250 feet on all perennial streams based on LWD recruitment and the height at maturity of trees in Pacific Northwest forests. These buffer widths of one SPTH would reasonably provide for a full range of riparian functions, and therefore, not contribute significantly to the loss of salmonid habitat. May (2000) and other extensive reviews provide detailed summaries of buffer width sizes necessary to achieve stream and riparian functions (Knutson and Naef 1997; FEMAT 1993).

As mentioned above, the disadvantage of uniform buffers is that a single buffer is designed to provide multiple functions. Depending on the stream and the adjacent use, some functions may continue to be provided on adjacent land outside of the buffer with appropriate management practices. For example, the riparian functions of bank stability and litter fall are primarily provided for within a relatively short distance of a waterbody (10 to 50 feet). Also, along highly managed streams such as in agricultural, residential, or commercial areas, some functions normally provided (at least in part) by riparian buffers, such as flow attenuation or filtration of pollutants, can be provided by application of appropriate BMPs in combination with smaller buffers. In addition, uniform buffers do not take into consideration the extent to which different vegetation communities in different parts of the buffer contribute to specific riparian functions. For example, impacts to the outer 25 feet of a 100-foot-wide buffer would likely have much less impact to bank stability and litter fall functions than would identically scaled impacts directly adjacent to the stream.

Table 7-1. Comparison of Functions of Stream and Lake Buffer Widths

	Buffer Width				
Stream Function	**15 Feet**	**50 Feet**	**150 Feet**	**300 Feet**	**600 Feet**
Microclimate	X	X	N	P	F
Wildlife Habitat	X	N	P	P	F
LWD Recruitment	X	N	P	F	F
Pollutant Removal	N	N	P	P	F
Sediment Filtration	X	N	P	F	F
Water Temperature	X	N	F	F	F
Organic Litter	X	P	F	F	F
Bank Stability	X	F	F	F	F

KEY
F = Buffer width fully supports/maintains stream function.
P = Buffer width partially supports/maintains stream function.
N = Buffer width nominally supports/maintains stream function.
X = Buffer does not adequately support/maintain stream function.

In an urban setting, the range of activities adjacent to a resource may affect the size or character of a buffer. Degradation of wildlife by domestic animals is difficult to address by buffer size, no matter how extensive. Buffers also may become habitat for feral domestic animals. In such a case, controls on domestic animals, such as fencing, may be needed in addition to buffers.

Buffer enhancement, particularly at the margins, protection from invasive species and other vegetation management is critical for effective buffers in areas dominated by human influence.

7.3.1.2 Dual-Zone Stream Buffers

This approach, commonly used in forestry applications, is similar to the single-zone stream buffer (see above). However, the overall stream buffer is composed of two smaller adjacent buffer zones, which when combined make up the overall riparian buffer. The two zones are:

An inner "core" buffer zone, located directly adjacent to the aquatic feature. In this area land uses are prohibited or severely restricted.

An outer riparian zone, landward and adjacent to the core zone, where land uses are still restricted, but to a lesser degree than within the core area.

Dual-zone buffers are not as common as single-zone buffers and are more complex from a public understanding and City administrative standpoint, although buffer averaging could still occur within the outer riparian zone.

The primary advantage of this type of buffer system is that the dual-zone system incorporates BAS indicating that riparian buffers are not uniform in the functions they provide relative to the width of the buffer. For example, for a relatively small stream that supports salmonid rearing and has a mixed forest riparian buffer, a continuous buffer width of 75 to 100 feet may be adequate to support the aquatic functions of LWD recruitment, temperature regulation, and the provision of detritus and nutrients to the stream. The segment of the buffer from 100 to 150 feet still supports important ecological functions such as pollutant filtration and microclimate regulation, but in this outer area a solid homogeneous buffer may not be required to support these functions to a high degree. In summary, as compared to a single-zone buffer, a dual-zone buffer may allow for different impact types within different parts of the buffer.

Examples of specific ecologically relevant provisions that could be applied to the outer buffer zone include:

A limit to the amount of clearing allowed within the outer buffer zone.

A minimum amount of forest required to be retained within the outer buffer zone.

A limit to the amount of impervious surface allowed within the outer buffer zone.

A limit to the development density allowed within the outer buffer zone.

In this system, the overall buffer width for the combined dual-zone buffers would be wider than for the single-zone buffer, because more uses are allowed within the outer portion of the dual-zone buffer. This approach has the advantage that it is adaptable to a wide range of land use activities, and gives the applicant choice on which approach is best suited to their particular situation, while still maintaining equal levels of aquatic habitat functions for the overall system. A disadvantage of the system is that it may be more difficult to administer, as compared to a single-zone buffer approach.

Dual zone systems are implicitly recognized in the 211(4)(c)(ii) in reference "parallel environments" that divide shorelands into different sections generally running parallel to the shoreline or along a physical feature such as a bluff or railroad right of way. Such environments may be useful, for example, to accommodate resource protection near the shoreline and existing development further from the shoreline.

7.3.1.3 Specific Stream or Lake Reach Buffers

An additional approach to stream buffers that combines some of the advantages of both the classification-based buffer system and a “no harm” approach are applying specific buffers for specific reaches based on assessment of the functions currently being provided by those reaches. This approach is particularly applicable to streams in areas of existing high-intensity land use where parcels are small and few remain undeveloped, and there is little practical opportunity to achieve buffers that will provide the full range of desired riparian functions.

In this case, the objective of the management approach is to preserve the existing functions and to improve, if possible, a limited range of functions such as improving temperature and water quality. Improving temperature through providing effective overhead shade can be achieved to varying degrees with intensive management of smaller buffers. Water quality improvements can be achieved by stormwater management and control of fertilizer and other chemical applications near streams.

7.3.2 “No Harm” Regulatory System

This type of regulatory system is best known in Washington State in its application to agricultural use in Skagit County. The approach was endorsed in challenges heard by the Growth Management Hearings Board for Western Washington and the Washington State Supreme Court (*Swinomish v Skagit 2006*). The “no harm” approach may be regarded as an “adaptive management” approach to protecting critical areas.

The most succinct overview of a no-harm system is provided in a Growth Management Hearings Board decision. Although not directly related to Shoreline Master Programs developed under RCW 90.58, the rationale can be considered applicable.

> "After careful consideration of all the arguments, and the entire record, we are no longer convinced that the Act requires the County to mandate that regulation of critical areas provide for all the functions in every watercourse that contains or contributes to watercourses that contain anadromous fish in ongoing commercially significant agricultural lands where some of those functions have been missing for many years and where these functions are not required for a particular life stage of anadromous fish. By reaching the above conclusion, we are not saying that farmers do not need to alter their practices if they are continuing activities which will further degrade the streams. Those activities must stop and practices must be implemented which ensure no additional harm or further loss of function (*Swinomish Indian Tribal Community et al. v. Skagit County; 02-2-0012c).*"

Essential elements for such a program are adequate monitoring, benchmarks, and the ability to require changes to the program if benchmarks are not achieved. In assessing the difference between a prescriptive approach such as buffers and a "no harm" approach, both the hearings board and the court have held that local governments must either be certain that their critical areas regulations will prevent harm, or be prepared to recognize and respond effectively to any unforeseen harm that arises.

Implementation of a "no harm" approach in Bremerton is not likely to be effective in regulating future development. Application to urban development is substantially different than application to agriculture where changes in farming practices may be developed. It would be difficult to meet a "no harm" standard if monitoring of a specific buffer area determined that a functional criterion was not being met. If, for example, a particular buffer dimension was not effective, the presence of physical improvements such as roads or buildings would generally preclude its expansion. In addition, developing performance standards, implementing a monitoring system, and taking action to correct deficiencies would be very resource demanding both for property owners and the City. To be practical, additional areas would likely need to be reserved from development or land alteration to provide the opportunity for future change as well as requiring substantial security deposits for monitoring and reporting and corrective measures.

A "no harm" system also is likely to be much more difficult and expensive to implement, especially the monitoring component, and provides little certainty to applicants of the standards likely to be imposed on their development. It also introduces an element of uncertainty to land owners in the continued use of facilities initially allowed, but subject to adaptive management requirements.

8. FUNCTIONAL ANALYSIS AND OPPORTUNITY AREAS

Watershed-scale processes that have been altered by land-use degrade ecological function in shorelines. This section summarizes the conditions within each shoreline and assesses the potential for restoring ecosystem processes and improving shoreline ecological function.

The City is highly urbanized, with most shoreline parcels in private ownership, and a relatively high level of development on the shoreline, as well as in contributing drainage basins. Combined with degraded ecological function, extensive development (expressed by lack of forest cover, large impervious areas, and armored shorelines) generally limits the potential for the City to implement projects within the City limits to restore processes at the watershed-scale.

Exploring other avenues to enhance ecological function within the shoreline, the City could:

1. Pursue restoration opportunities as properties redevelop along the shoreline – particularly in the Gorst Estuary.
2. Partner with others in WRIA 15 to implement salmon recovery actions that were identified within the City. Opportunities should be sought to restore gently sloping beach area with native vegetation along Puget Sound shorelines for juvenile Chinook salmon, and to remove or modify docks and in water structures to reduce shading and potential effects on juvenile Chinook.
3. The City could also adopt stringent stormwater standards and rules that implement LID to reduce stormwater quality/quantity that routes to rivers and streams and adversely affects shoreline functions.
4. Evaluate how LID and other stormwater management options can address the large number of outfalls along marine shorelines.
5. Initiate a program, with incentives, to encourage removal of derelict structures and pilings (esp. creosote pilings).
6. Establish an incentive program for landowners to replace existing hard armoring with softer or bioengineered alternatives where armoring is necessary, and for removal of armoring and restoring natural beach profiles where armoring is not necessary to protect life or property.
7. Encourage water conservation and the use of native plants in all landscaping applications to reduce water use.
8. Aggressively control invasive plants on all City-owned properties in the shorelines and other areas and work with adjacent property owners to control these species on their properties to reduce spread.
9. Work with shoreline parcel owners along Kitsap Lake and Puget Sound to encourage and provide incentives for native revegetation and/or vegetation management to reduce impervious surfaces and reduce or eliminate the use of fertilizers or pesticides adjacent to the water.
10. Work with Kitsap County to obtain a reduction in property tax for property owners that voluntarily improve their shoreline (not required as mitigation) to improve shoreline functions. There are technical resources available to help property owners make improvements to their shorelines that would improve functions.

11. Launch a database that includes the number/type/location of shoreline restoration actions and degradation actions within the City to determine if shoreline functions are improving over time.

In addition, the City can implement projects outside the City limits either individually or jointly with other government agencies. The City can also implement projects and/or management actions within jurisdictional shoreline focused on enhancing specific functions in areas where the functional benefits will be greatest – these areas could be used as mitigation banks. Generally, restoration actions should be prioritized where multiple processes can be enhanced (to be developed in the restoration plan).

Reach Number	Reach Name	Condition Ranking – Ecological Functions				Notes
		High	**Medium**	**Medium to Low**	**Low**	
1	North Kitsap Lake			X		Dense residential development; armoring; docks; water quality issues (phosphorus); does have bald eagle foraging and nesting habitat
2	South Kitsap Lake	X				Some armoring and residential development; large wetland complex to south provides water quality (nutrient removal, sediment) and water storage/water supply functions
3	Twin Lakes	X				Largely undeveloped; forested watershed provides water supply and water quality functions; small wetland complexes associated with shoreline provide water quality functions
4	Lake Union Reservoir	X				Largely undeveloped; forested watershed provides water supply and water quality functions; small wetland complexes associated with shoreline provide water quality functions
5	Upper Union River	X				Forested watershed provides habitat, water quality and water supply functions; protected watershed; riparian buffers provide habitat and water quality functions
6	Lower Gorst Creek		X			Protected upper watershed with low levels of impervious surface and largely forested – water supply, water quality, and habitat functions. Lower stream segment/floodplain provides

Reach Number	Reach Name	Condition Ranking – Ecological Functions				Notes
		High	Medium	Medium to Low	Low	
						some water storage/flood protection functions, although floodplain filling and hardening impacts function in the lowermost reaches. Lowermost reaches of the stream near the mouth are highly altered with a lack of riparian vegetation, armoring, impervious surfaces, and water quality impairments (DO, fecal). Culverts in lower reaches are passage barriers, including at SR3, Old Belfair Highway, and Navy railroad. Gorst Creek does support fish hatchery for Chinook and Gorst and tributaries
7	Sinclair Inlet – Blackjack Creek		X			Not in City
8	Sinclair Inlet – Gorst Estuary		X			Biological resources include eelgrass, fringing salt marsh, mudflats, surf smelting spawning, shorebird and waterfowl concentrations, shallow nearshore areas that support juvenile salmonids and shellfish concentrations. Impairments include large areas of fill in the estuary mouth, large areas of shoreline armoring and highways in the estuary and adjacent to the shoreline, tidal barriers, lack of riparian vegetation, and water quality/sediment impairments.
9	Sinclair Inlet – Puget Sound Naval Shipyard				X	Highly altered and modified shoreline from presence of the Naval Shipyard – armoring, overwater structures, fill in

Reach Number	Reach Name	Condition Ranking – Ecological Functions				Notes
		High	**Medium**	**Medium to Low**	**Low**	
						nearshore, lack of riparian vegetation, and sediment/water quality impairment.
10	Port Washington Narrows West			X		Biological resources include patchy kelp, some surf smelt spawning, hardshell clam, waterfowl concentrations, and bald eagle nesting and foraging. High intensity residential and commercial development has resulted in impairments to water and sediment processes (shoreline armoring, fill in nearshore, culverts/covered streams include culverts and filling/covering of small streams entering the nearshore. Numerous piers, docks, pilings, and overhanging structures, including the Bremerton Marina, alter light levels and contribute to sediment/water quality issues (old creosote pilings).
11	Phinney Bay	X				Biological resources include eelgrass, marsh, surf smelt spawning, oyster beds, kelp, and shallow mud and sand flats. The contributing drainage basin has relatively low impervious surface and forested land cover due to the low density residential development. Some areas of unarmored high bank shorelines maintain sediment processes. Impairments include numerous outfalls, water quality (DO, fecal coliform, prohibited shellfish growing area). Shoreline armoring is moderately high, but lower than in many other parts of the

Reach Number	Reach Name	Condition Ranking – Ecological Functions				Notes
		High	Medium	Medium to Low	Low	
						City. Few overhanging structures – primarily one moderately large marina.
12	Rocky Point	X				Biological resources include kelp, mixed and salt marsh, oyster beds off Rocky Point (but prohibited shellfish growing area), surf smelt spawning, some areas of intact riparian vegetation, shallow mud and sand flats, waterfowl concentrations, and bald eagle nesting and foraging areas. Contributing drainage areas are mostly forested or low intensity residential with relatively low impervious surface area (<30%). Impairments include moderate shoreline armoring (about 50%), some tidal barriers, numerous small overhanging structures and docks, but a low overall percentage of area with overwater structures.
13	Mud Bay	X				Biological resources include kelp, mixed and salt marsh, some areas of intact riparian vegetation, shallow mud and sand flats, waterfowl concentrations, and bald eagle nesting and foraging areas. Contributing drainage areas are mostly forested or low intensity residential with relatively low impervious surface area (<30%). Impairments include moderate shoreline armoring (about 50%), some tidal barriers, numerous small overhanging structures and docks, but a low overall percentage of area with overwater structures.

Reach Number	**Reach Name**	**Condition Ranking – Ecological Functions**				**Notes**
		High	**Medium**	**Medium to Low**	**Low**	
14	Marine Drive North		X			Biological resources include several areas of mapped surf smelt and sand lance spawning, bald eagle foraging, patchy eelgrass, kelp, and salt marsh. Impairments include high levels of shoreline armoring (>65%), roads adjacent to the shoreline with some impact to riparian vegetation. However, overall impervious surface in the contributing basins and adjacent to the shoreline are moderate to low. Impairment from nearshore fill, overwater structures, and tidal barriers is relatively low.
15	Marine Drive		X			Biological resources include areas of mapped surf smelt spawning, bald eagle foraging, patchy kelp, and salt marsh. Impairments include high levels of shoreline armoring (>65%), lack of riparian vegetation, numerous piers/docks/floats, pilings, boat launches and tidal construction. However, overall impervious surface in the contributing basins and adjacent to the shoreline are moderate to low.
16	Oyster Bay	X				Biological resources include areas of salt marsh, eelgrass, and shallow sand and mud flats. Impairments include significant numbers of tidal barriers, moderately high shoreline armoring, roads along the shoreline, and water quality issues (prohibited shellfish growing area). Impairments from nearshore fill and overwater structures is relatively low.

Reach Number	Reach Name	Condition Ranking – Ecological Functions				Notes
		High	Medium	Medium to Low	Low	
17	Ostrich Bay	X				Biological resources include coho, chum and cutthroat in Ostrich Bay Creek and associated pocket estuary, seal and sea lion haulout area, surf smelt spawning, patchy eelgrass and salt marsh, and bald eagle nesting and foraging. Contributing basins are largely forested with low intensity residential, but with some areas of high intensity residential and commercial. Impairments include some passage barriers in Ostrich Bay Creek, fair to poor riparian vegetation, moderate shoreline armoring, and low amounts of fill, overwater structures, or roads along the shoreline. Water quality impairments are moderate, with fecal coliform, mercury, and DO listings; prohibited shellfish growing area.
18	Erlands Point	X				Biological resources include a small marsh and associated pocket estuary, patchy eelgrass and salt marsh, and bald eagle foraging. Contributing basins are largely mixed forest and grasses with low intensity residential. A large area of shoreline is owned by the Navy (including some park area) with relatively intact riparian vegetation and forested cover. Impervious surface is relatively low. Impairments include fair to poor riparian vegetation in some areas, moderate shoreline armoring, numerous tidal barriers, and numerous small docks,

Reach Number	**Reach Name**	**Condition Ranking – Ecological Functions**				**Notes**
		High	**Medium**	**Medium to Low**	**Low**	
						pilings, boat ramps, and piers.
19	Chico Bay	X				Not in the City
20	Port Washington Narrows East			X		Biological resources include surf smelt spawning, kelp, hardshell clam, waterfowl concentrations, and bald eagle nesting and foraging areas. This reach is important for sediment source and transport, with numerous areas of high bank/eroding bluffs and strong currents. Contributing basins have high levels of impervious surface, and are mostly high intensity residential and commercial. Impairments are significant with heavily armored shorelines (>80%), numerous roads adjacent to the shoreline and a lack of riparian vegetation, some areas of fill in the nearshore, and numerous overhanging structures, piers, docks, and pilings.
21	Point Herron			X		Biological resources include areas of kelp, but also continuous and patchy areas of the non-native Sargassum. No forage fish spawning, eelgrass, or marsh areas occur here, although there is a herring holding area just offshore. Portions of the reach are important in sediment processes (sediment source and transport from high banks/bluffs). These processes have been altered however, by heavy shoreline armoring (>70%), roads adjacent to the shoreline, a lack of riparian vegetation,

Reach Number	Reach Name	Condition Ranking – Ecological Functions				Notes
		High	Medium	Medium to Low	Low	
						overwater structures, and fill in the nearshore. Contributing basins have high levels of impervious surface, and are mostly high intensity residential and commercial development.
22	Port Orchard Bay	X				Biological resources include Dee Enetai Creek with a small pocket estuary, which supports chum, coho, and cutthroat in the lower reaches. The lower reaches are in a steep ravine with relatively good riparian buffer and in-stream habitat conditions. The nearshore reach is important in sediment supply and transport. Much of the shoreline has relatively intact riparian vegetation, some unarmored bluffs, patchy kelp, some surf smelt spawning, and bald eagle nesting and foraging. Contributing basins are low intensity to high intensity residential, with large areas of intact forest cover; areas with intact riparian vegetation, and relatively moderate amounts of impervious surfaces. Impairments include moderate shoreline armoring, culverts and passage barriers in Enetai Creek, and roads adjacent to the shoreline. There are relatively few overwater structures or pilings in this reach. , shoreline armoring and overwater structures.

9. REFERENCES

Abbe, T. B. and D. R. Montgomery. 1996. Large woody debris jams, channel hydraulics, and habitat formation in large rivers. Regulated Rivers Research and Management 12: 201-221.

Adamus, P.R. 2005. Rapid Assessment Method for Tidal Wetlands of the Oregon Coast: Volume 1 of a Hydrogeomorphic (HGM) Guidebook. Operational Draft. Coos Watershed Association, US Environmental Protection Agency, and Oregon Department of State Lands, Salem.

Adamus, P.R. 2005. Science Review and Data Analysis for Tidal Wetlands of the Oregon Coast: Part 2 of a Hydrogeomorphic (HGM) Guidebook. Report to Coos Watershed Association, US Environmental Protection Agency, and Oregon Department of State Lands, Salem.

Addy, K.L., A.J. Gold, P.M. Groffman, and P.A. Jacinthe. 1999. Ground water nitrate removal in subsoil of forested and mowed riparian buffer zones. Journal of Environmental Quality, v. 28, n. 3, p. 962-970.

Alberti, M. and M. Bidwell. 2005. Assessing the impacts of urbanization on shellfish growing areas of Puget Sound. Final Report. Urban Ecology Research Lab, University of Washington. Prepared for the Puget Sound Action Team and the U.S. Environmental Protection Agency.

Anchor QEA. 2009. Geospatial methodology used in the PSNERP comprehensive change analysis of Puget Sound. Puget Sound Nearshore Ecosystem Restoration Project. Prepared for the U.S. Army Corps of Engineers, Seattle District and the Washington Department of Fish and Wildlife. May 2009.

Albertson, S.L., K. Erickson, J.A. Newton, G. Pelletier, R.A. Reynolds, and M.L. Roberts, 2002. South Puget Sound Water Quality Study, Phase 1. Washington State Department of Ecology Publication No. 02-03-021. www.ecy.wa.gov/biblio/0203021.html.

Atwater, T.M. 1989. Plate tectonic history of the northeast Pacific and western North America. Pp. 21-72 in The geology of North America v. N; The northeastern Pacific Ocean and Hawaii, E.L. Winterer, D.M. Hussong, and R.W. Decker (eds.). Boulder, CO: Geological Society of America.

Bauer, H.H. and M.C. Mastin. 1997. Water-Resources Investigations Report Number 96-4219: Recharge from precipitation in three small glacial-till-mantled catchments in the Puget Sound Lowland, Washington.

Beamer, E., Mcbride, A., Greene, C., Henderson, R., Hood, G., Wolf, K., Larsen, K., Rice, C., and Fresh, K. 2005. Delta and Nearshore Restoration for the Recovery of Wild Skagit River Chinook Salmon: Linking Estuary Restoration to Wild Chinook Salmon Populations. Skagit River System Cooperative, LaConner, Washington.

Beamer, E., Mcbride, A., Henderson, R., and Wolf, K. 2003. The Importance of Non-Natal Pocket Estuaries in Skagit Bay to Wild Chinook Salmon: An Emerging Priority for Restoration. Skagit System Cooperative Research Department, La Conner.

Beamer, E.M., Mcbride, A., Henderson, R., Griffith, J., Fresh, K.L., Zackey, T., Barsh, R., Wyllie- Echeverria, T., and Wolf, K.. 2006. Habitat and Fish Use of Pocket Estuaries in the Whidbey Basin and North Skagit County Bays, 2004 and 2005. Skagit River System Cooperative, LaConner, Washington.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski, and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: Past, present, and future. Pp. 143-190 in: Streamside management: forestry and fishery interactions. E. O. Salo and T. W. Cundy (eds.), Seattle, WA: University of Washington, Institute of Forest Resources, Contribution No. 57.

Booth, D.B. 1994. Glaciofluvial infilling and scour of the Puget Lowland, Washington, during ice-sheet glaciation: Geology, v. 22, n. 8, p. 695-698.

Booth, D. B., D. H. Harley, and R. B. Jackson. 2002. Forest cover, impervious surface area, and stormwater impacts. Journal of American Water Resources, 38(3): 835-947.

Borde, Amy B., Judd, C., Sather, N. K., and Thom, R. M. 2009. East Kitsap County Nearshore Habitat Assessment and Restoration Prioritization Framework. Prepare for Kitsap County. Battelle marine Sciences Laboratory, Sequim, Washington. Marh 2009.

Bottom, D.L., Simenstad, C.A., Burke, J., Baptista, A.M., Jay, D.A., Jones, K.K., Casillas, E., and Schiewe, M.H. 2005. Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS NWFSC-68, 246p.

Brennan, J.S. 2007. Marine Riparian Vegetation Communities of Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-02. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Brennan, J.S. and H. Culverwell. 2004. Marine Riparian: An Assessment of Riparian Functions in Marine Ecosystems. Published by Washington Sea Grant Program. Copyright 2005, UW Board of Regents. Seattle, Washington.

Brennan, J. S., H. Culverwell, R. Gregg, and P. Granger. 2009. Protection of marine riparian functions in Puget Sound, Washington. Prepared for Washington Department of Fish and Wildlife (WDFW Agreement 08-1185). Washington Sea Grant, Seattle, WA.

Buchanan, J.B. 2006. Nearshore Birds in Puget Sound. Puget Sound Nearshore Partnership Report number 2006-05. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Canning, Douglas J. and Hugh Shipman. 1995. *Coastal erosion management studies in Puget Sound, Washington: Executive summary. Coastal Erosion Management Studies, Volume 1.* Washington Department of Ecology, Olympia.

Cederholm, C.J., D.H. Johnson, R.E. Bilby, L.G. Dominguez, A.M. Garrett, W. H. Graeber, E.L. Greda, M. D. Kunze, B. G. Marcot, J. F. Palmisano, R. W. Plotnikoff, W. G. Pearcy, C. A. Simenstad, and P. C. Trotter. 2000. Pacific Salmon and Wildlife: Ecological contexts, relationships, and implications for management. Pages 628-685, *In* D. H. Johnson and T. A. O'Neil (eds), *Wildlife-Habitat Relationships in Oregon and Washington*, Oregon State University Press, Corvallis, Oregon.

Clancy, M., I. Logan, J. Lowe, J. Johannessen, A. MacLennan, F.B. Van Cleve, J. Dillon, B. Lyons, R. Carman, P. Cereghino, B. Barnard, C. Tanner, D. Myers, R. Clark, J. White, C. A. Simenstad, M. Gilmer, and N. Chin. 2009. Management Measures for Protecting the Puget Sound Nearshore. Puget Sound Nearshore Ecosystem Restoration Project Report No. 2009-01. Published by Washington Department of Fish and Wildlife, Olympia, Washington.

Collins, B.D., D.R. Montgomery, and A.J. Sheikh. 2003. Reconstructing the historical riverine landscape of the Puget Lowland. Pp. 79 – 128 in Restoration of Puget Sound Rivers, D.R. Montgomery, S.M. Bolton, D.B. Booth, and L. Wall (eds.), Seattle, WA: University of Washington Press.

Collins, B.D. and D.R. Montgomery. 2002. Forest Development, Wood Jams, and Restoration of Floodplain Rivers in the Puget Lowland, Washington. Restoration Ecology, v. 10, n. 2, p. 237 247.

Collins, B.D. and A.J. Sheikh. 2005. Historic reconstruction, classification, and change analysis of Puget Sound tidal marshes. Project Completion Report to Washington Department of Natural Resources, Aquatic Resources Division, Olympia, Washington. Available: http://riverhistory.ess.washington.edu/research/tidal_marshes.php; Puget Sound T-Sheets. Undated. Available: http://riverhistory.ess.washington.edu/tsheets/framedex.htm

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated buffers in the Coastal Zone: a summary review and bibliography. Coastal Resources Center, Rhode Island Sea Grant, University of Rhode Island. ISBN 0-938 412-37-x. 71 pp.

Dethier, M.N. 1990. *A marine and estuarine habitat classification system for Washington State*. Washington Natural Heritage Program, Department of natural Resources. 56 pp. Olympia, Washington.

Dethier, M.N. 2006. Native Shellfish in Nearshore Ecosystems of Puget Sound. Puget Sound Nearshore Partnership Report No. 2006-04. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Diefenderfer HL, KL Sobocinski, RM Thom, CW May, SS Southard, AB Borde, C Judd, J Vavrinec, III, and NK Sather. 2006. *Multi-Scale Restoration Prioritization for Local and Regional Shoreline Master Programs: A Case Study from Jefferson County, Washington*. PNWD-3762, Battelle, Pacific Northwest Division, Richland, Washington.

Diefenderfer, H.L., R.M. Thom, and K.D. Hofseth. 2005. A framework for risk analysis in ecological restoration projects. *In* R.J.F. Bruins, and M.T. Heberling. Eds, *Economics and Ecological Risk Assessment: Applications to Watershed Management*. CRC Press, Boca Raton, Florida.

Diefenderfer, HL, KL Sobocinski, RM Thom, CW May, AB Borde, SS Southard, J Vavrinec, NK Sather. In Press. Multi-Scale Analysis of Restoration Priorities for Marine Shoreline Planning. *Environmental Management.*

Downing, J. 1983. *The Coast of Puget Sound: Its Processes and Development*, University of Washington,Washington Sea Grant Publication, 126p.

Easterbrook, D. 1986. Stratigraphy and chronology of quaternary deposits of the Puget Lowland and Olympic Mountains of Washington and the Cascade Mountains of Washington and Oregon. Quaternary Science Reviews, pp. 145-159.

Ecology (Washington State Department of Ecology). 2002. Seasonal Patterns and Controlling Factors of Primary Production in Puget Sound's Central Basin and Possession Sound. Available: http://www.ecy.wa.gov/biblio/wria10.html.

Ecology (Washington State Department of Ecology). 2009. Water Quality Assessment for Washington: 2007/2008 Candidate List. Available: http://www.ecy.wa.gov/Programs/wq/303d/2008-index.html

Ecology (Washington State Department of Ecology). 2009. 2008 Water Quality Assessment (Final) – Category 5 Listings for WRIA 15. Available: http://www.ecy.wa.gov/programs/wq/303d/2008_documents/wria_pdfs-5final/kk-active-5-wria15.pdf

Ecology (Washington State Department of Ecology). Digital Coastal Atlas. Shorelands and Environmental Assistance Program. Available:

http://apps.ecy.wa.gov/website/coastal_atlas/viewer.htm.

EnviroVision, Herrera Environmental, and Aquatic Habitat Guidelines Working Group. 2007. Protecting Nearshore Habitat and Functions in Puget Sound: an interim guide. Prepared for WDFW, WDNR, Ecology, WSDOT, CTED, RCO, and the PSP. October 2007.

Evans NR, RM Thom, GD Williams, J Vavrinec, III, KL Sobocinski, LM Miller, AB Borde, VI Cullinan, JA Ward, CW May, and C Allen. 2006. Lower Columbia River Restoration Prioritization Framework. PNWD-3652, Battelle, Pacific Northwest Division, Richland, Washington.

Finlayson, D. 2006. The geomorphology of Puget Sound beaches. Puget Sound Nearshore Partnership Technical Report 2006-02.

Forman, R.T.T and M. Godron. 1986. *Landscape ecology*. John Wiley and Sons.

Franklin, J. F. and C. T. Dyrness. 1988. Natural vegetation of Oregon and Washington. Corvallis, OR: Oregon State University Press.

Fresh, K., C. Simenstad, J. Brennan, M. Dethier, G. Gelfenbaum, F. Goetz, M. Logsdon, D. Myers, T. Mumford, J. Newton, H. Shipman, and C. Tanner. 2004. Guidance for protection and restoration of the nearshore ecosystems of Puget Sound. Puget Sound Nearshore Partnership Report No. 2004-02. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington. Available at http://pugetsoundnearshore.org.

Fresh, K.L. 2006. Juvenile Pacific Salmon in Puget Sound. Puget Sound Nearshore Partnership Report No. 2006-06. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Fresh, K.L., Small, D.J., Kim, H., Waldbillig, C., Mizell, M., Carr, M.I., and Stamatiou, L. 2006. Juvenile Salmon Use of Sinclair Inlet, Washington, in 2001 and 2002. Washington Department of Fish and Wildlife, Olympia, Washington.

Gersib, R. A., B. Aberle, L. Driscoll, J. Franklin, B. Haddaway, T., Hilliard, K. Lautz, J. Neugebauer-Rex, J. Park, A. Perez, R. Schanz, L. Van Natta, A. Wald, and B. Wood. 2004. Enhancing Transportation Project Delivery Through Watershed Characterization. Washington Department of Transportation, Olympia, WA.

Gerstel, W.J. and J.F. Brown. 2006. Alternative Shoreline Stabilization Evaluation Project Final Report. Prepared for Puget Sound Action Team. Available: http://www.psat.wa.gov/Programs/shorelines/FinalPSAT9_15_06withphotos.pdf

Gerstel, W.J. et al. 1997. Puget Sound Bluffs: The Where, Why, and When of Landslides Following the Holiday 1996/97 Storms. Washington Geology, v. 25, n. 1.

Greenway, D. R. 1987. Vegetation and Slope Stability. In Slope Stability, M. F. Anderson and K. S. Richards (eds.), New York, NY: Wiley and Sons.

Gregory, S.V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An ecosystem perspective of riparian zones. BioScience, v. 41, p. 540-551.

Griggs, G. B. 2005. The impacts of coastal armoring. Shore and Beach, v. 73, n. 1, p. 13- 22

Groffman, P. M., A. J. Gold, and R. C. Simmons. 1992. Nitrate dynamics in riparian forests: micro-ecosystems and their relationships to multi-use natural resource management. Pp. 80-92 in: Strategies for protection and management of floodplain wetlands and other riparian ecosystems. Proceedings of the Symposium, Dec. 11-13, 1978, Callaway Gardens, GA. Washington, D.C.: USDA and USFS.

Gustafson, R.G., W.H. Lenarz, B.B. McCain, C.C. Schmitt, W.S. Grant, T.L. Builder, nd R.D. Methot. 2000. Status Review of Pacific Hake, Pacific Cod, and Walley Pllock from Puget Sound, Wahington. U.S. Dept. Commerce, NOAA Tech. Mmo. NMFS-NWFSC-44, 275 p.

Hampton, M., G. Griggs, T. Edil, D. Guy, J. Kelly, P. Komar, D. Mickleson, and H. Shipman. 2004. P. 7-38 in Processes that Govern the Formation and Evolution of Coastal Cliffs: Formation, Evolution, and Stability of Coastal Cliffs—Status and Trends, Hampton, M.A. and Griggs, G.B. (eds.), USGS Professional Paper 1693.

Haring, 2000. Salmonid Habitat Limiting Factors. Water Resource Inventory Area 15 (East) Final Report. Washington State Conservation Commission.

Healey, M.C. 1982. Juvenile Pacific Salmon in Estuaries: The Life Support System. In: Estuarine Comparisons. Edited by V.S. Kennedy. Academic Press, New York. pp. 315-341.

Higgins, K, P Schlenger, J Small, D Hennessy, and J Hall. 2005. Spatial relationships between beneficial and detrimental nearshore habitat parameters in WRIA 9 and the City of Seattle. *Proceedings of the 2005 Puget Sound Georgia Basin Research Conference, Seattle, Washington*.

Johannessen, J. and A. MacLennan. 2007. Beaches and Bluffs of Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-04. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Johannessen, J. and A. MacLennan. 2007. Eastern Kitsap County Net Shore-drift Revisions. Coastal Geological Services, Inc. (CGS), Bellingham, Washington.

Judd, C. 2009. West Kitsap Addendum to the East Kitsap County Nearshore Habitat Assessment and Restoration Prioritization Framework. Battelle Marine Sciences Laboratory, Sequim Washington. Prepared for Kitsap County Department of Community Development. PNWD-4053-ADD. November 2009.

Judd C, DL Woodruff, RM Thom, MG Anderson, and AB Borde. 2007. Restoration Prioritization Toolset: Documentation and User’s Guide. PNNL-17054, Pacific Northwest National Laboratory, Richland, Washington.

Kitsap County, Department of Community Development. 2004. A Summary of Best Available Science Review: Kitsap County Critical Areas.

Kitsap County, Department of Emergency Management. 2008. Kitsap County Hazard Identification and Vulnerability Assessment. Revision October, 2008.

Kitsap County Health District. 2008. Sinclair Inlet Watershed: 2008 Water quality monitoring report.

Kuttell, M. 2003. Salmonid Habitat Limiting Factors: Water Resource Inventory Areas 15 (West), Kitsap Basin, and 14 (North), Kennedy-Goldsborough Basin. Washington State Conservation Commission. Olympia, WA.

Macdonald, Keith, David Simpson, Bradley Paulson, Jack Cox, and Jane Gendron. 1994. *Shoreline armoring effects on physical coastal processes in Puget Sound, Washington. Coastal Erosion Management Studies, Volume 5*. Washington Department of Ecology, Olympia.

Maser, C., R. F. Tarrant, J. M. Trappe, and J. F. Franklin (eds.). 1988. From the forest to the sea: a story of fallen trees. General Technical Report PNW-GTR-229. Portland, OR: USDA Forest Service. 153 pp.

Mason, C. 2000. Bibliography and index of the Geology of Kitsap County, Washington. Washington Department of Natural Resources, Division of Geology and Earth Resources. Olympia, Washington.

May, C., R. R. Horner, J. R. Karr, B. W. Mar, E. B. Welch. 1998. Effects of urbanization on small streams in the Puget Sound ecoregion. Watershed Protection Techniques. 2(4): 483-494.

May, C.W. and G. Peterson. 2003. Kitsap Salmonid Refugia Report: Landscape assessment and conservation prioritization of freshwater and nearshore salmonid habitat in Kitsap County. Prepared for Kitsap County, Washington. 247 pp.

Mofjeld, H.O., A.J. Venturato, V.V. Titov, F.I. Gonzalez and J.C. Newman. 2002. Tidal Datum Distributions in Puget Sound, Washington, Based on a Tidal Model. NOAA, Pacific Marine Environmental Laboratory, Seattle. 35 p.

Montgomery, D. R., S. Bolton, D. B. Booth, and L. Wall. 2003a. Restoration of Puget Sound Rivers. University of Washington Press, Seattle, WA.

Montgomery, D. R., D. B. Booth, and S. Bolton. 2003b. Puget Sound Rivers and Salmon Recovery. In, Montgomery et al. (eds), Restoration of Puget Sound Rivers, pages 1 – 13. University of Washington Press, Seattle, WA.

Morlan, JC. 1991. Ecological Status and Dynamics of a Salt Marsh Restoration in the Salmon River Estuary, Oregon. Masters thesis, Oregon State University, Corvallis, Oregon.

Mumford, T.F. 2007. Kelp and Eelgrass in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-05. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Naiman, R. J., R. E. Bilby, and P. A. Bisson. 2000. Riparian ecology and management in the Pacific coastal rain forest. BioScience, v. 50, p. 996-1011. National Research Council (NRC). 2002. Riparian Areas: Functions and Strategies for Management. Committee on Riparian Zone Functioning and Strategies for Management, Water Science and Technology Board, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council. National Academy Press, Washington D.C., 428 pp.

NMFS 2009 (National Marine Fisheries Service) 2009 Endangered Species Act Section 7 Consultation, Biological Opinion, Environmental Protection Agency Registration of Pesticides Containing Carbaryl, Carbofuran, and Methomyl, National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, Washington 98112. April 20, 2009 http://www.nmfs.noaa.gov/pr/pdfs/carbamate.pdf

National Research Council (NRC). 1992. Restoration of Aquatic Ecosystems. National Academy Press, Washington, D.C.

Nightingale, B. and C. Simenstad. 2001. Overwater structures: marine issues. Prepared for: Washington Department of Fish and Wildlife, Washington Department of Ecology, Washington Department of Transportation. May 9, 2001.

O'Toole, M. 1995. Puget Sound Herring: A Review. Pp. 849-854 in Proceedings of Puget Sound Research. Puget Sound Water Quality Authority, Seattle, Washington.

Palsson, Wayne A, Tien-Shui Tsou, Greg G. Bargmann, Raymond M. Buckley, Jim E. West, Mary Lou Mills, Yuk Wing Cheng, and Robert E. Pacunski. 2009 The Biology and Assessment of Rockfishes in Puget Sound. Washington Department of Fish and Wildlife, Publication Number: FPT 09-04 September 2009 Available at http://wdfw.wa.gov/publications/pub.php?id=00926

Pentilla, D. E. 2001. Effects of shading from upland vegetation on egg survival for summer-spawning surf smelt on upper intertidal beaches in Puget Sound. Proceedings of the Puget Sound Georgia Basin Research Conference, February 12-14, 2001. Puget Sound Action Team, Bellevue, WA.

Penttila, D. 2007. Marine Forage Fishes in Puget Sound. Puget Sound Nearshore Partnership Report No. 2007-03. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Poff, N. LeRoy; J. David Allan; Mark B. Bain; James R. Karr; Karen L. Prestegaard; Brian D. Richter. 1996. The natural flow regime: a paradigm for river conservation and restoration. Bioscience Vol. 47, No. 11, pp. 769-784.

Richter; Richard E. Sparks; Julie C. Stromberg PSP (Puget Sound Partnership). 2008. Action Agenda for Puget Sound Recovery. Available at: http://www.psp.wa.gov/aa_action_agenda.php

Puget Sound Naval Shipyard & Intermediate Maintenance Facility Project ENVVEST. 2004. Fecal Coliform Model Verification Sampling Plan Winter 2004, Addendum To The Fecal Coliform Total Maximum Daily Load Study Plan For Sinclair And Dyes Inlets.

Puget Sound Naval Shipyard Project ENVVEST Regulatory Working Group. 2002. Fecal Coliform Total Maximum Daily Load Study Plan For Sinclair And Dyes Inlets.

Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks. 1999. Terrestrial ecoregions of North America – a conservation assessment. Island Press, Washington, DC.

Roni, P., T. J. Beechie, R. E. Bilby, F. E. Leonetti, M. M. Pollock, and G. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. North American Journal of Fisheries Management 22:1-20.

Ruckelshaus, M. H and M. M. McClure. 2007. Sound Science: Synthesizing ecological and

socioeconomic information about the Puget Sound ecosystem. 2007. Prepared in cooperation with the Sound Science collaborative team. U.S. Dept. of Commerce, National Oceanic & Atmospheric Administration (NMFS), Northwest Fisheries Science Center. Seattle, Washington.

Schlenger, P., A. MacLennan, E. Iverson, K. Fresh, C. Tanner, B. Lyons, S. Todd, R. Carman, D. Myers, S. Campbell, and A. Wick. 2010. Strategic Needs Assessment Report. Prepared for the Puget Sound Nearshore Ecosystem Restoration Project. Technical Report 2010.

Schwartz ML, BD Harp, BE Taggart, and M Chrzastowski. 1991. Net shore drift in Washington State: Volume 3, Central Puget Sound region. Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia, Washington.

Schneider, L. 2003. Quality Assurance Project: 2003 Beach Pilot Project. Department of Ecology, 03-03-202.

Shreffler, D.K. and R.M. Thom. 1993. Restoration of Urban Estuaries: New Approaches for Site Location and Design. Prepared for Washington State Department of Natural Resources. Battelle Pacific Northwest Laboratories; 1993107.

Shipman, H. 2004. Coastal bluffs and sea cliffs on Puget Sound, Washington. Pages 81-94 *in* M.A. Hampton and G.B. Griggs (eds.), Formation, Evolution, and Stability of Coastal Cliffs – Status and Trends. Professional Paper 1693. U.S. Geological Survey.

Shipman, H. 2008. A Geomorphic Classification of Puget Sound Nearshore Landforms. Puget Sound Nearshore Partnership Report No. 2008-01. Published by Seattle District, US Army Corps of Engineers, Seattle, Washington. Available online at http://pugetsoundnearshore.org

Simenstad, C.A. and J.R. Cordell. 2000. Ecological assessment criteria for restoring anadromous salmonid habitat in Pacific Northwest estuaries. Ecological Engineering 15:283-302.

Simenstad, C.A. and R.M. Thom. 1992. Restoring wetland habitats in urbanized Pacific Northwest estuaries. In: Restoring the Nation's Environment. G. Thayer, editor. College Park, Maryland: Maryland Sea Grant, pp. 423-472.

Simenstad, C, D Reed, and M Ford. 2006 When is restoration not?: Incorporating landscape-scale processes to restore self-sustaining ecosystems in coastal wetland restoration. Ecological Engineering 26(1): 27-39.

Simenstad, C. A., W. G. Hood, R. M. Thom, D. A. Levy, and D. L. Bottom. 2000. Landscape structure and scale constraints on restoring estuarine wetlands for Pacific Coast juvenile fishes. Pages 597-632, *In* M. P. Weinstein and D. A. Kreeger (eds), *Concepts and Controversies in Tidal Marsh Ecology*. Kluwer Academic Publishers, Dordrecht, The Netherlands.

Simenstad, C, M Logsdon, K. Fresh, H. Shipman, M. Dethier, and J. Newton. 2006. Conceptual Model for Assessing Restoration of Puget Sound Nearshore Ecosystems. Puget Sound Nearshore Partnership Report No. 2006-03. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington. Available online at http://pugetsoundnearshore.org

Simenstad, C., M. Ramirez, J. Burke, M. Logsdon, H. Shipman, C. Tanner, C. Davis, J. Fung, P. Bloch, K. Fresh, S. Campbell, D. Myers, E. Iverson, A. Bailey, P. Schlenger, C. Kiblinger, P. Myre, W. I. Gertsel, and A. MacLennan. 2009. Historic Change and Impairment of Puget Sound Shorelines: Atlas and Interpretation of Puget Sound Nearshore Ecosystem Restoration Project Change Analysis.

Spalding, M. D., H. E. Fox, G. R. Allen, N. Davidson, Z. A. Ferdaña, M. Finlayson,

B. S. Halpern, M. A. Jorge, A Lombana, S. A. Lourie, K. D. Martin, E. Mcmanus, J. Molnar, C. A. Recchia, and J. Robertson . 2007. Marine ecoregions of the world: a bioregionalization of coastal and shelf areas. Bioscience 57(7): 373 – 583.

Stanley, S., J. Brown, and S. Grigsby. 2005. Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes. Washington State Department of Ecology. Publication #05-06-027. Olympia, WA.

Taggart BE. 1984. Net shore-drift of Kitsap County, Washington. M.S. Thesis. Western Washington University. Bellingham, Washington.

Tanner, CD, JR Cordell, J Rubey and L Tear. 2002. Restoration of freshwater intertidal habitat functions at Spencer Island, Everett, Washington. Restoration Ecology 10:564–576.

Thom RM, GD Williams, and HL Diefenderfer. 2005. Balancing the need to develop coastal areas with the desire for an ecologically functioning coastal environment: Is net ecosystem improvement possible? Restoration Ecology 13(1):193-203.

Thom, RM, R Ziegler and AB Borde. 2002. Floristic development patterns in a restored Elk River estuarine marsh, Grays Harbor, Washington. Restoration Ecology 10:487–496.

Thom, RM, Vavrinec, J, III, HL Diefenderfer, and AB Borde. In Review. Restoring resiliency: Case studies from Pacific Northwest estuarine eelgrass (Zostera marina L.) dominated systems. Ecological Restoration.

Todd, S., N. Fitzpatrik, O. Odum, M. Koschak, A. McBride. 2008. SSHIAP Mapping of Puget Sound Shoreline Geomorphology: Applications and Next Steps. Presented at NWIFC Tribal Habitat Conference, May 22 2008. Available online www.habitatconference.org/2008/download.php?f=10dgeomorphic_ mapping.pps

USDA 1986 US Department of Agriculture Soil Conservation Service (SCS)TR-55: Urban Hydrology for Small Watersheds Technical Release No. 55 , (210-VI-TR-55, Second Ed., June 1986).

Washington Department of Fish and Wildlife. 2009. Land use planners guide to salmon habitat protection & recovery http://wdfw.wa.gov/habitat/plannersguide/index.html

Washington Department of Health. 2009. Early warning system summary for growing areas in Kitsap County. Available at: http://www.doh.wa.gov/ehp/sf/Pubs/gareports/kitsap-ews.pdf

Washington State Department of Health. 2009. Office of shellfish protection: annual growing area review – Dyes Inlet, Port Madison, Port Orchard Passage. Available at: http://www.doh.wa.gov/ehp/sf/Pubs/gareports/dyes.pdf

WDFW. Washington Department of Fish and Wildlife. 2000. Forage Fish. Available at: http://www.wa.gov/wdfw/fish/forage/forage/htm

WDNR (Washington State Department of Natural Resources). 2001. *Washington State ShoreZone Inventory*. Nearshore Habitat Program, Washington Department of Natural Resources, Olympia, Washington.

Williams, G.D., and R.M. Thom. 2001. Development of Guidelines for Aquatic Habitat Protection and Restoration: Marine and Estuarine Shoreline Modification Issues. PNWD-3087. Prepared for the Washington State Department of Transportation, Washington Department of Fish and Wildlife, and the Washington Department of Ecology, by Battelle Marine Sciences Laboratory, Sequim, Washington.

Williams, G.D., Evans NR, and RM Thom 2004. *Bainbridge Island Nearshore Habitat Assessment Management Strategy Prioritization, and Monitoring Recommendations*. PNWD-3391. Prepared for the City of Bainbridge Island, Bainbridge Island, Washington, by Battelle Marine Sciences Laboratory, Sequim, Washington. Available online at: http://www.ci.bainbridge-isl.wa.us/nearshore_report.aspx

Williams, G.D., R.M. Thom, M.C. Miller, D.L. Woodruff, N.R. Evans, P.N. Best. 2003. *Bainbridge Island Nearshore Assessment: Summary of the Best Available Science*. PNWD-3233. Prepared for the City of Bainbridge Island, Bainbridge Island, Washington, by Battelle Marine Sciences Laboratory, Sequim, Washington. Available online at: http://kitsap.wsu.edu/shore_stewards/bas/index.htm

Williams, G. D., R. M. Thom, J. E. Starkes, J. S. Brennan, J. P. Houghton, D. Woodruff, P. L. Striplin, M. Miller, M. Pedersen, A. Skillman, R. Kropp, A. Borde, C. Freeland, K. McArthur, V. Fagerness, S. Blanton, and L. Blackmore. 2001. *Reconnaissance Assessment of the State of the Nearshore Ecosystem: Eastern Shore of Central Puget Sound, Including Vashon and Maury Islands (WRIAs 8 and 9)*. Ed., J. S. Brennan. PNNL-14055. Report prepared for King County Department of Natural Resources, Seattle, Washington. 353 pp. http://dnr.metrokc.gov/wlr/watersheds/puget/nearshore/sonr.htm.

Websites

Public Access

Trust for Public Land. Public Access Regional Maps. http://www.tpl.org/tier3_cd.cfm?content_item_id=19981&folder_id=262

Washington Department of Ecology BEACH Program. Public Access Information. http://www.ecy.wa.gov/programs/eap/beach/

Washington State Parks. 2006. Washington State Accessible Outdoor Recreation Guide North Puget Sound Region. Available: http://www.parks.wa.gov/adarec/detail.asp?region=NPS#12.

Cultural/Historical Resources

Washington Department of Archeology and Historic Preservation (WDAHP). 2009a. Archeological and historic resources database. Available at WDAHP offices, Olympia, Washington.

Washington Department of Archaeology and Historic Preservation. 2009b. The Washington Information System for Architectural and Archaeological Records Data (WISAARD). Available: http://www.oahp.wa.gov/pages/wisaardIntro.htm

Washington Office of Financial Management. 2009. Historical Data. Available: http://www.ofm.wa.gov/pop/

Shoreline Management Act

Geoengineers. 2005. Examples of Regulator Language for Nearshore and Marine Shoreline Protection, Prepared for the Puget Sound Action Team By GeoEngineers January 2005. http://www.mrsc.org/govdocs/PugetSoundRegEx05.pdf

Washington State Department of Ecology. 2009. SMP Guidelines, Available at: http://www.ecy.wa.gov/programs/sea/sma/laws_rules/173-26/SMP_Guidelines_Final.pdf

Washington State Departmetn of Ecology. 2009. SMP Handbook, Available at: http://www.ecy.wa.gov/programs/sea/shorelines/smp/handbook/index.html

Geospatial Databases

PSNERP Change Analysis http://www.nws.usace.army.mil/PublicMenu/Menu.cfm?sitename=PSNERP&pagename=Change_Analysis

East Kitsap County Nearshore Habitat Assessment: maps and data http://www.kitsapgov.com/dcd/nr/nearshore/nearshore2.htm; individual features maps http://www.kitsapgov.com/dcd/nr/nearshore/nearshore3.htm; main page http://www.kitsapgov.com/dcd/nr/nearshore/nearshore4.htm; data (shp) http://www.kitsapgov.com/dcd/nr/nearshore/nearshore1.htm

Ecology Digital Coastal Atlas http://www.ecy.wa.gov/programs/sea/SMA/atlas_home.html

Ecology Geospatial Data http://www.ecy.wa.gov/services/gis/data/data.htm

Ecology Sediment Management, http://www.ecy.wa.gov/programs/tcp/smu/sediment.html

Ecology, Oblique Aerial Shoreline Photographs, 2005-1006

Ecology – Puget Sound Landslides http://www.ecy.wa.gov/programs/sea/femaweb/kitsap.htm

WDNR http://fortress.wa.gov/dnr/app1/dataweb/dmmatrix.html (ShoreZone Inventory, WDNR Hydrography Data, WDNR Geology Data)

SSHIAP (Salmon Steelhead Habitat Assessment Program)

USGS Hydrology/Hydrography; Geology http://www.dnr.wa.gov/ResearchScience/Topics/GeosciencesData/Pages/gis_data.aspx

WA Department of Health http://ww4.doh.wa.gov/gis/gisdata.htm

UWA http://wagda.lib.washington.edu/data/geography/wa_state/#lclu

USFWS Washington State Geospatial Data http://www.fws.gov/data/statdata/wadata.html

FEMA national flood hazards maps http://www.fws.gov/data/statdata/wadata.html

Washington Seismic Hazards http://www.dnr.wa.gov/ResearchScience/Topics/GeosciencesData/Pages/geology_portal.aspx

WA Natural Resources Information Portal http://www.swim.wa.gov/

Streamnet http://www.streamnet.org/

Seattle earthquake hazard maps http://earthquake.usgs.gov/regional/pacnw/hazmap/seattle/

Pacific Northwest Seismic Network http://www.pnsn.org/

Geology - DNR http://www.dnr.wa.gov/AboutDNR/Divisions/GER/Pages/home.aspx

USGS earthquake hazard http://earthquake.usgs.gov/hazards/qfaults/google.php

Kitsap County GIS http://www.kitsapgov.com/dcd/gis/Maps_Data/main.htm; http://www.kitsapgov.com/dcd/gis/Maps_Data/Data_downloads/sidmap.htm; http://www.kitsapgov.com/dcd/gis/Maps_Data/Data_downloads/topomap.htm

West Sound Watersheds Council http://www.westsoundwatersheds.org/

NRCS, Kitsap Soil Survey, http://datagateway.nrcs.usda.gov/NextPage.aspx?Progress=1&AValue=1&QuickCounty=Kitsap&QuickState=Washington&ExtentMinX=-125.808265306122&ExtentMinY=42.0618571428571&ExtentMaxX=-111.881734693878&ExtentMaxY=51.8104285714285&HitTab=2

NRCS Geospatial Data Gateway http://datagateway.nrcs.usda.gov/GatewayHome.html

Kitsap kml formats http://www.kitsapgov.com/dcd/gis/maps_data/kml/main.htm

Seismic site class definitions http://www.conservationtech.com/FEMA-WEB/FEMA-subweb-EQ/02-02-EARTHQUAKE/1-BUILDINGS/D2-Geological-screen.htm

Land Cover - NOAA coastal change analysis program http://www.csc.noaa.gov/digitalcoast/data/ccapregional/

http://www.csc.noaa.gov/crs/lca/pacificcoast.html

Land Cover – USGS Land Cover Institute http://landcover.usgs.gov/usgslandcover.php

Priority Habitat & Species documentation & data layers http://wdfw.wa.gov/hab/phspage.htm

Aquatic habitat guidelines http://wdfw.wa.gov/hab/ahg/index.htm

WDFW data http://wdfw.wa.gov/hab/release.htm (in particular, forage fish spawning habitat data is important for Bremerton shorelines

Shellfish and Public Access; WA Dept. of Fish and Wildlife: http://www.wdfw.wa.gov/fishing/

National register historic places, WA:

http://www.nationalregisterofhistoricplaces.com/WA/Kitsap/state.html

Maritime Heritage Network:

http://www.maritimeheritage.net/attractions/attraction_select.asp?id=89

MAPS

Shoreline Master Program Update
City of Bremerton

Shoreline Planning Area
Map 1

Legend

- Stream Flow 20cfs or Greater
- Study Area
- Rivers and Streams
- Road
- Approximate Location of Shoreline Jurisdiction
- County Boundary
- Wetland (WDFW/NWI)
- Waterbody
- City Boundary
- Urban Growth Area

November 15, 2010

0 5,500

Scale in Feet

N

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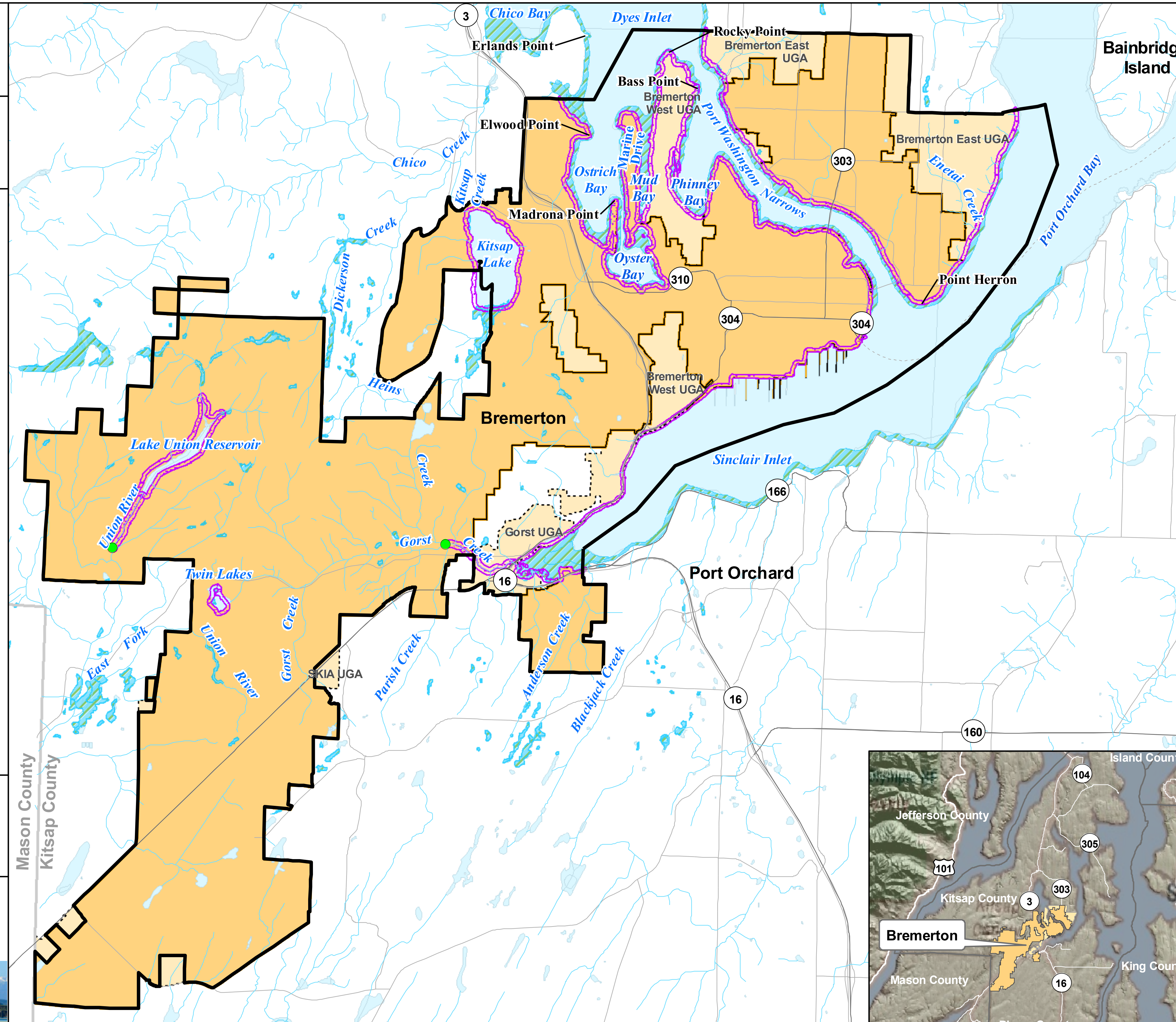
Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Washington Department of Ecology, Washington Department of Transportation, Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Regional Context
Map 2

Legend

- Study Area
- County Boundary
- Water Resource Inventory Area (WRIA)
- Bremerton City Limits
- Urban Growth Area
- Wetland (WDFW/NWI)
- Waterbody

WRIA 15 Subbasins
(Hydrologic Unit Code (HUC) Subbasin)

- Hood Canal
- Kitsap

November 15, 2010

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Scale in Feet

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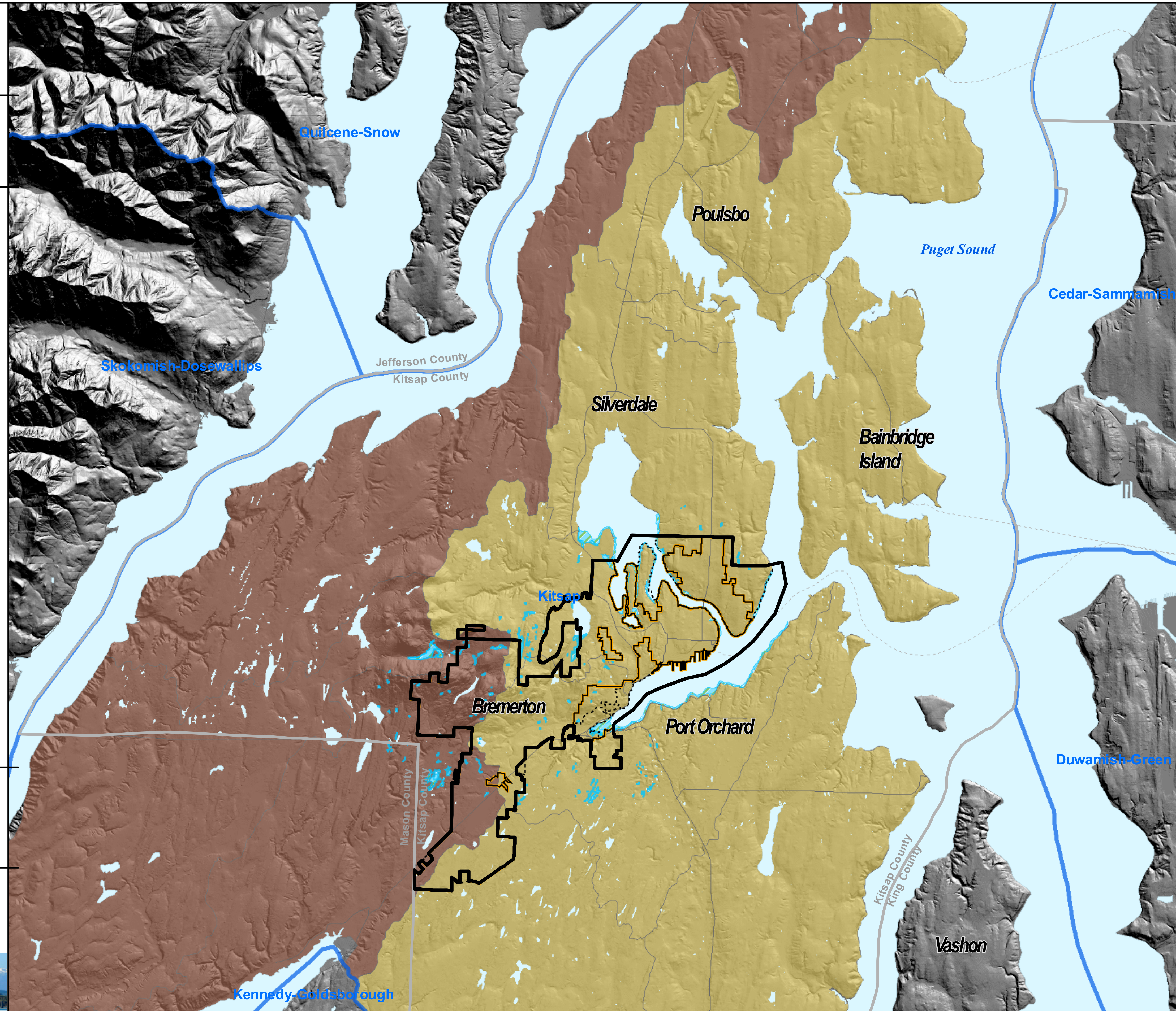
Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Washington Department of Ecology, Washington Department of Transportation, Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Topography
Map 3A

Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- County Boundary
- Wetland (WDFW/NWI)
- Waterbody

November 15, 2010

0 5,500

Scale in Feet

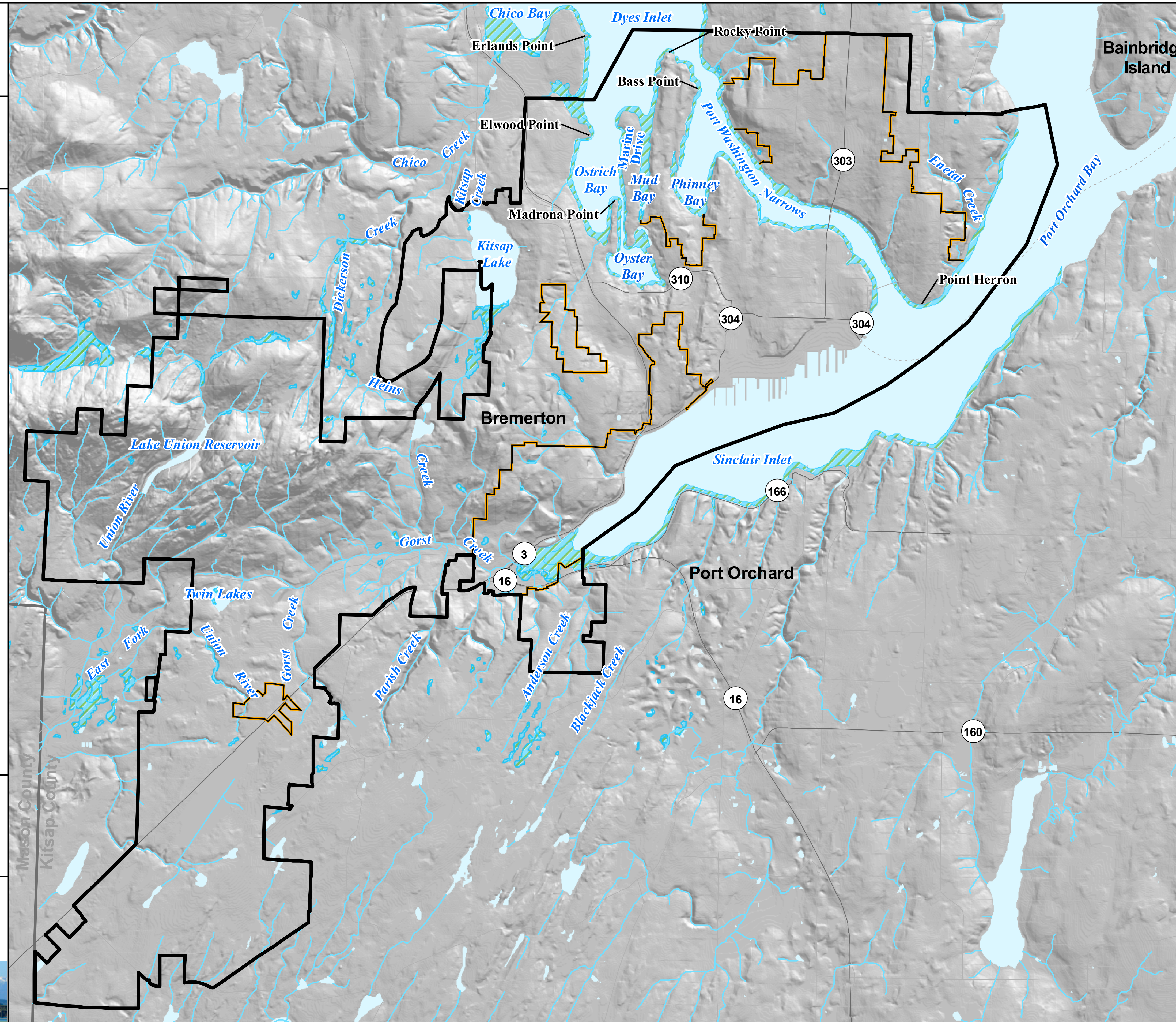
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f3a_Topography.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Washington Department of Ecology, Washington Department of Transportation, Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

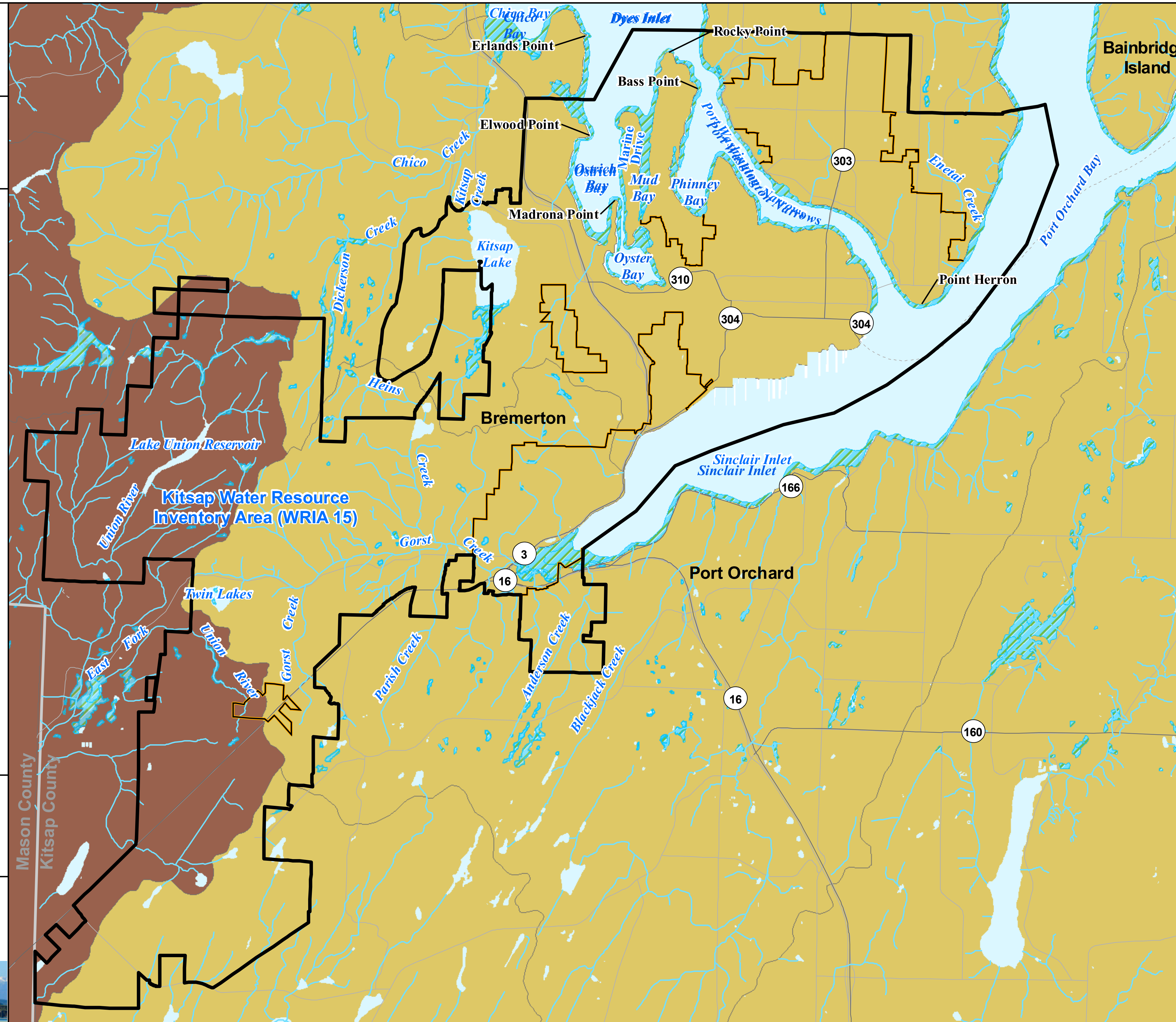
Waterbodies and Wetlands
Map 3B

Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- County Boundary
- Wetland (WDFW/NWI)
- Waterbody

WRIA 15 Subbasins (Hydrologic Unit Code (HUC) Subbasin)

- Hood Canal
- Kitsap



November 15, 2010

0 5,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f3b_WaterbodiesWetlands.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Washington Department of Ecology, Washington Department of Transportation, Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Surficial Geology
Map 4A

Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- County Boundary
- Waterbody

Surficial Geology

- Water
- Quaternary alluvium, dune sand, loess, and artificail fill
- Quaternary alluvial fans, beach deposits, undifferentiated sedimentary deposits, lacustrine deposits, landslides, peat, terraced deposits, and talus
- Pleistocene continental glacial, glaciolacustrine, and outburst flood deposits, Fraser-age
- Oligocene to Oligocene-Eocene marine sedimentary rocks
- Oligocene to Paleocene intrusive igneous rocks
- Eocene volcanic rocks
- Tertiary continental sedimentary rocks

November 15, 2010

0 5,500

Scale in Feet

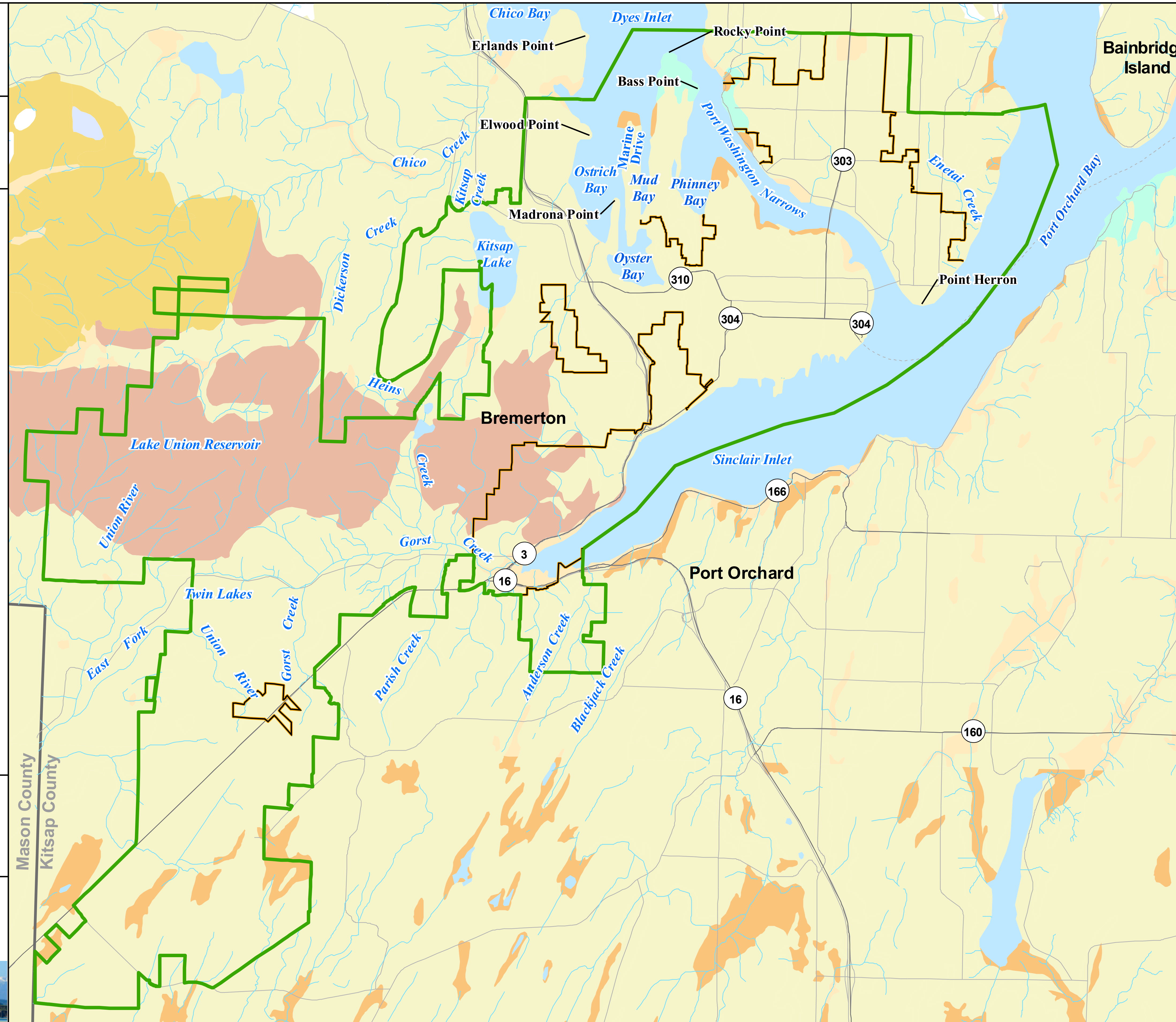
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f4a_SurficialGeology.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Washington Department of Ecology, Washington Department of Transportation, United States Geologic Survey (USGS)

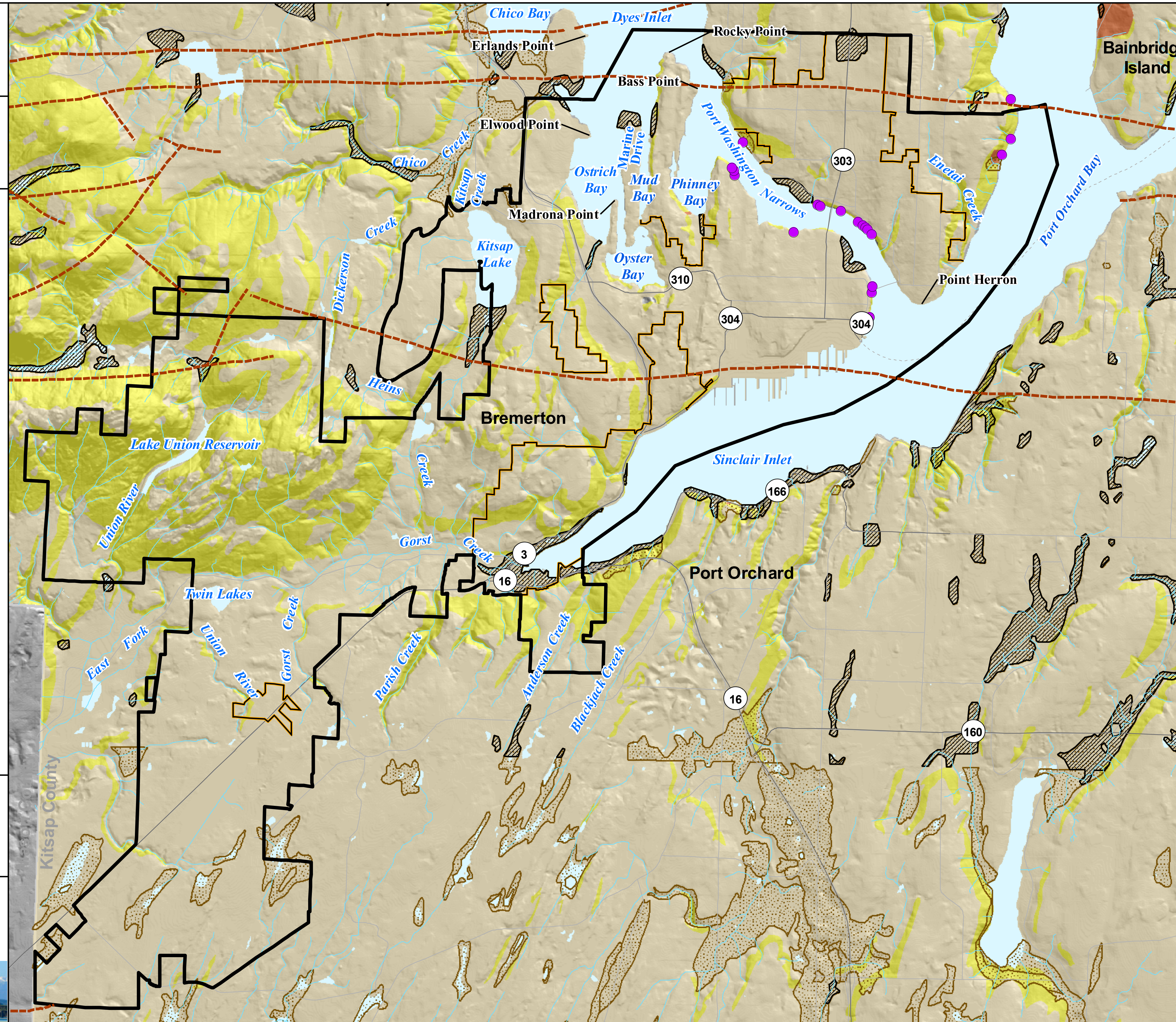
Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Landslides and Seismic Hazard Areas
Map 4B



Legend

- Landslide Hazard (EKNI)
- Quaternary Fault Locations (DNR)
- Study Area
- City Boundary
- Rivers and Streams
- Road
- Waterbody
- County Boundary
- Seismic Hazard
- Liquefaction Hazard

Erosion Hazard (Kitsap County)

- High (Historic or Active Landslide)
- Moderate (Slope 15-30% or Greater, Unstable Slope)
- Low to Very Low (Slope < 15%)

November 15, 2010

0 5,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f4b_LandslideSeizmicHaz.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources (DNR), Washington Department of Ecology, Washington Department of Transportation, Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI) East Kitsap Nearshore Inventory (EKNI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Soils
Map 4C

Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- Waterbody
- County Boundary

Soils (DNR/SCS)

- ALDERWOOD, 1
- ALDERWOOD, 2
- ALDERWOOD, 3
- BEACHES, 4
- BELFAST, 5
- BELLINGHAM, 6
- CATHCART, 7
- CATHCART, 8
- CATHCART, 9
- DYSTRIC XERORTHENTS, 10
- GROVE, 11
- GROVE, 12
- GROVE, 13
- HARSTINE, 14
- HARSTINE, 15
- HARSTINE, 16
- HARSTINE, 17
- INDIANOLA, 18
- INDIANOLA, 19
- INDIANOLA, 20
- INDIANOLA-KITSAP, 21
- KAPOWSIN VARIANT, 24
- KAPOWSIN, 22
- KAPOWSIN, 23
- KILCHIS, 25
- KILCHIS, 26
- KILCHIS-SHELTON, 27
- KITSAP, 28
- KITSAP, 29
- KITSAP, 30
- KITSAP, 31
- MCKENNA, 32
- MUKILTEO, 33
- NEILTON, 34
- NEILTON, 35
- NEILTON, 36
- NO SURVEY, 0
- NORMA, 37
- PITS, 38
- POULSBO, 39
- POULSBO, 40
- POULSBO, 41
- POULSBO-RAGNAR, 42
- POULSBO-RAGNAR, 43
- RAGNAR, 44
- RAGNAR, 45
- RAGNAR, 46
- RAGNAR-POULSBO, 47
- SCHNEIDER, 48
- SEMIAHMOO, 49
- SHALCAR, 50
- SHELTON, 51
- SHELTON, 52
- SHELTON, 53
- SHELTON, 54
- SHELTON, 55
- SHELTON, 56
- SHELTON, 57
- SHELTON-MCKENNA, 58
- SINCLAIR, 59
- SINCLAIR, 60
- SINCLAIR, 61
- TACOMA, 62
- URBANLAND-ALDERWOOD, 63

November 15, 2010

0 5,500

Scale in Feet

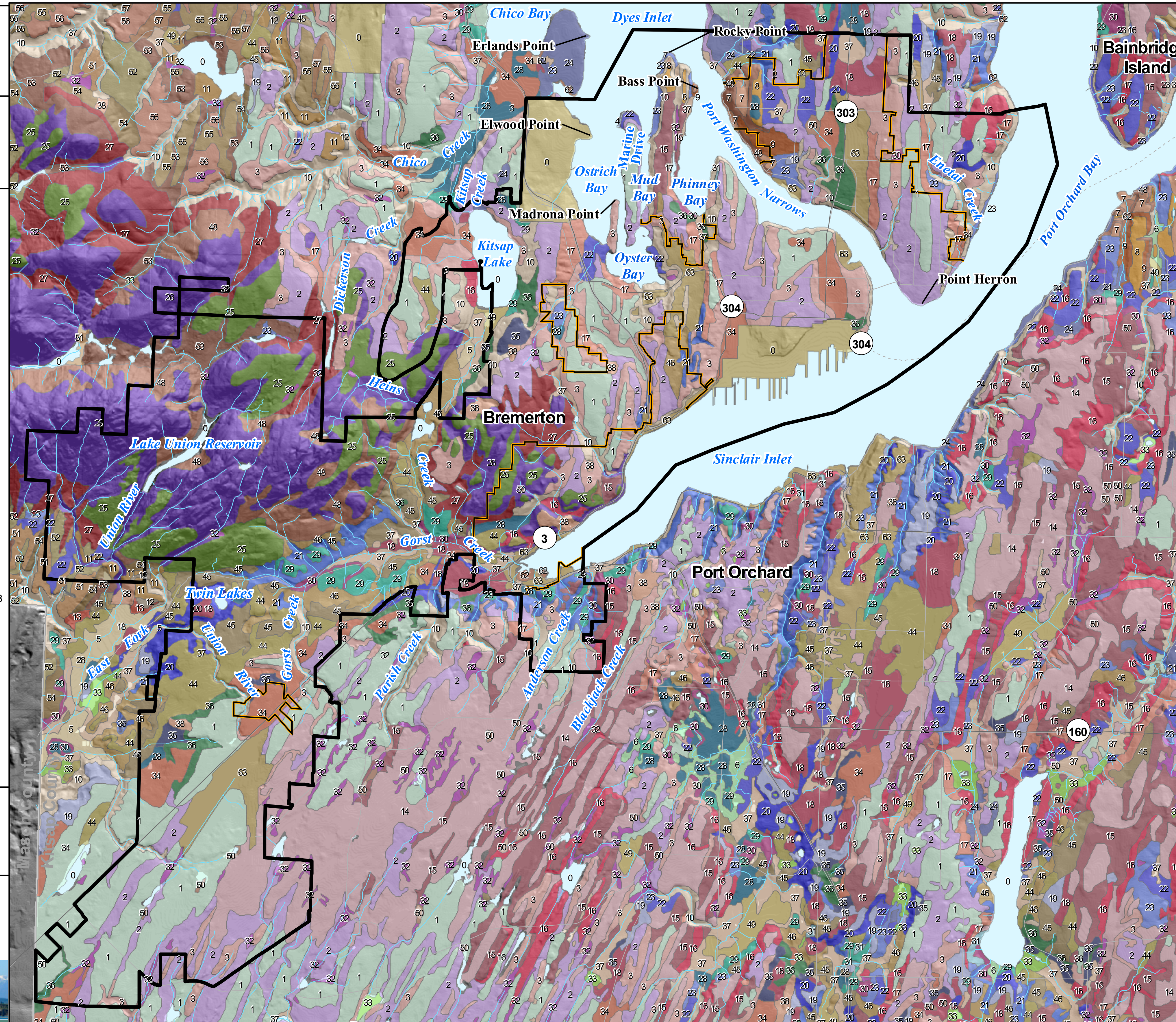
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f4c_Soils.mxd

Data Sources: Kitsap County, Washington Department of Ecology, City of Bremerton, USGS, Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Hydric Soils
Map 4D

Legend

- Study Area
- City Boundary
- Rivers and Streams (DNR)
- Road
- Waterbody (DNR)
- County Boundary
- Hydric Soils (Kitsap County/NRCS 2008)

November 15, 2010

0 5,500

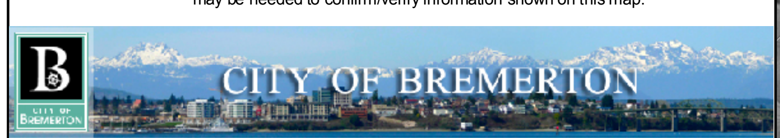
Scale in Feet

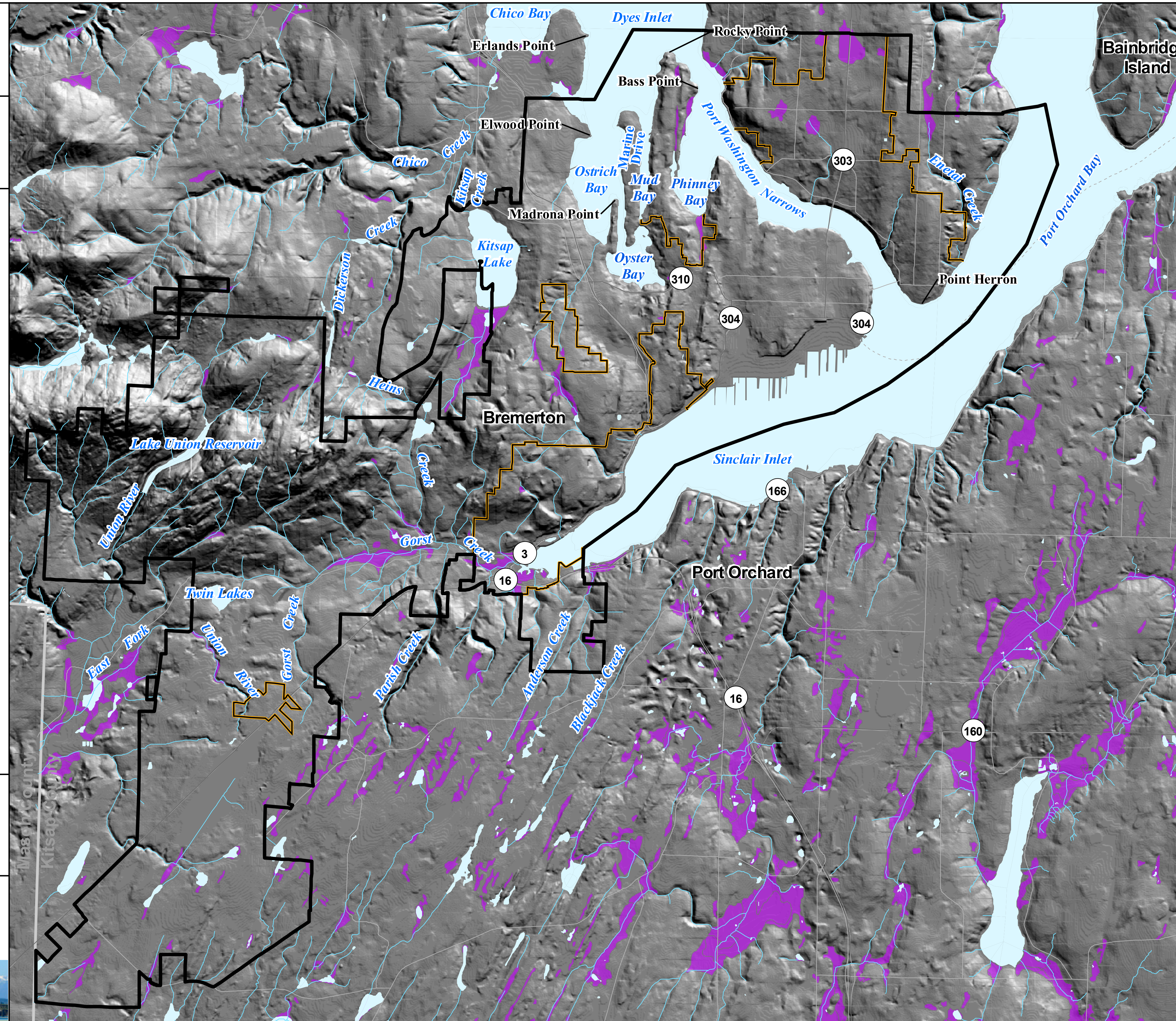
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f4d_HydricSoils.mxd

Data Sources: Kitsap County, Washington Department of Ecology, City of Bremerton, USGS, Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.





Shoreline Master Program Update
City of Bremerton

Marine Sediment Processes
Drift Cells
Map 4E

Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- Waterbody

Ecology Drift Cell

- Left to Right
- Right to Left
- No Appreciable Drift

November 15, 2010

0 3,500

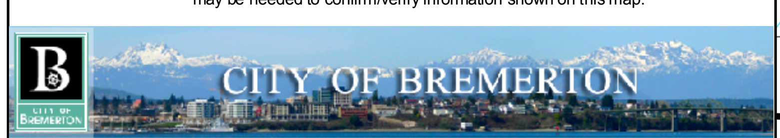
Scale in Feet

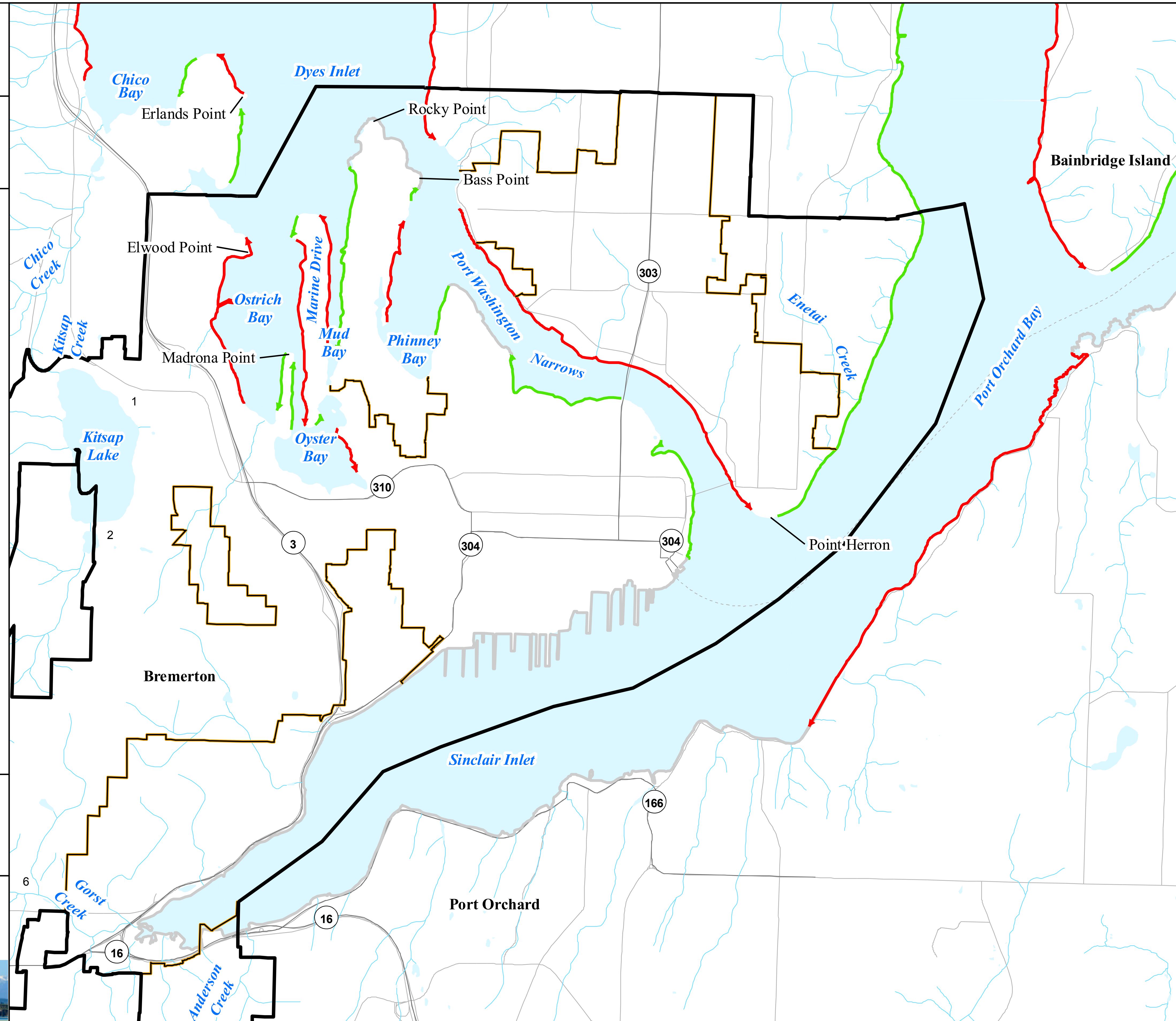
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f4e_DriftCells.mxd

Data Sources: Kitsap County, City of Bremerton, East Kitsap Nearshore Inventory (EKNI), Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.





Shoreline Master Program Update
City of Bremerton

Marine Sediment Processes Analysis Reaches
Map 4F

Legend

- City Boundary
- Study Area
- Rivers and Streams
- Road
- Drift Cell Boundary

Shoreline Reach Name and East Kitsap Assessment Number

Shoreline

- Blackjack Creek 34C
- Chico Bay 138, 90
- Erlands Point 51, 52, 53, 89
- Gorst Estuary 34B
- Kitsap Lake North
- Lake Union Reservoir
- Marine Drive 87
- Marine Drive North 44, 86
- Mud Bay 42, 43
- North Kitsap Lake
- Ostrich Bay 140
- Oyster Bay 48, 49, 50, 88
- Puget Sound Naval Shipyard 34A
- Phinney Bay 37, 38, 39, 85
- Point Herron 55, 56A
- Port Orchard Bay 56B
- Port Washington Narrows East 107, 108, 135, 137
- Port Washington Narrows West 35, 36, 149, 150, 151
- Rocky Point 40, 41
- South Kitsap Lake
- Twin Lakes
- Union River
- Waterbody

November 15, 2010

0 3,500

Scale in Feet

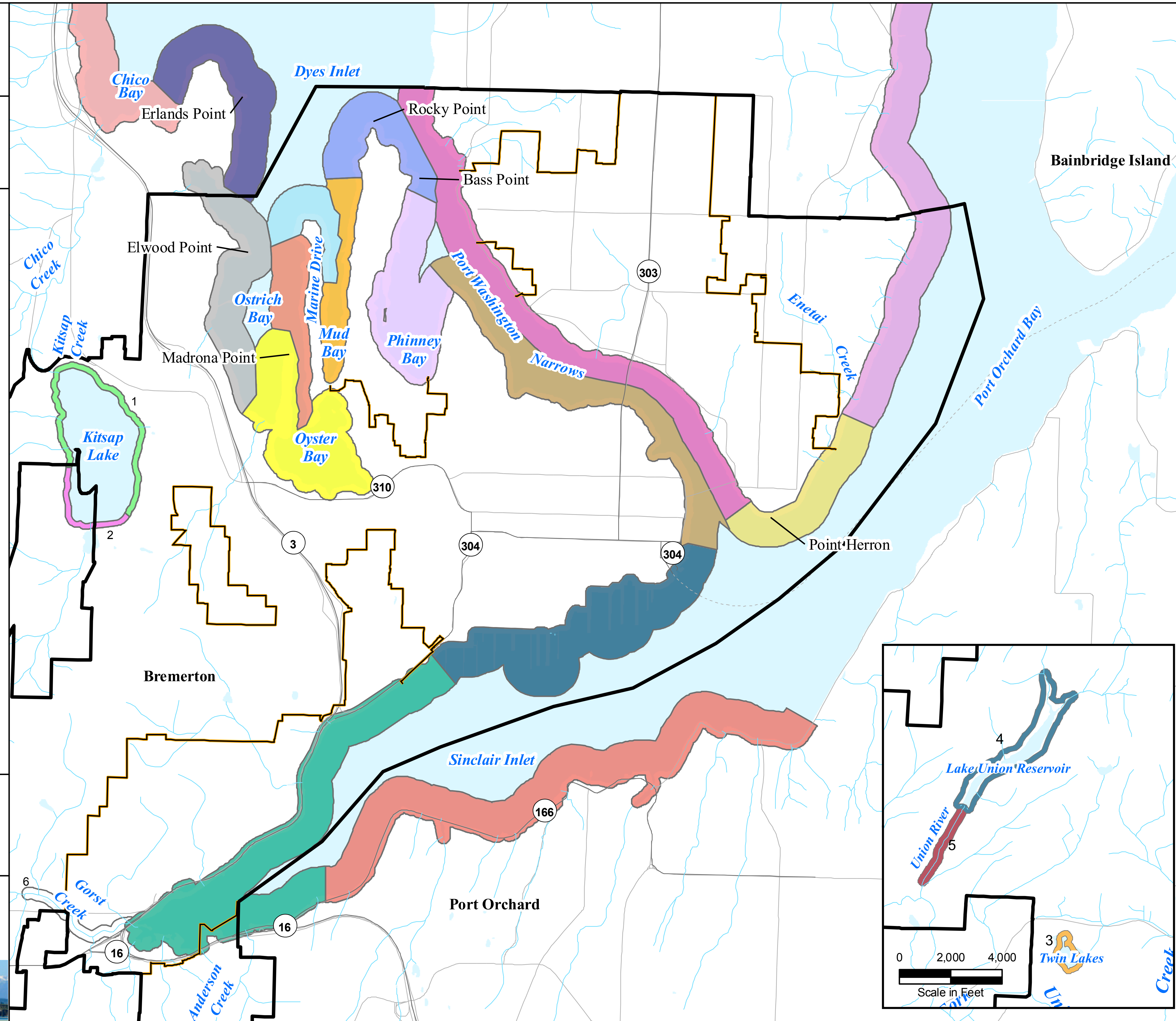
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f4f_AnalysisReaches.mxd

Data Sources: Kitsap County, City of Bremerton, East Kitsap Nearshore Inventory (EKNI), Parametrix

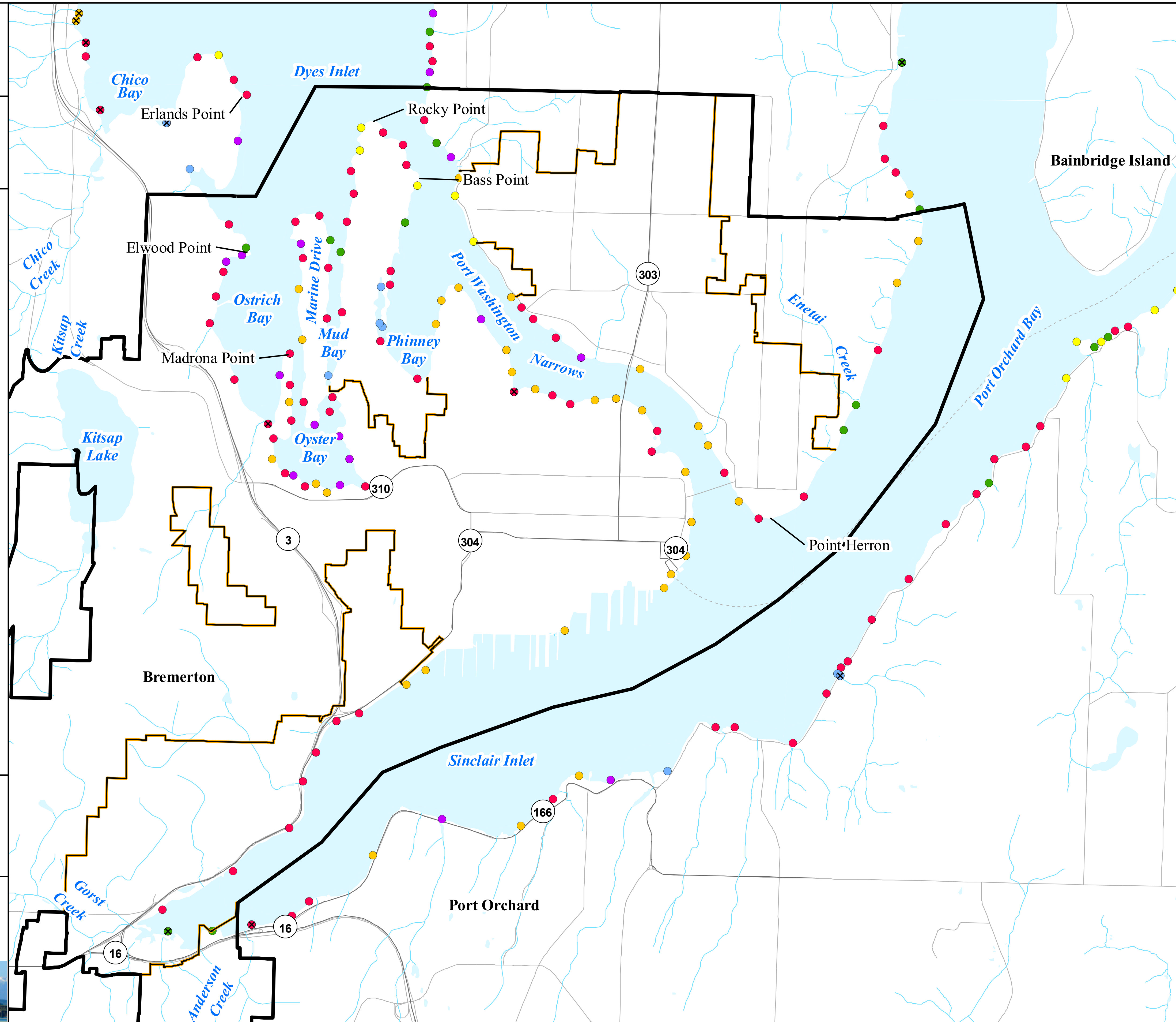
Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Coastal Geomorphology/Shoreforms Map 4G



Legend

- City Boundary
- Study Area
- Rivers and Streams
- Road
- Waterbody

Pocket Estuary

- Pocket Estuary

Bank Type

- High Bank
- Low Bank
- Marsh or Lagoon
- No Bank
- Rocky
- Varied

November 15, 2010

0 3,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f4g_Shoreforms.mxd

Data Sources: Kitsap County, City of Bremerton, East Kitsap Nearshore Inventory (EKNI), Washington Department of Natural Resources, Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

Shoreline Master Program Update
City of Bremerton

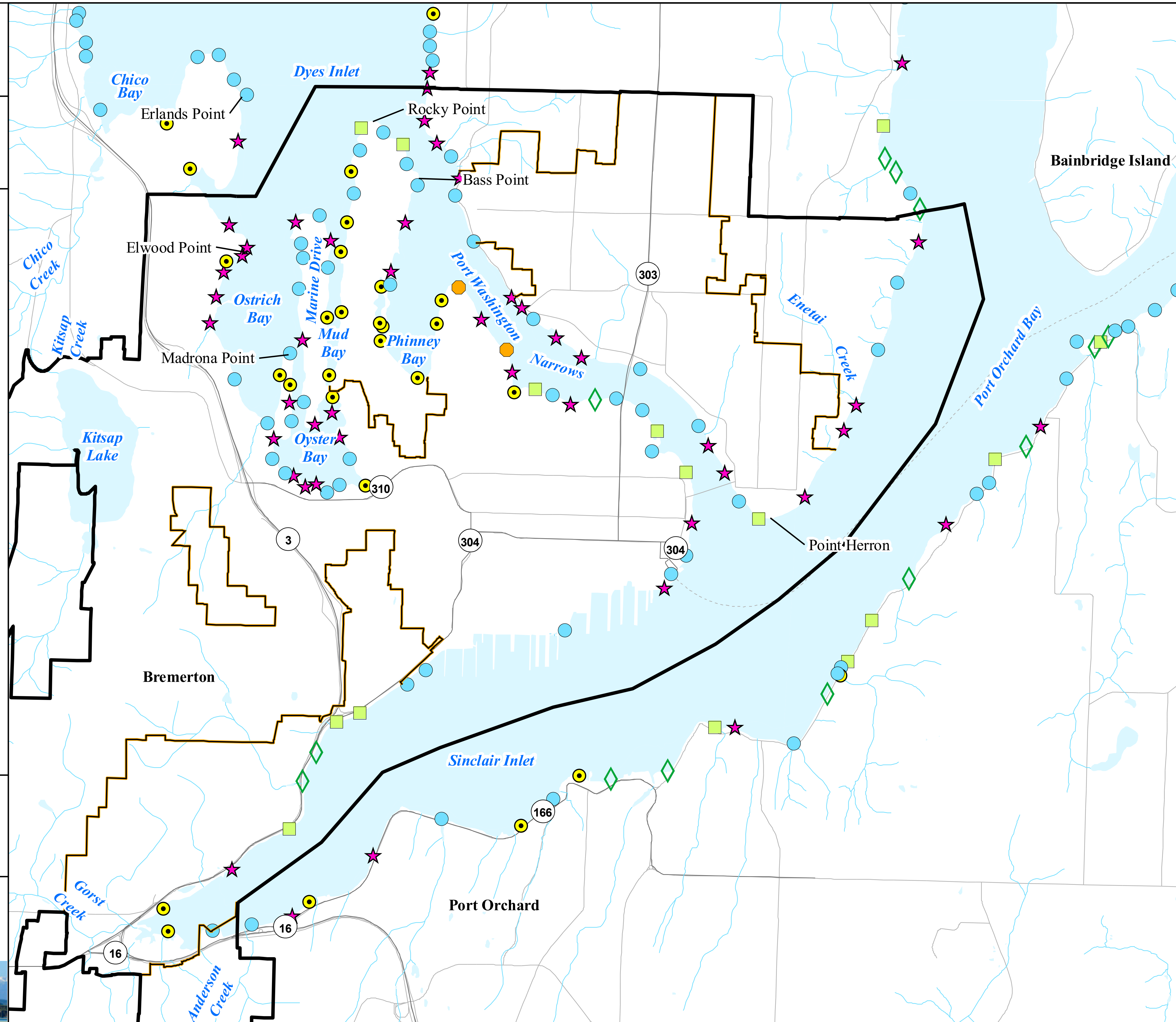
Substrate Type
Map 4H

Legend

- City Boundary
- Study Area
- Rivers and Streams
- Road
- Waterbody

Substrate Type

- Mixed Coarse
- Clay
- Cobble
- Gravel
- Mud
- Sand



November 15, 2010

0 3,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f4h_SubstrateType.mxd

Data Sources: Kitsap County, City of Bremerton, East Kitsap Nearshore Inventory (EKNI), Washington Department of Natural Resources, Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

FEMA Floodplain
Map 4I

Legend

- City Boundary
- Study Area
- Rivers and Streams
- Road
- 100 Year Flood Zone
- Waterbody
- County Boundary
- Wetland (WDFW/NWI)

November 15, 2010

0 5,500
Scale in Feet

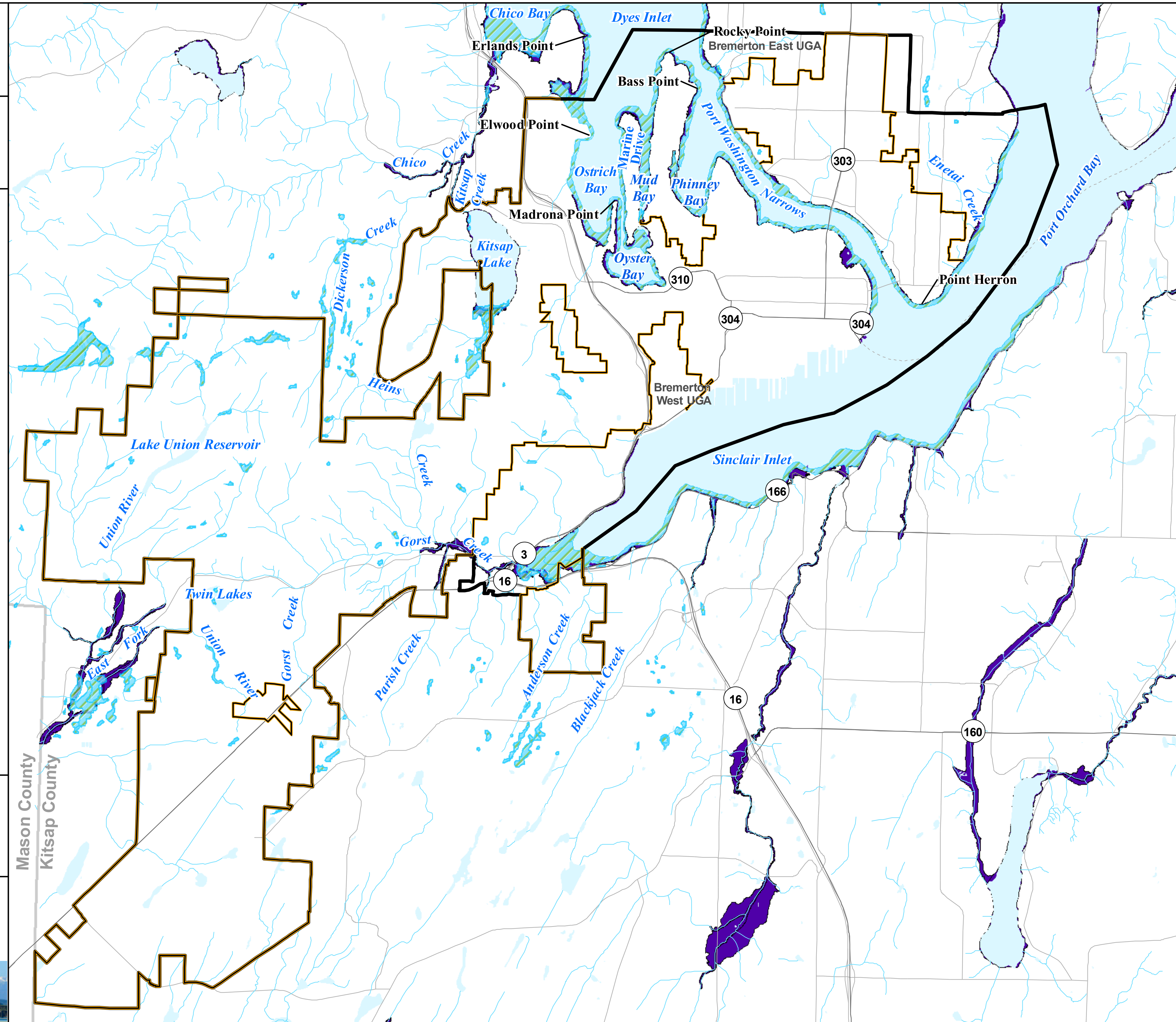
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f4i_Floodplain.mxd

Data Sources: Kitsap County, City of Bremerton, FEMA, Parametrix, Washington Department of Natural Resources

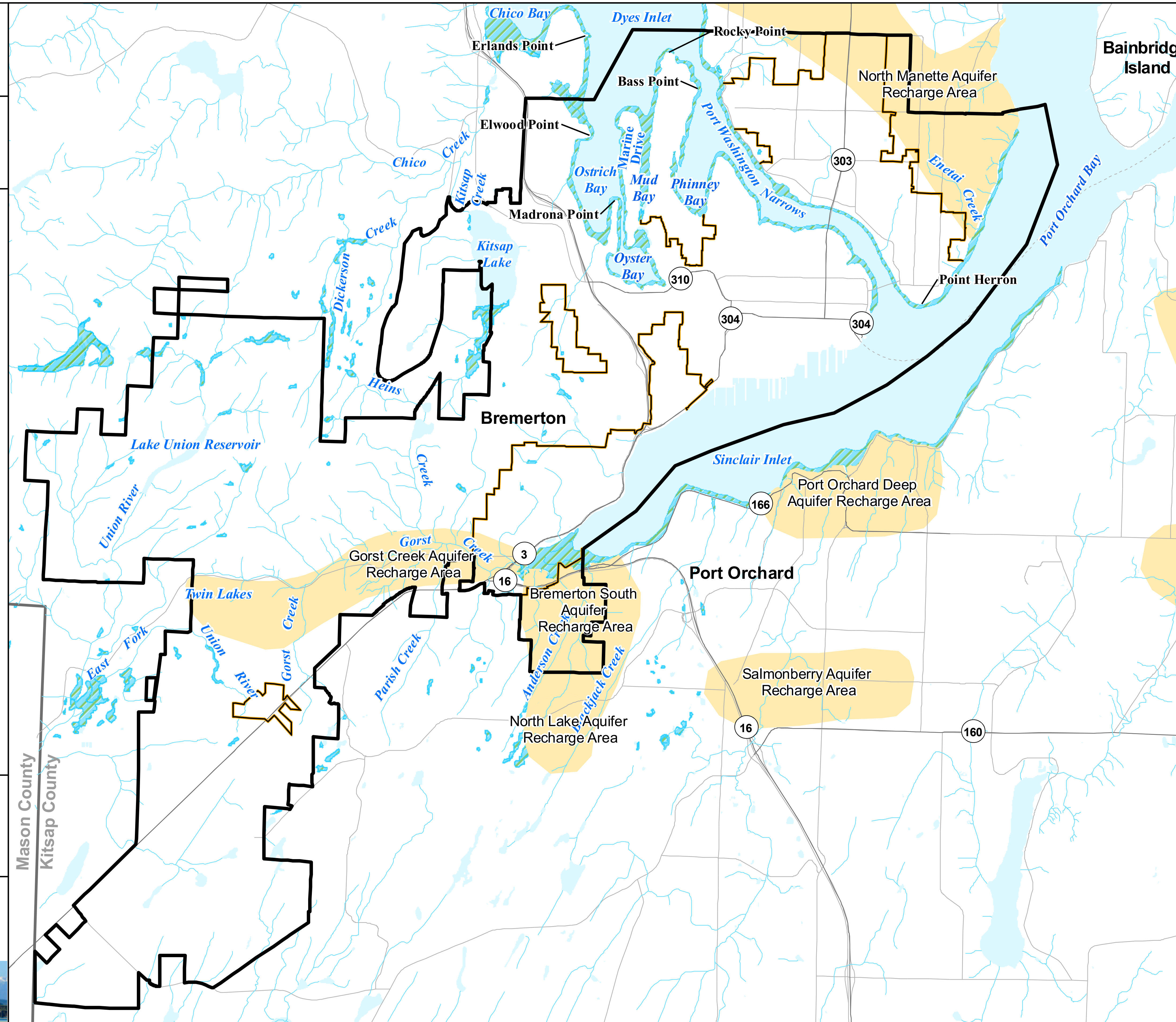
Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Groundwater Resources
Map 5



Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- Critical Aquifer Recharge Area
- County Boundary
- Waterbody
- Wetland (WDFW/NWI)

November 15, 2010

0 5,500
Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f5_Groundwater.mxd

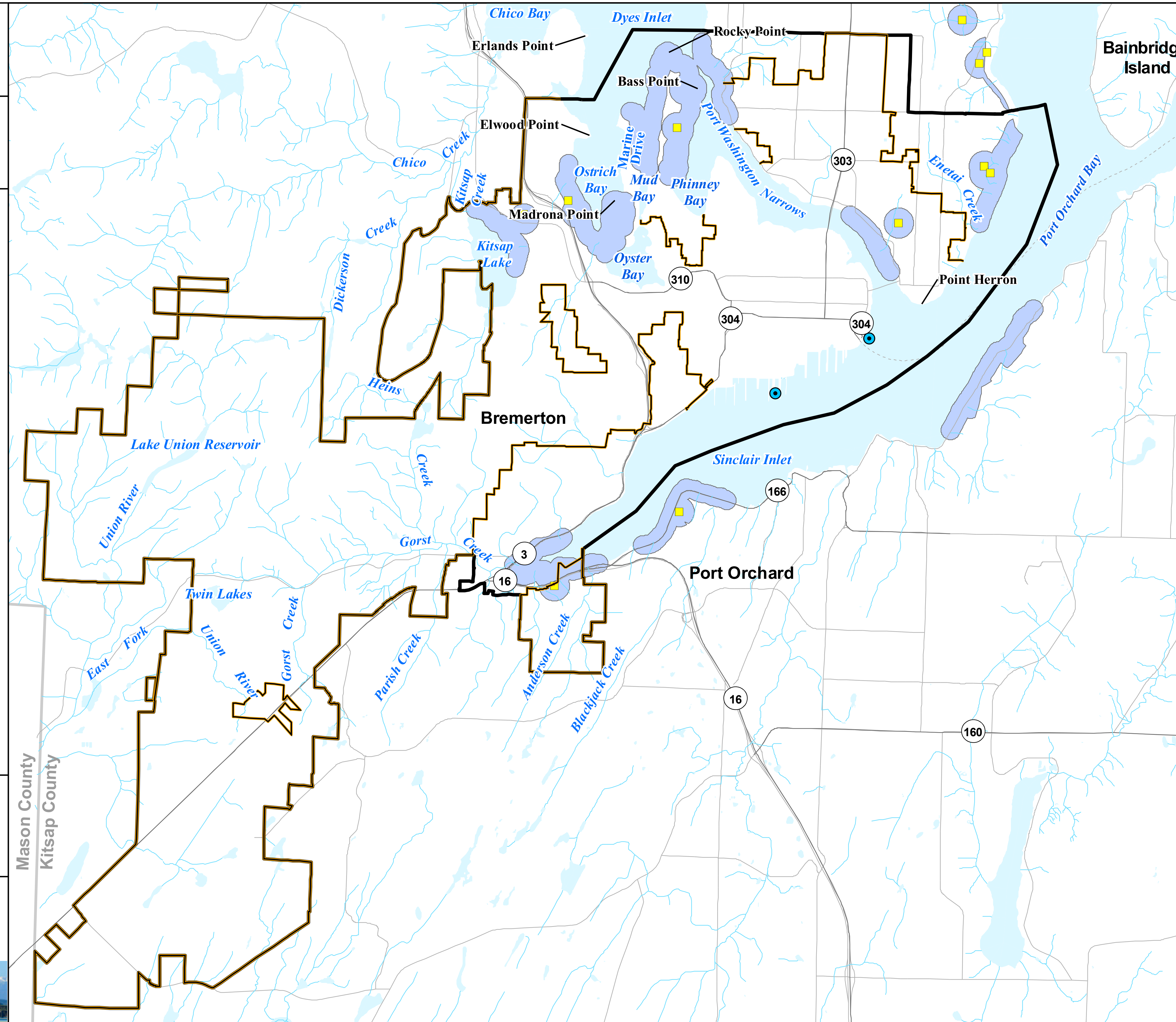
Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Washington Department of Ecology, Washington Department of Transportation, Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Wildlife
Bald Eagle, Murrelet*, and Seabird Colonies
Map 6A



Legend

- Bald Eagle Nest
- Seabird Colony
- Study Area
- City Boundary
- Rivers and Streams
- Road
- Bald Eagle
- Waterbody
- County Boundary

November 15, 2010

0 5,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f6a_WildlifeBaldEagle.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Fish and Wildlife (WDFW), Parametrix, Washington Department of Natural Resources

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Wildlife
Marine Mammal Haulouts and Shellfish
Map 6B

Legend

- Seal and Sea Lion Haulout Sites
- Study Area
- Rivers and Streams
- City Boundary
- Road
- County Boundary
- Waterbody

Shellfish

- Geoduck
- Hardshell Clam
- Subtidal Hardshell Clam

November 15, 2010

0 5,500

Scale in Feet

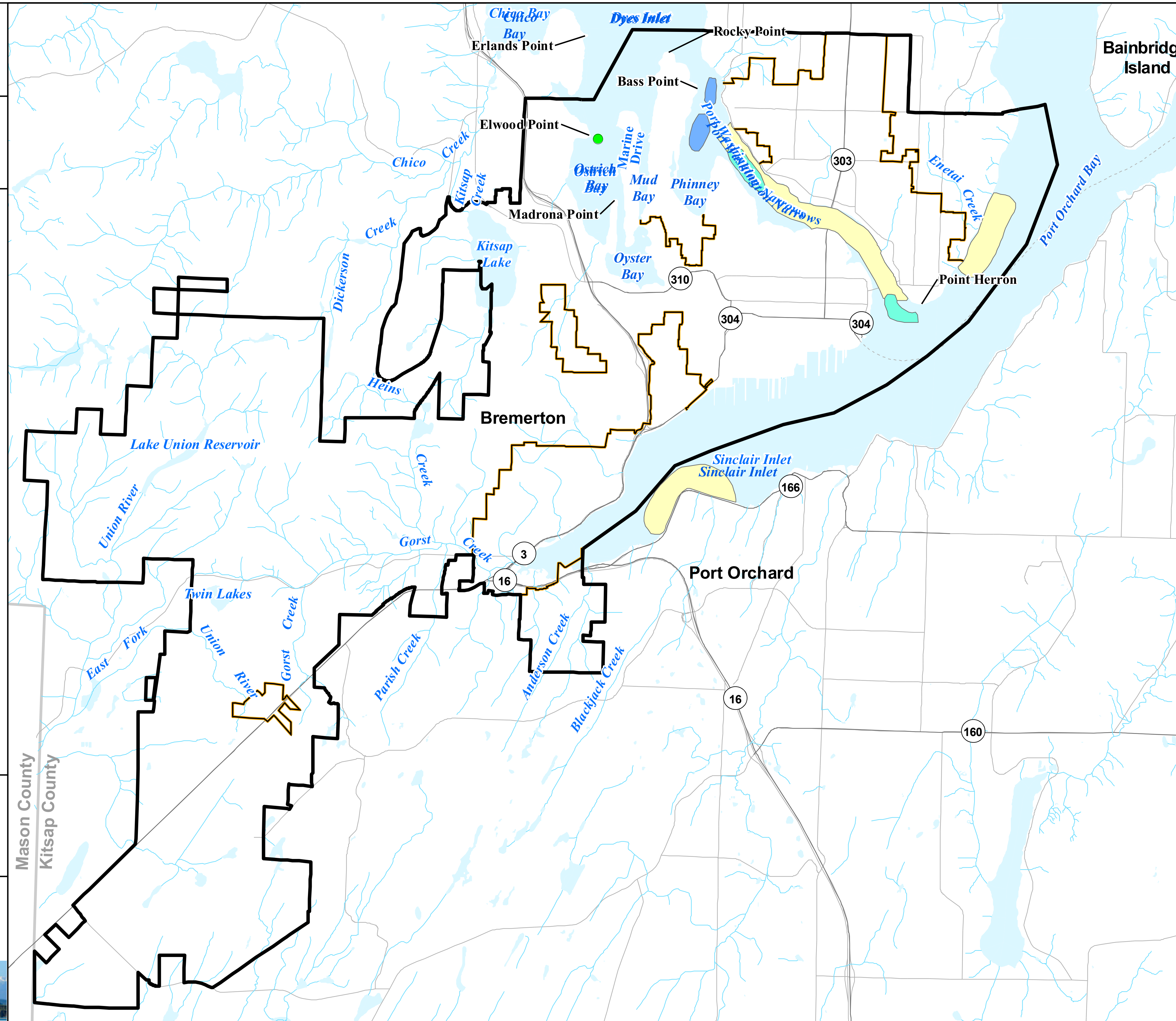
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f6b_WildlifeMarine.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Fish and Wildlife, Washington Department of Natural Resources, Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Fish Usage
Fish Distribution
Map 7A

Legend

- Fish Presence (WDFW)
- Study Area
- Rivers and Streams
- City Boundary
- Road
- County Boundary
- Waterbody

Anadromous/Resident Fish Distribution (WDFW)

- Presence - Documented
- Presence - Potential
- Presence - Presumed

November 15, 2010

0 7,000

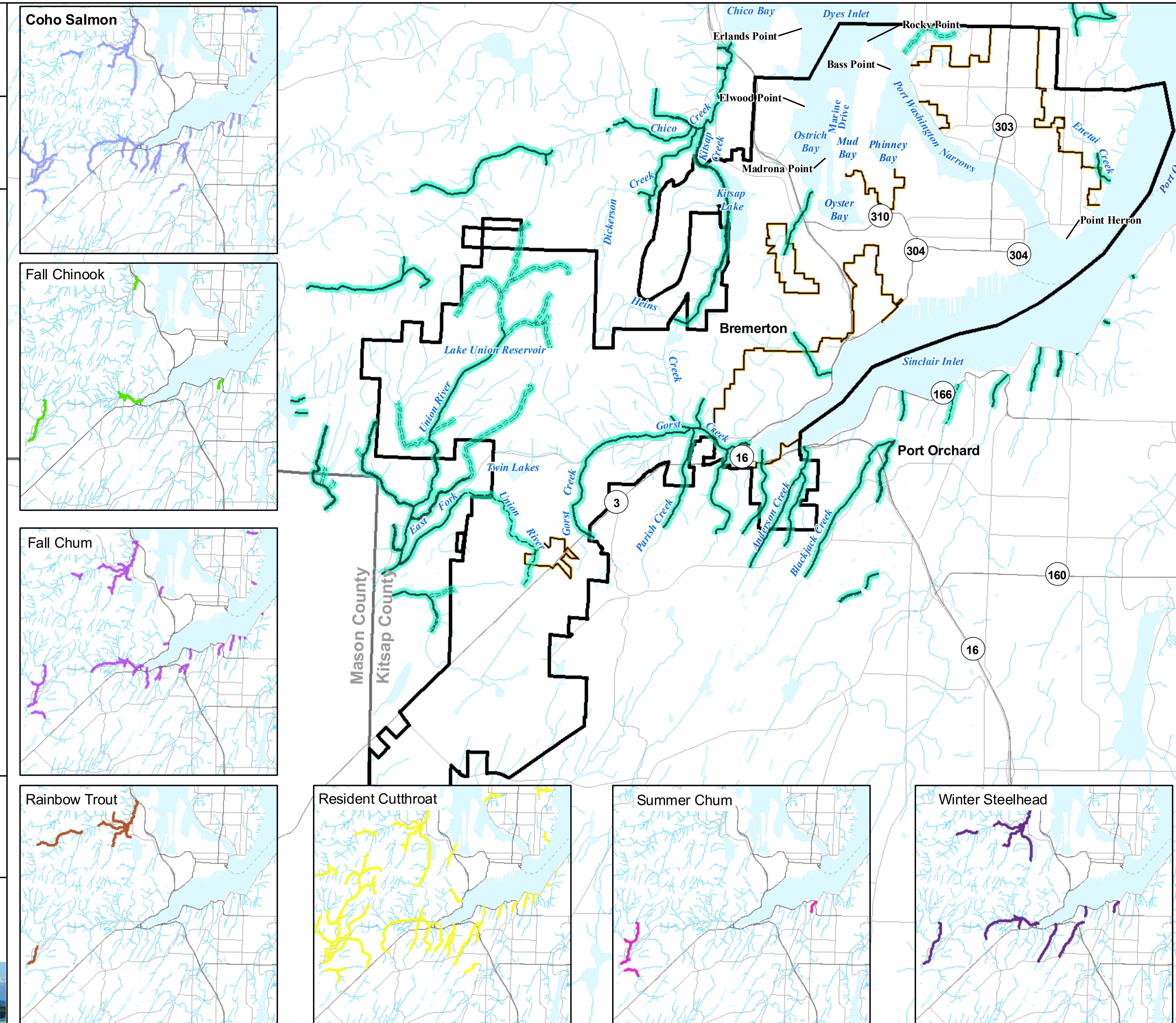
Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f7a_FishDistSalmonid.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Fish and Wildlife (WDFW), Washington Department of Natural Resources, Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.



Shoreline Master Program Update
City of Bremerton

Fish Usage
Salmonid Stock Status
Map 7B

Legend

- Study Area
- Rivers and Streams
- Road
- City Boundary
- Waterbody
- County Boundary

Salmonid Stock Status (WDFW)

- Depressed
- Healthy
- Not Rated
- Unknown

ESA Status (WDFW)

- Threatened

November 15, 2010

0 5,500

Scale in Feet

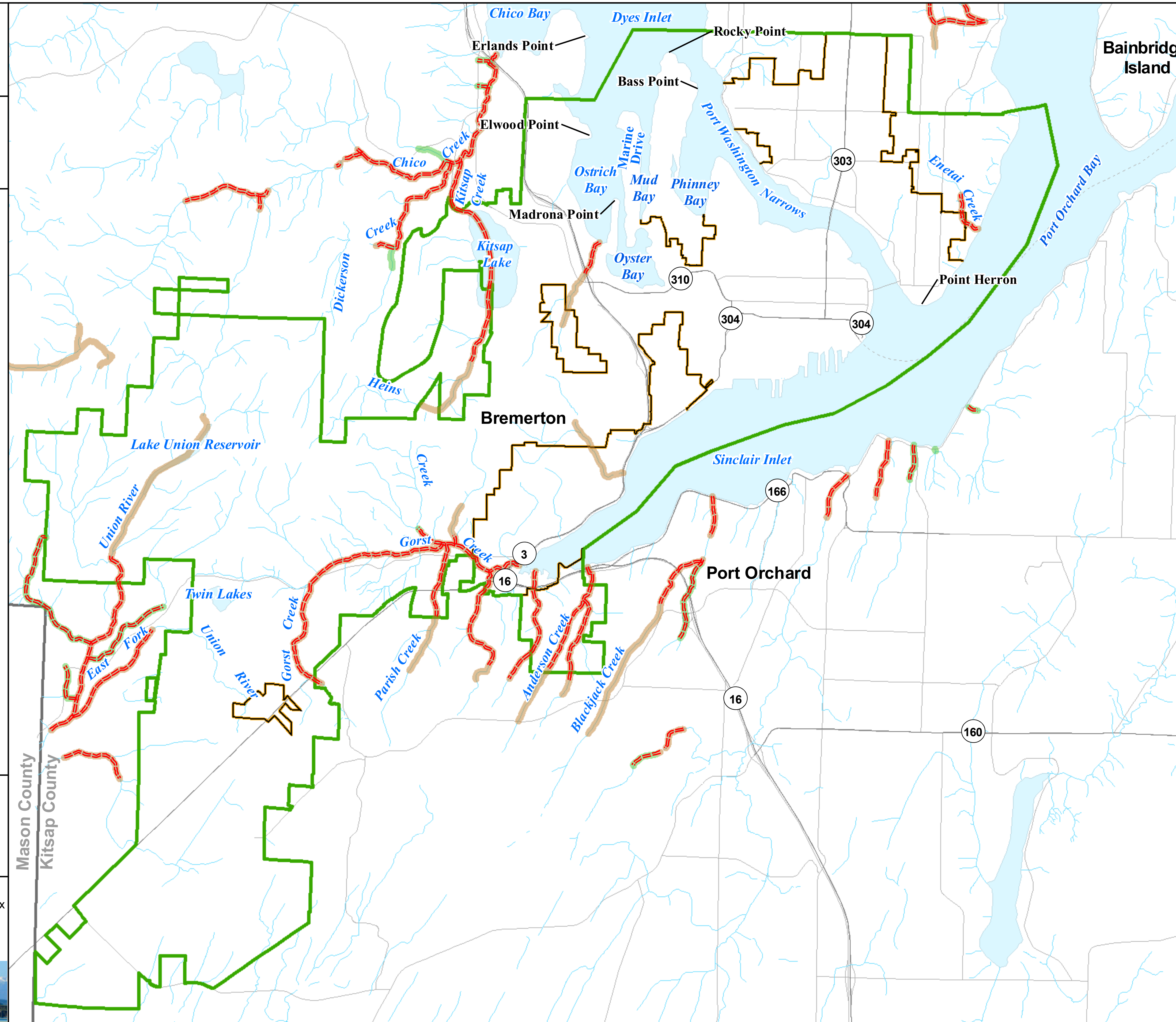
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f7b_SalmonidStockStat.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Fish and Wildlife (WDFW), East Kitsap Nearshore Inventory (EKNI), Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Fish Usage
Marine Fish/Forage Fish
Map 7C

Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- Waterbody
- Herring Holding Area (WDFW)
- Documented Smelt Intertidal Habitat (WDFW)
- Documented Sand Lance Intertidal Habitat (WDFW)
- Documented Sand Lance and Smelt Intertidal Habitat (WDFW)

Presence of Spawning Habitat (WDFW)

- Sand Lance
- Smelt
- Sand Lance and Smelt

November 15, 2010

0 3,500

Scale in Feet

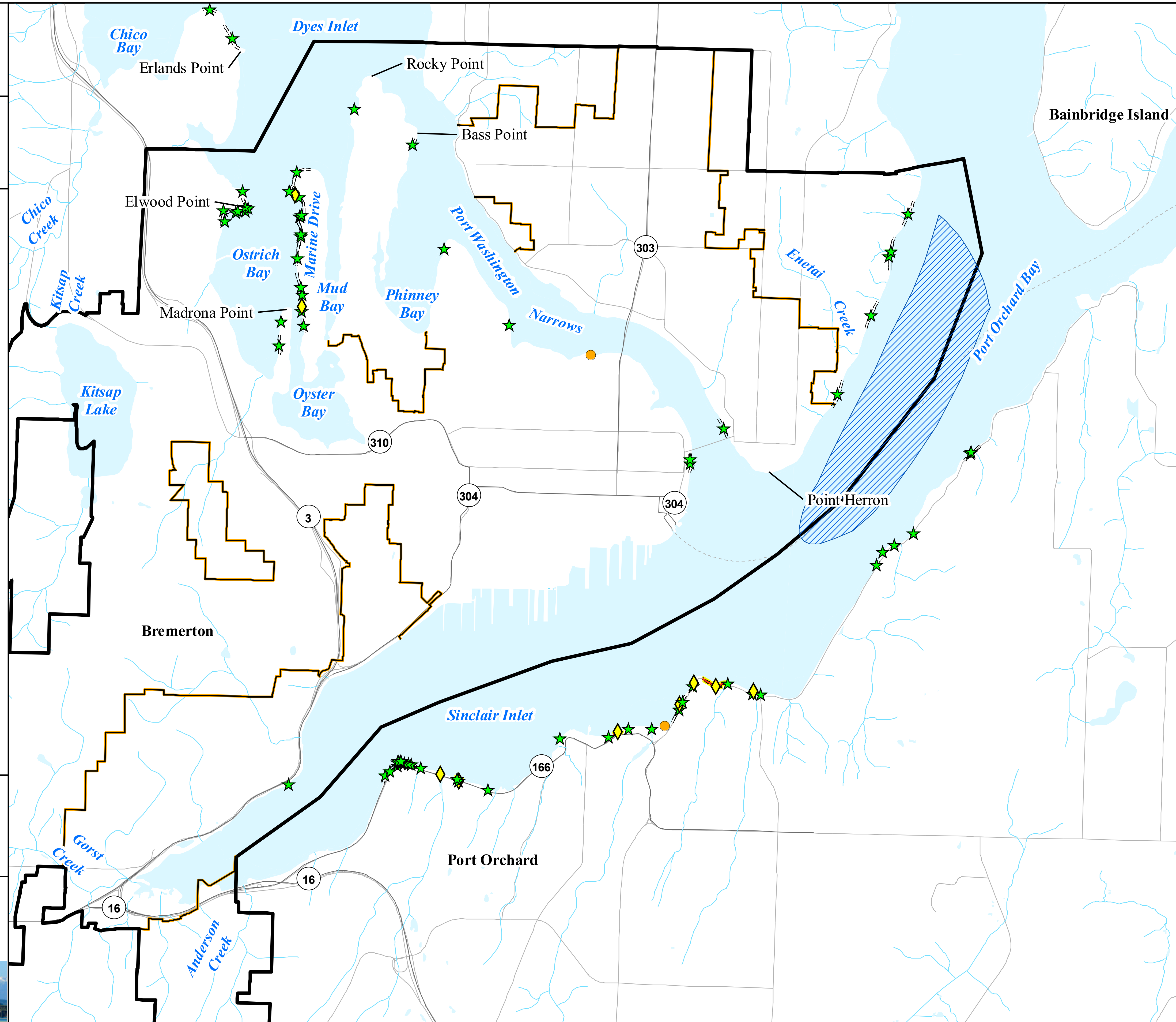
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f7c_MarineFish.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Fish and Wildlife (WDFW), Washington Department of Natural Resources, Parametrix

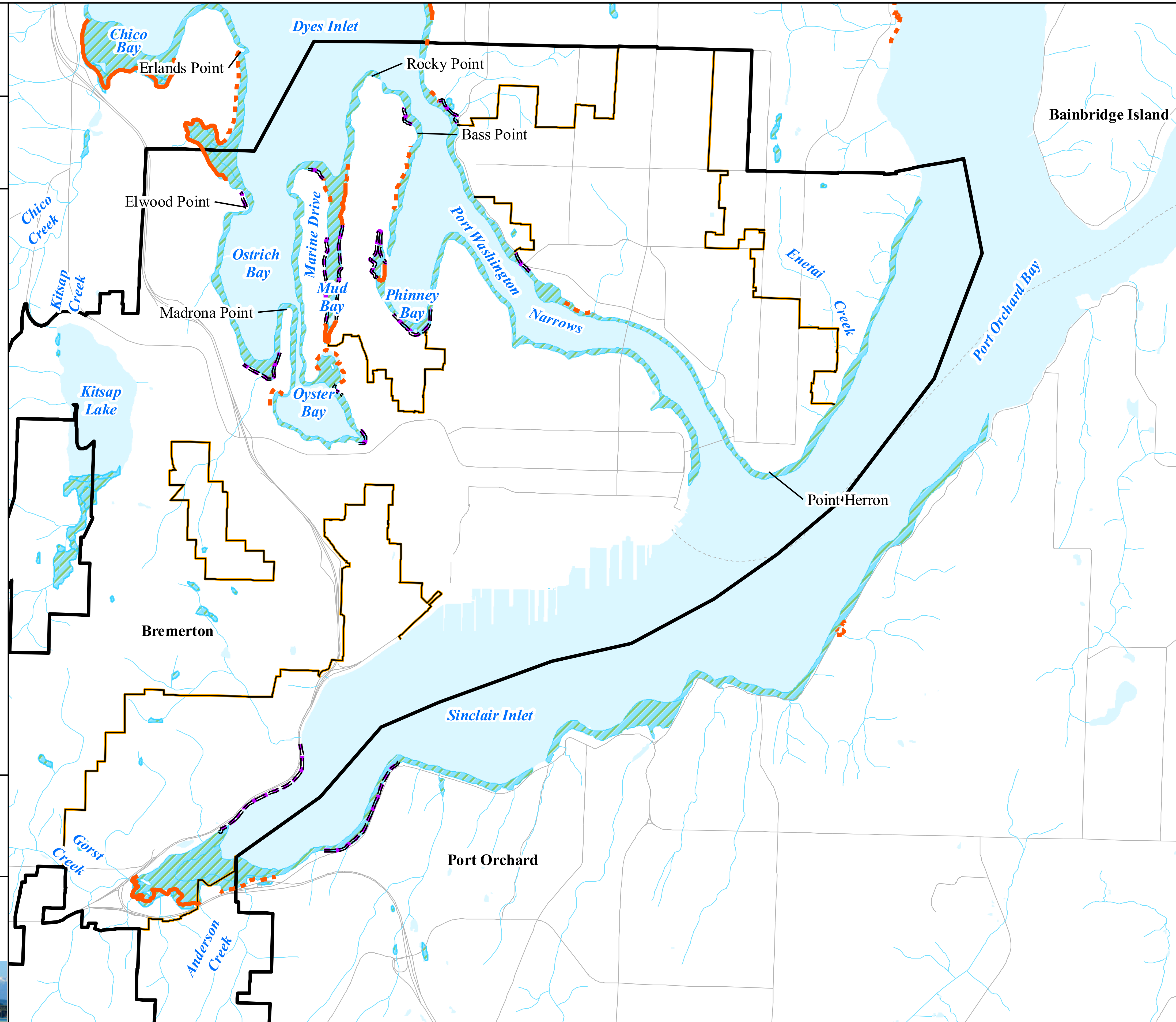
Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Nearshore Vegetation
Marsh Areas
Map 8A



Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- Waterbody

Mixed Marsh

- Continuous Mixed Marsh
- Patchy Mixed Marsh

Low Marsh

- Continuous Low Marsh
- Patchy Low Marsh

Salt Marsh

- Continuous Salt Marsh
- Patchy Salt Marsh
- Wetland (WDFW/NWI)

November 15, 2010

0 3,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f8a_NearshoreVegMarsh.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Parametrix, East Kitsap Nearshore Inventory (EKNI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Nearshore Vegetation
Kelp
Map 8B

Legend

- Study Area
- Rivers and Streams
- Road
- Waterbody
- City Boundary

Non-Floating Kelp

- Continuous Non-Floating Kelp
- Patchy Non-Floating Kelp
- Wetland (WDFW/NWI)

November 15, 2010

0 3,500

Scale in Feet

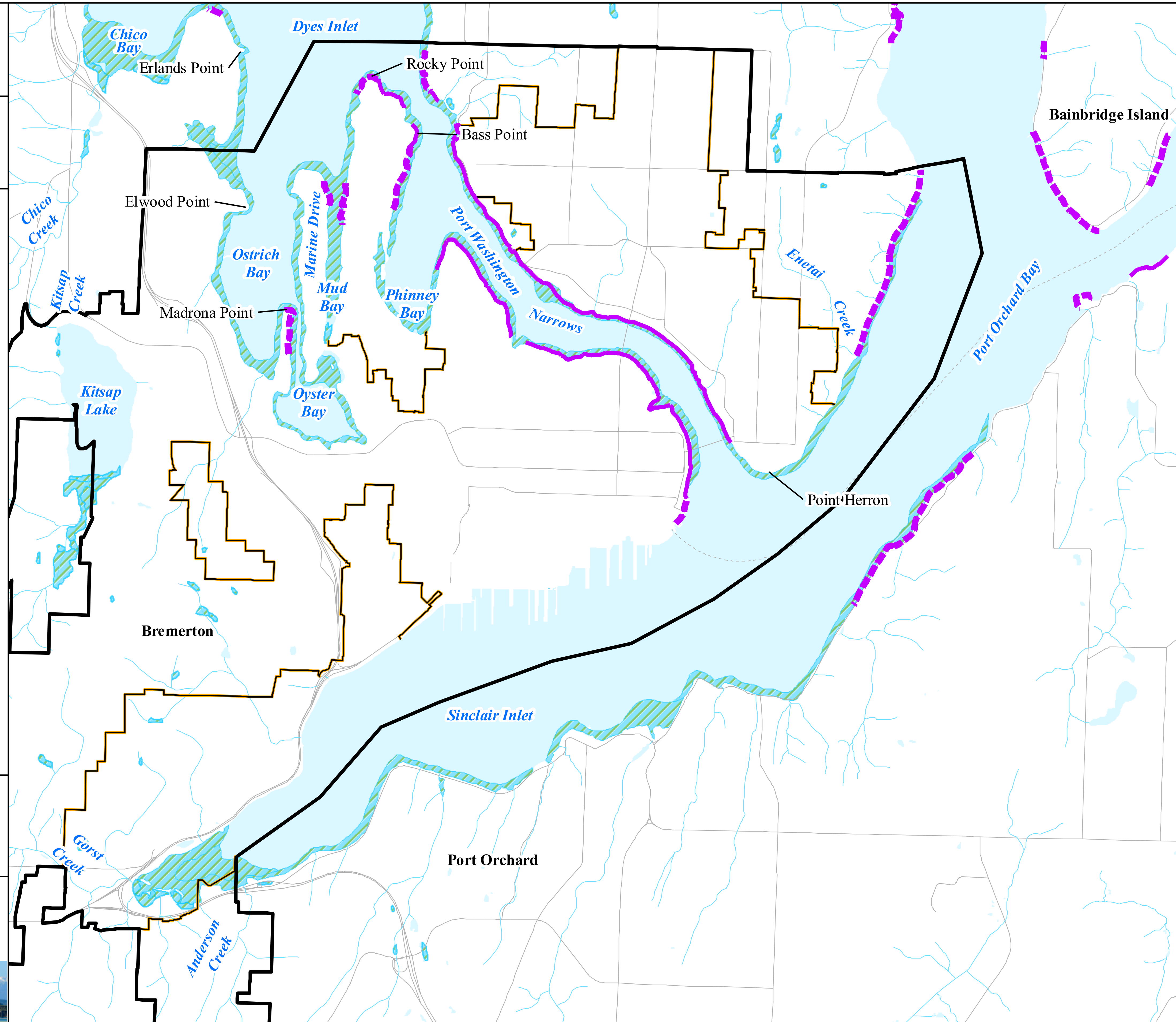
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f8b_NearshoreVegKelp.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Parametrix, East Kitsap Nearshore Inventory (EKNI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Nearshore Vegetation
Sargassum
Map 8C

Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- Waterbody
- Wetland (WDFW/NWI)

Sargassum

- Continuous Sargassum
- Patchy Sargassum

November 15, 2010

0 3,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f8c_NearshoreVegSarg.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Parametrix, East Kitsap Nearshore Inventory (EKNI)

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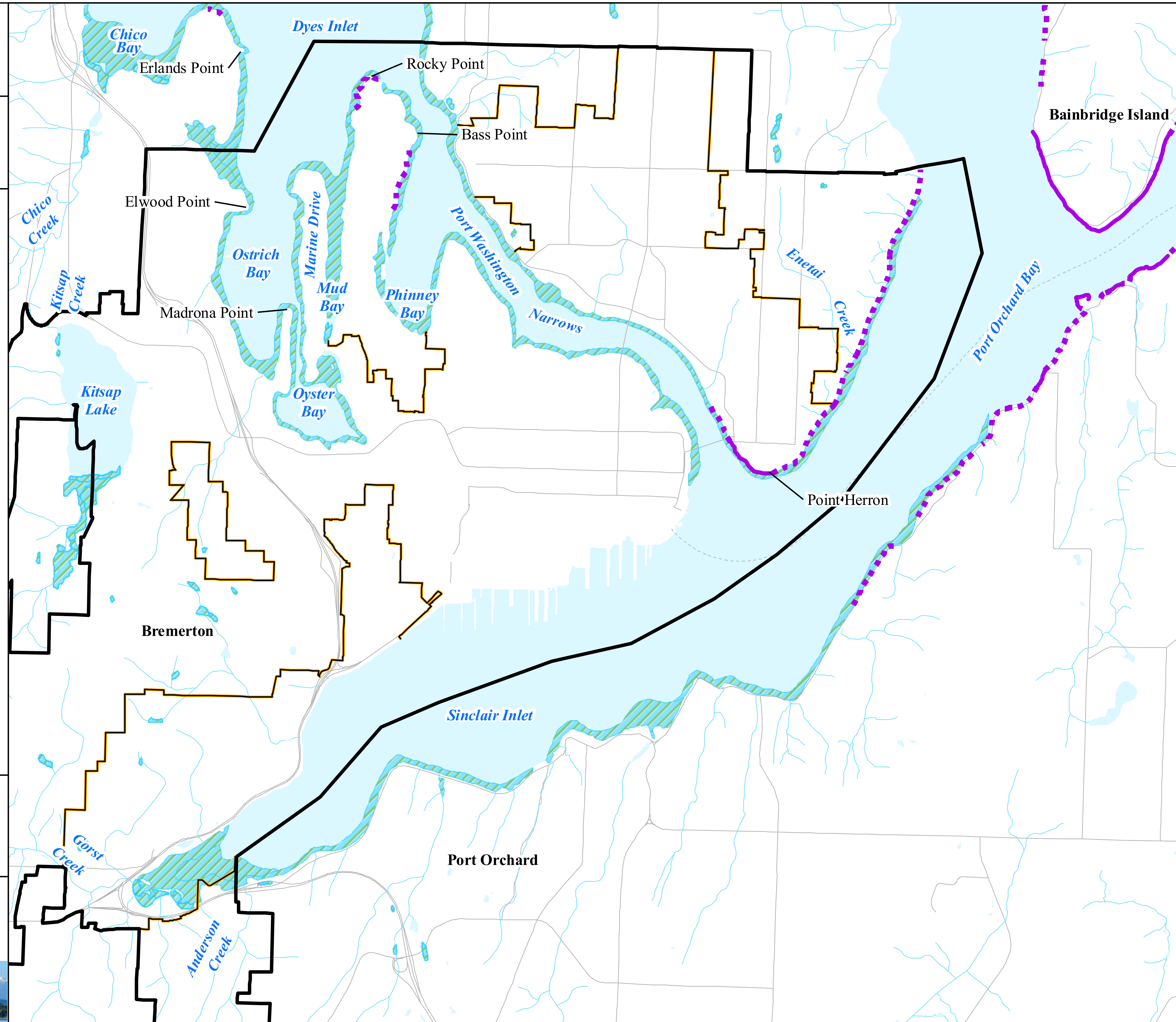
CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Nearshore Vegetation
Eelgrass
Map 8D

Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- Waterbody
- Wetland (WDFW/NWI)

Eelgrass

- Continuous Eelgrass
- Patchy Eelgrass

November 15, 2010

0 3,500

Scale in Feet

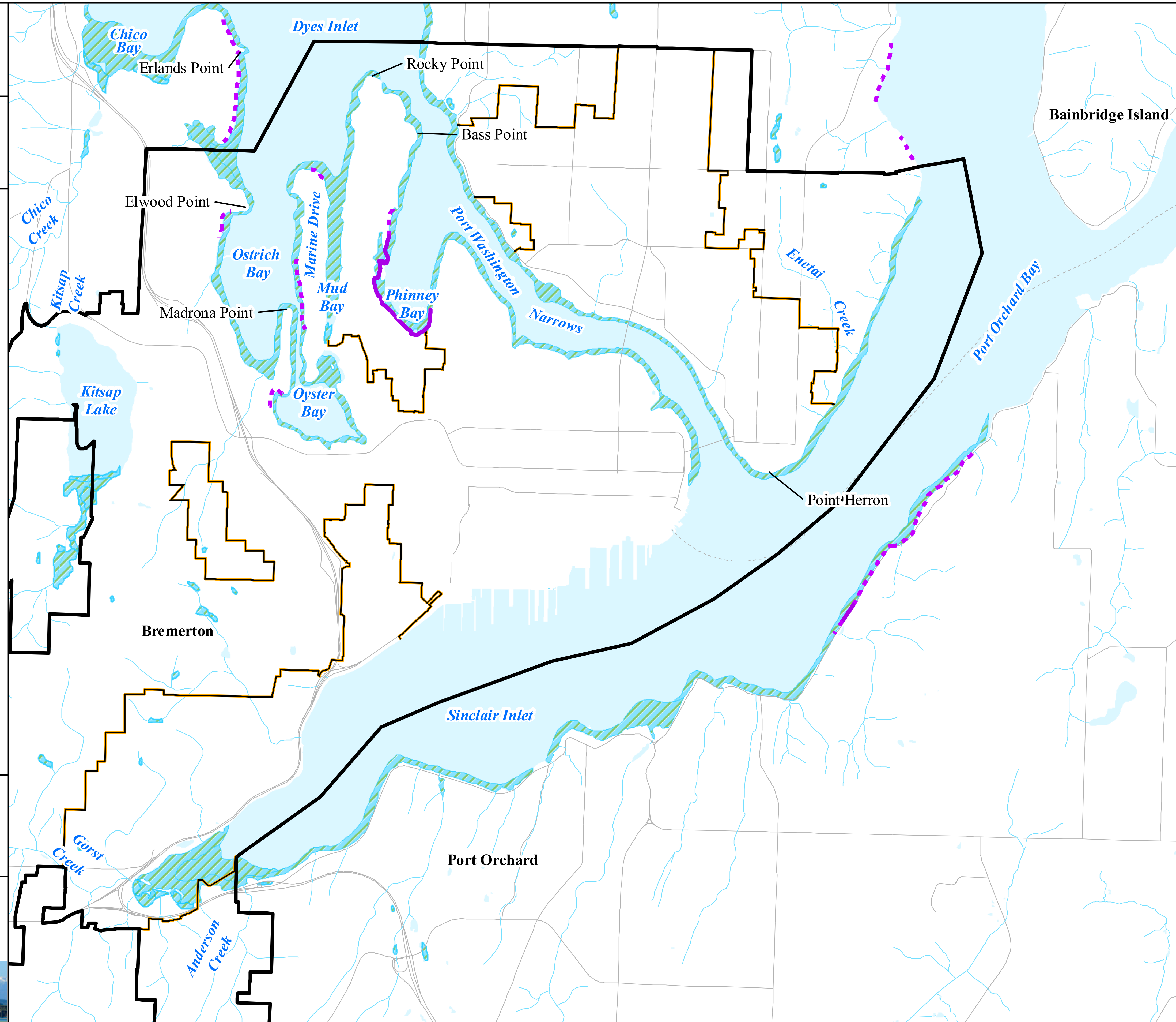
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f8d_NearshoreVegEelgrass.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Natural Resources, Parametrix, East Kitsap Nearshore Inventory (EKNI)

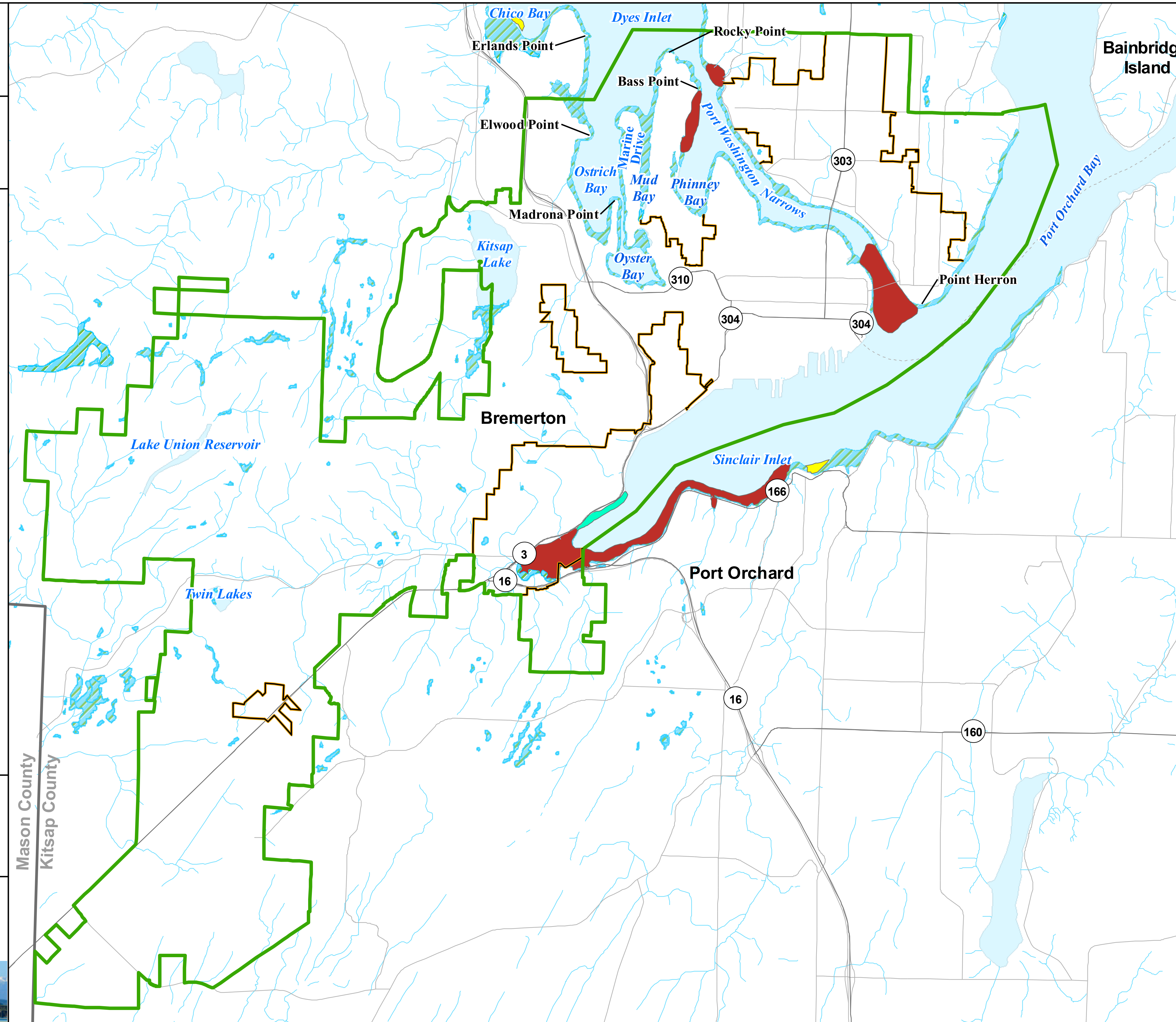
Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Priority Habitats and Species
Map 9



Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- Waterbody
- County Boundary

Priority Habitats and Species (WDFW)

- Esturine Zone
- Shorebird Concentrations
- Waterfowl Concentrations
- Wetlands (WDFW & NWI)

November 15, 2010

0 5,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f9_PriorityHabitats.mxd

Data Sources: Kitsap County, City of Bremerton, Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI), Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

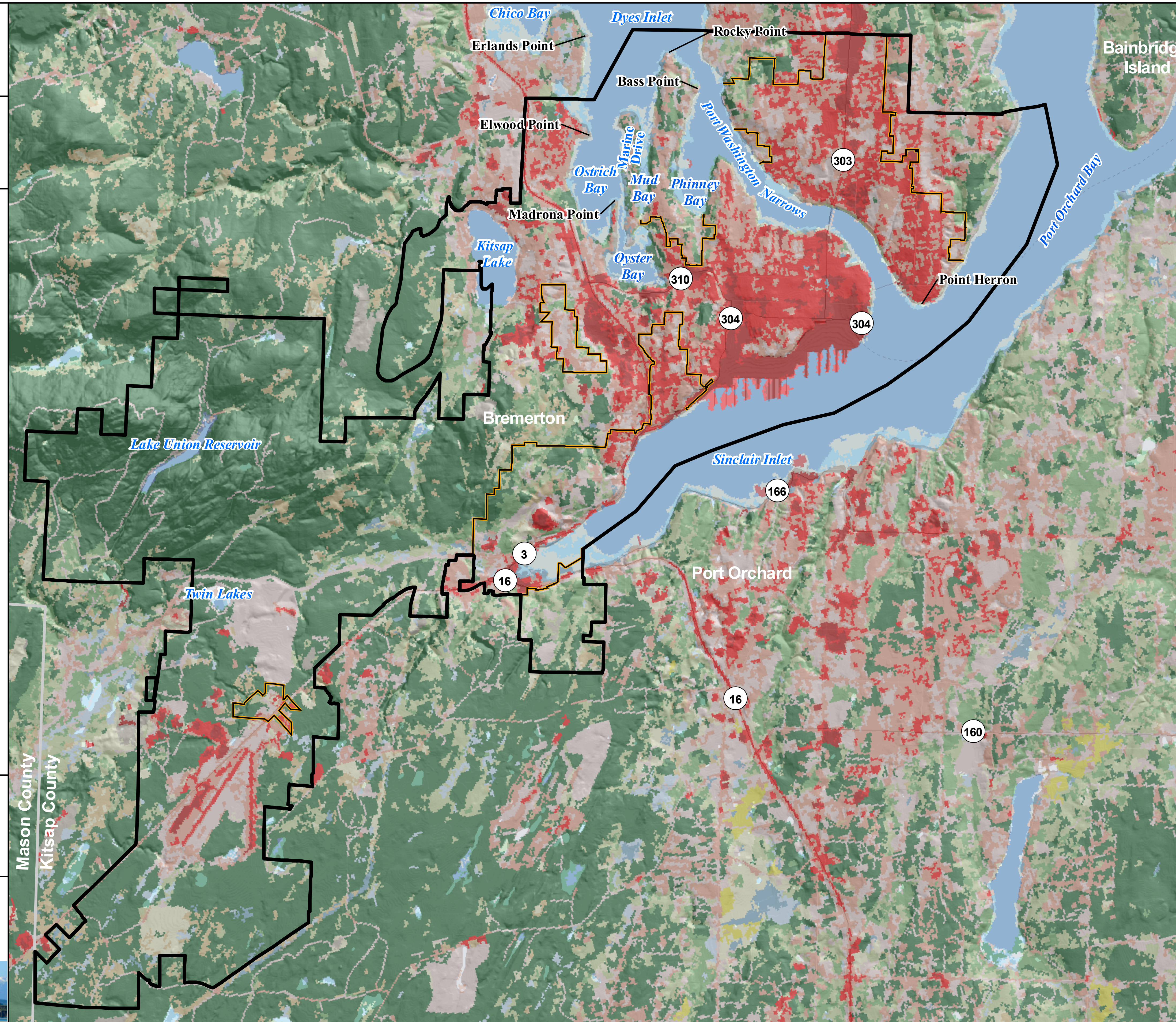
CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Landcover
Map 10

Legend

- Study Area
- City Boundary
- Road
- Waterbody
- County Boundary
- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Bare rock, sand, quarry, strip mine, gravel pit, transitional barren
- Deciduous forest
- Evergreen forest
- Mixed forest
- Scrub/Shrub
- Grasslands, herbaceous
- Pasture, hay
- Cultivated Crops



November 15, 2010

0 5,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f10_Landcover.mxd

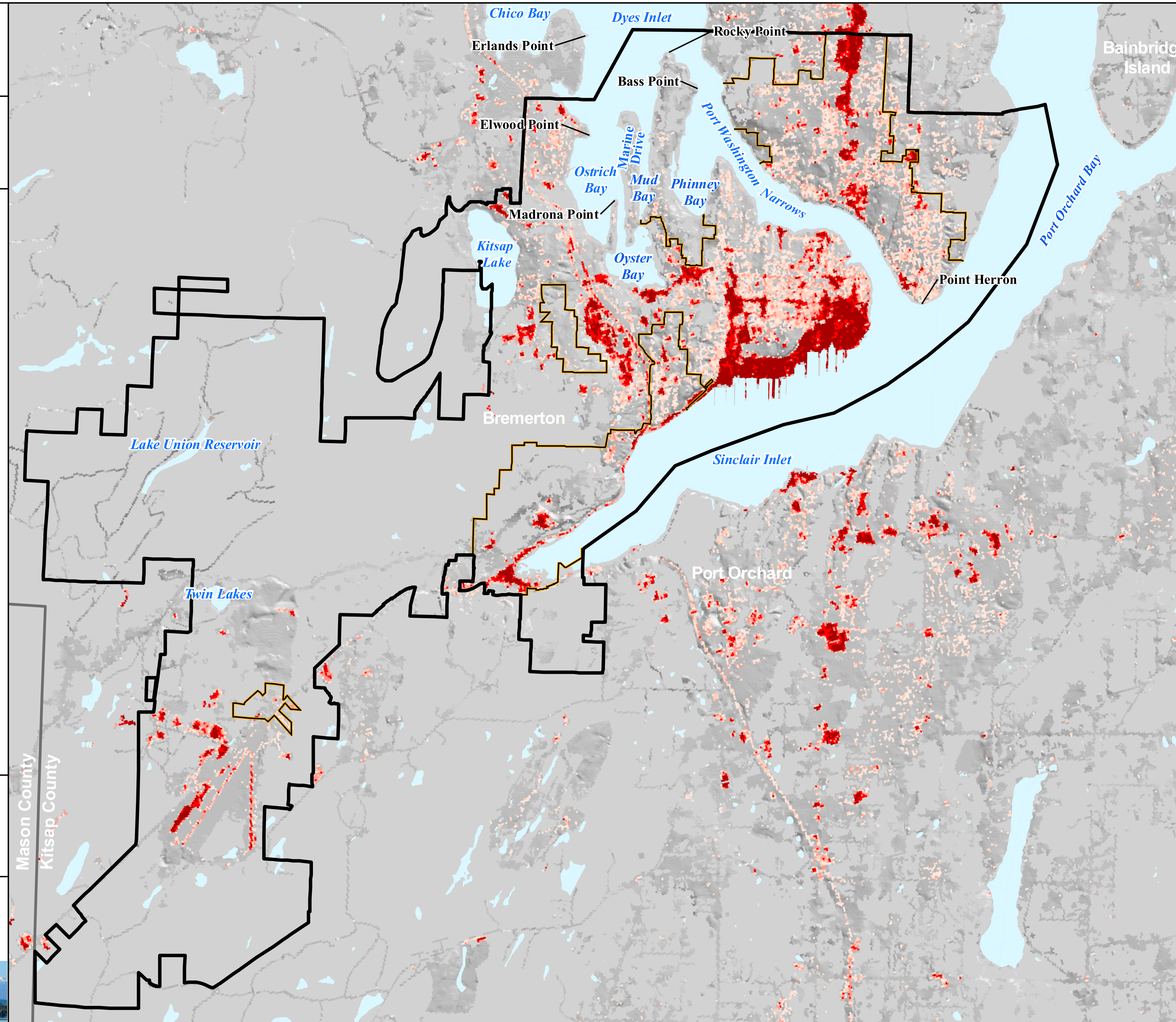
Data Sources: Kitsap County, City of Bremerton, United States Geological Survey (USGS), Parametrix, Washington Department of Natural Resources

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Impervious Surface
Map 11



Legend

- Study Area
- City Boundary
- County Boundary
- Waterbody

Percent Impervious

- < 50%
- 50-60%
- 60-70%
- 70-80%
- 80-90%
- 90-100%

November 15, 2010

0 5,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f11_ImperviousSurface.mxd

Data Sources: Kitsap County, City of Bremerton, United States Geololgical Survey (USGS), Parametrix, Washington Department of Natural Resources

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Water Quality Impairment and Sediment Contamination
Map 12

Legend

- Stormwater Outfall
- Study Area
- City Boundary
- Rivers and Streams
- Road
- County Boundary
- Waterbody
- Wetland (WDFW & NWI)

303d Waterbodies
- Dissolved Oxygen
- Fecal Coliform
- Mercury
- PCB
- Sediment Bioassay
- Temperature
- Total Phosphorus
- pH

305b Waterbodies
- 2
- 4A
- 4B
- 4C

Shellfish Growing Areas
- Conditional
- Prohibited

November 15, 2010

0 5,500
Scale in Feet

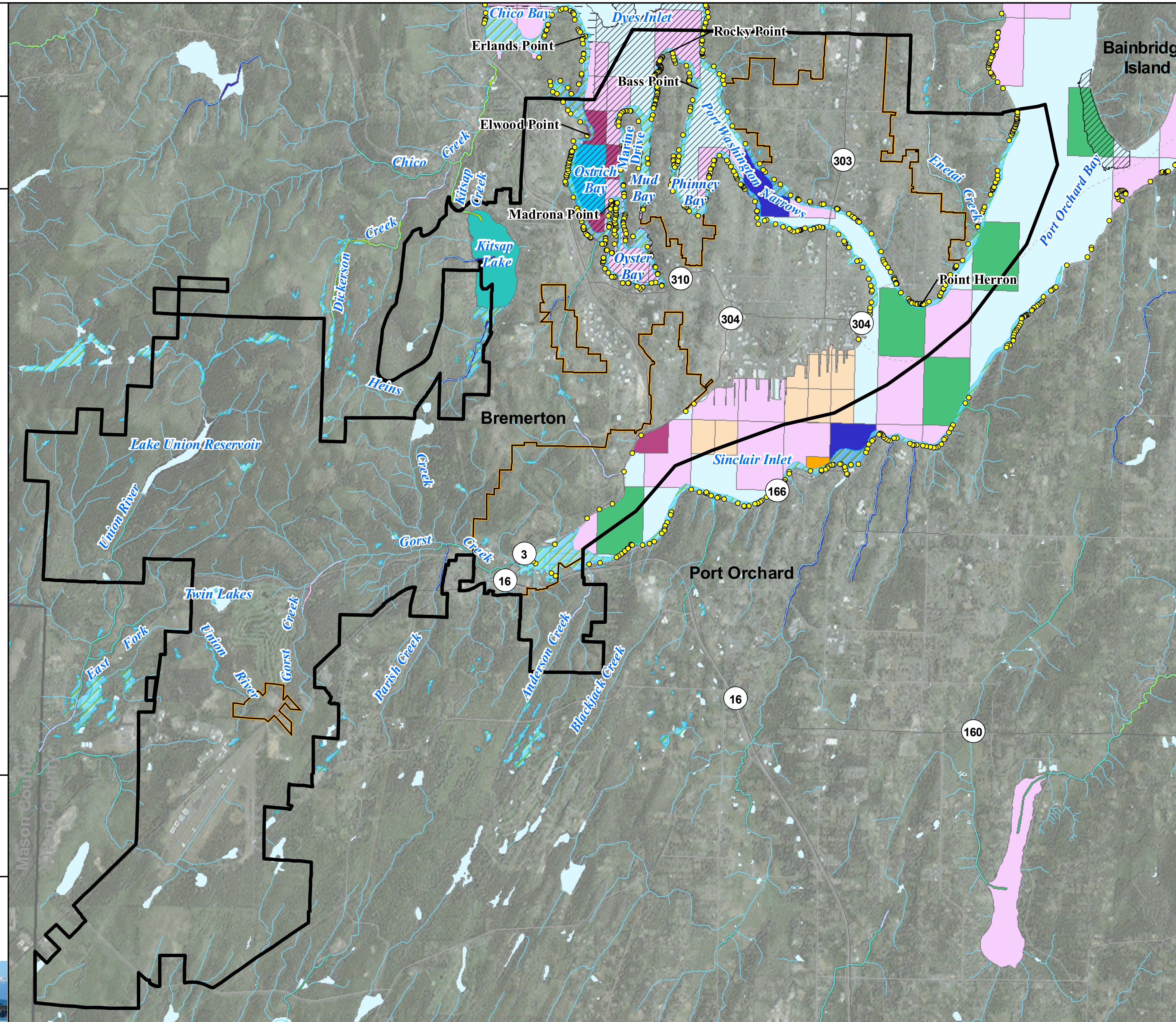
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f12_WaterQuality.mxd

Data Sources: Kitsap County, City of Bremerton, Parametrix, Washington Department of Ecology, Washington Department of Natural Resources, East Kitsap Nearshore Inventory (EKNI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Parks, Open Space and Public Land
Map 13

Legend

- City Boundary
- Urban Trail
- Shellfish Beach
- Rivers and Streams
- Road
- DNR Owned Aquatic Land
- County Boundary
- Waterbody
- Open Space Corridor
- Park/Open Space

Non-DNR Major Public Land Owner

- City or Municipal Government
- County Government
- US Federal Government
- Washington State

November 17, 2010

0 5,500

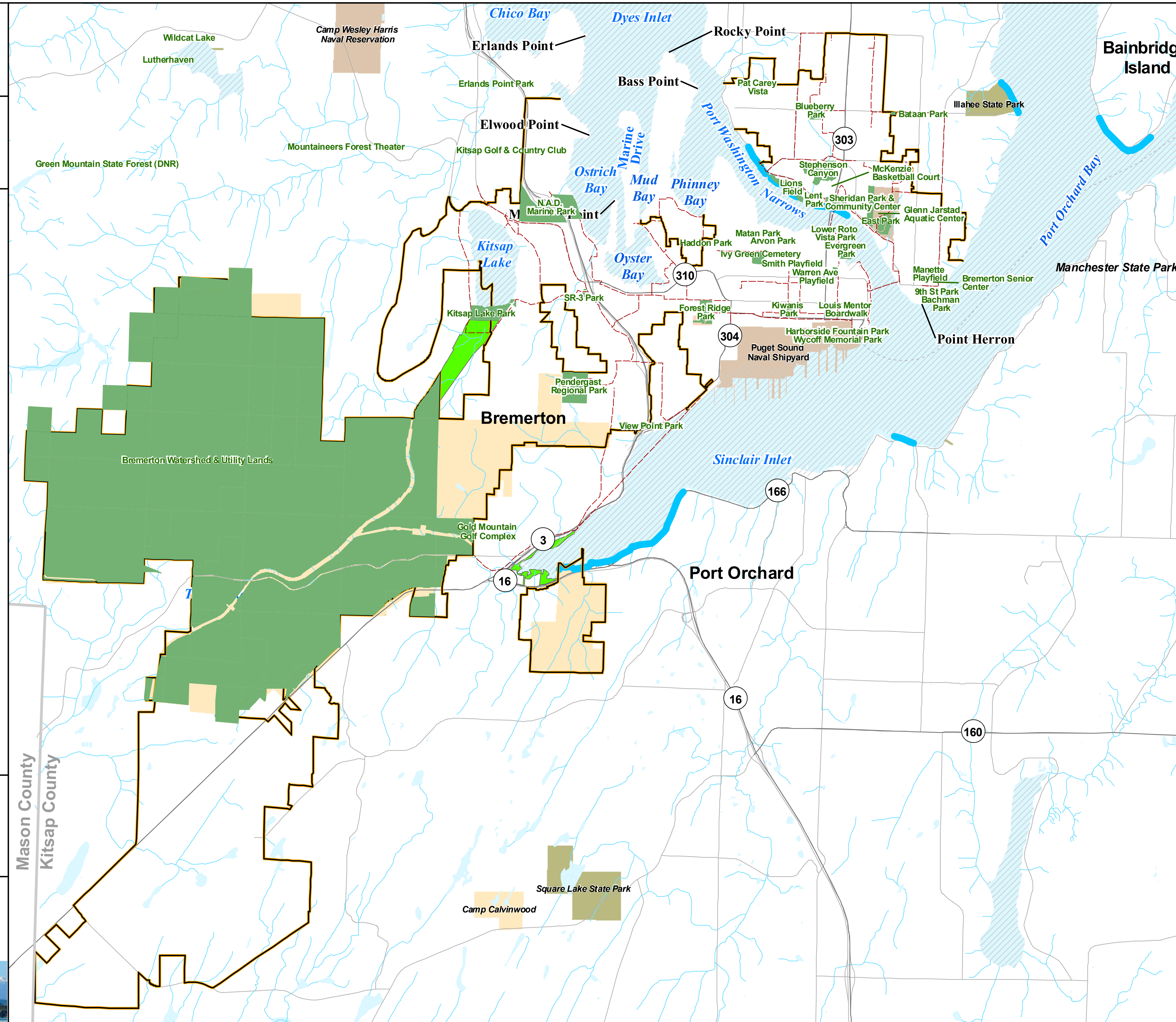
Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f13_ParksPublicLand.mxd

Data Sources: Kitsap County, City of Bremerton, Parametrix, Washington Department of Ecology, Washington Department of Natural Resources, East Kitsap Nearshore Inventory (EKNI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.



Shoreline Master Program Update
City of Bremerton

Comprehensive Plan
Landuse and Zoning
Map 14

Legend

- Study Area
- City Boundary
- Rivers and Streams
- Road
- Waterbody
- County Boundary
- Urban Growth Area
- City Parcel

Landuse

- Regional Center
- District Center
- Manufacturing/ Industrial Center
- Neighborhood Center
- Employment Center
- Low Density Residential
- City Core Residential
- Commercial Corridor
- Wheaton Way Redevelopment Corridor
- Limited Commercial
- Neighborhood Business
- Freeway Corridor
- Industrial
- Industrial Park
- Marine Industrial
- Higher Education
- Open Space
- Puget Sound Naval Shipyard
- Public Sector Redevelopment Site
- Watershed
- City Utility Lands
- Transportation, Utilities, and Public Facilities

November 15, 2010

0 5,500

Scale in Feet

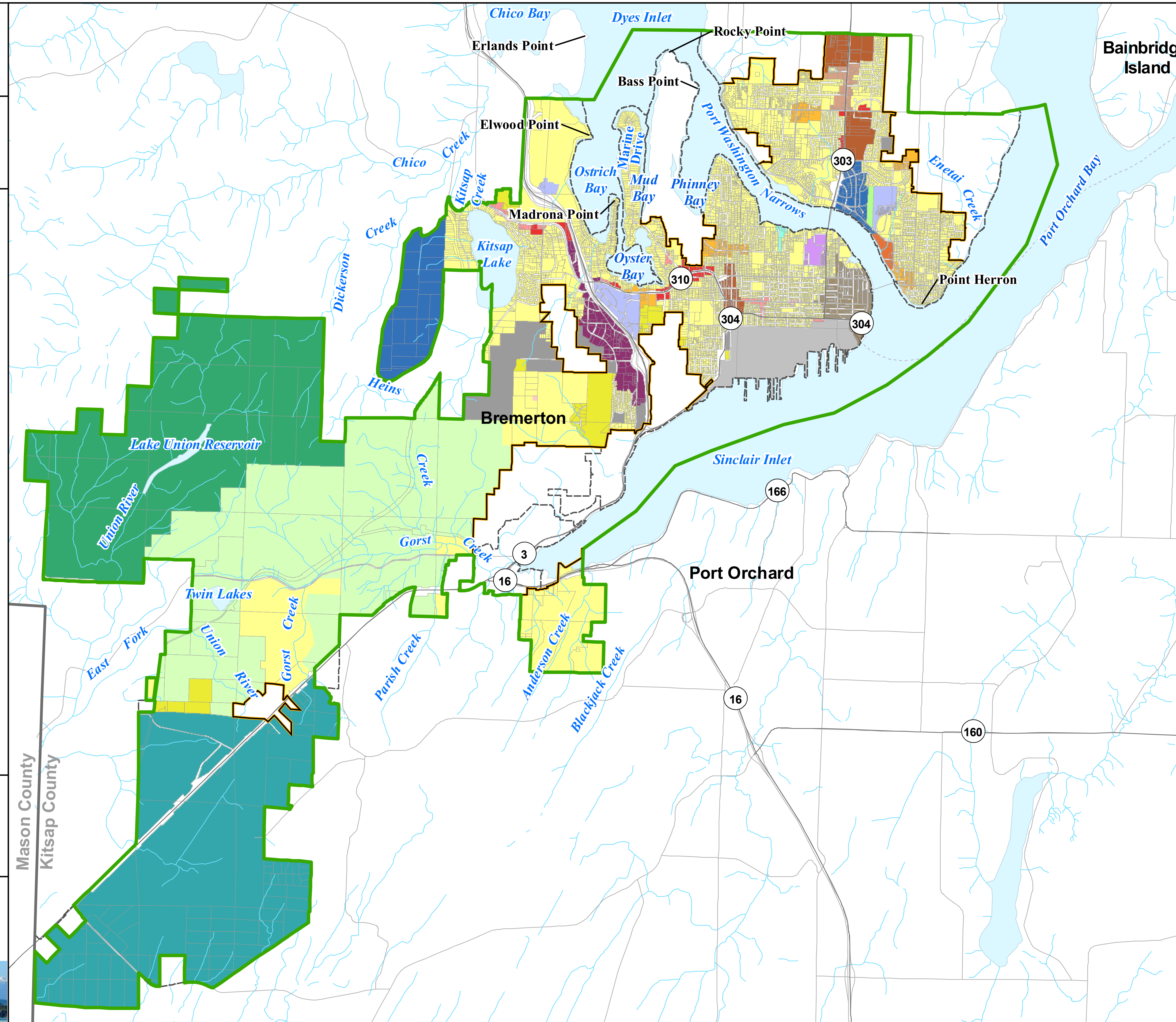
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f14_Landuse.mxd

Data Sources: Kitsap County, City of Bremerton, Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Shoreline Designations
Map 15

Legend

- Study Area
- Rivers and Streams
- City Boundary
- Road
- Waterbody
- County Boundary

Bremerton Shoreline Designations

- Urban Conservancy
- Urban Residential
- Urban Commercial
- Downtown Waterfront
- Urban Industrial
- Wetland (WDFW & NWI)

November 29, 2010

0 5,500

Scale in Feet

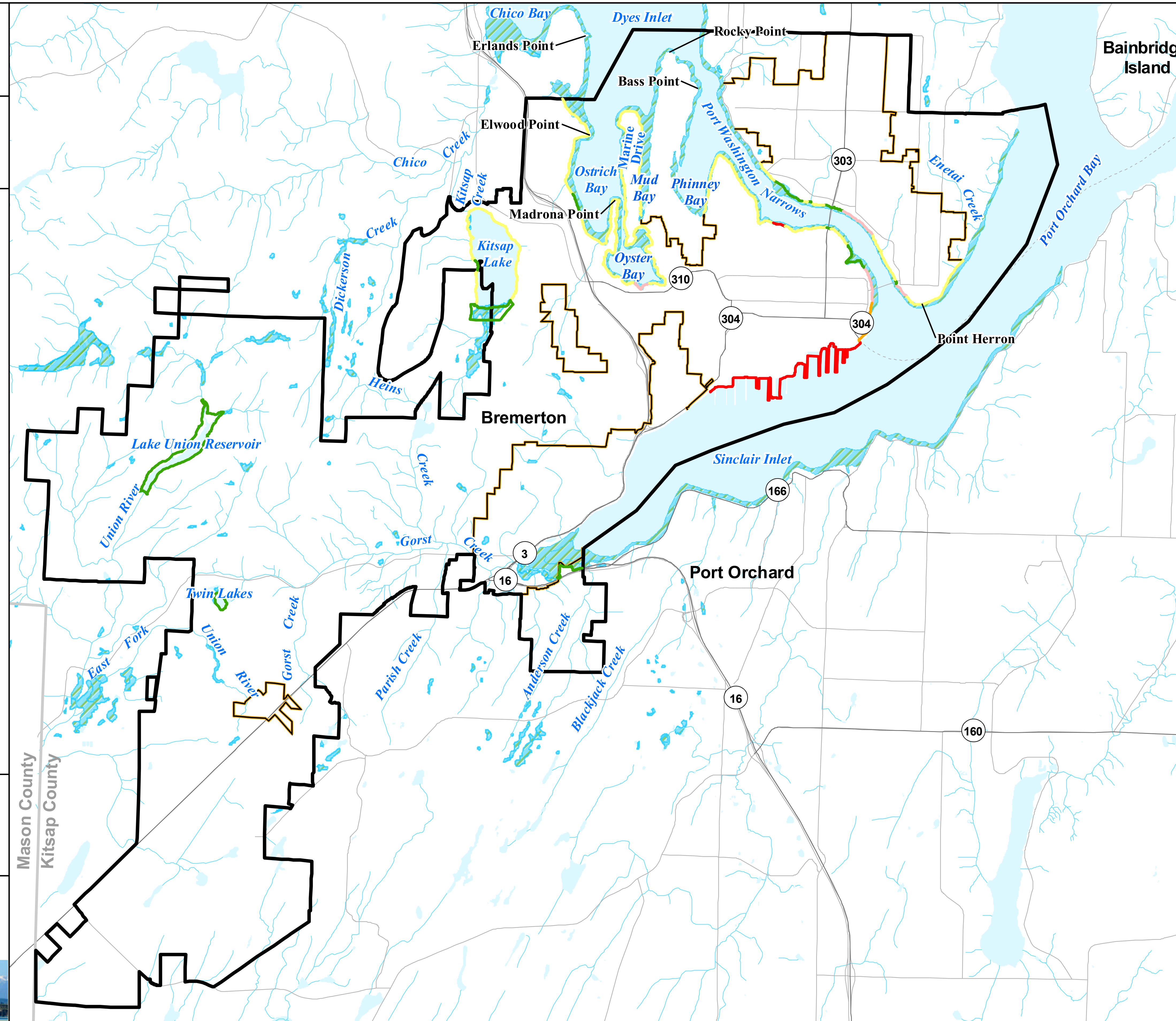
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f15_ShorelineDesignations.mxd

Data Sources: Kitsap County, City of Bremerton, Parametrix, Washington Department of Ecology, Washington Department of Natural Resources, Washington Department of Fish and Wildlife (WDFW) National Wetlands Inventory (NWI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

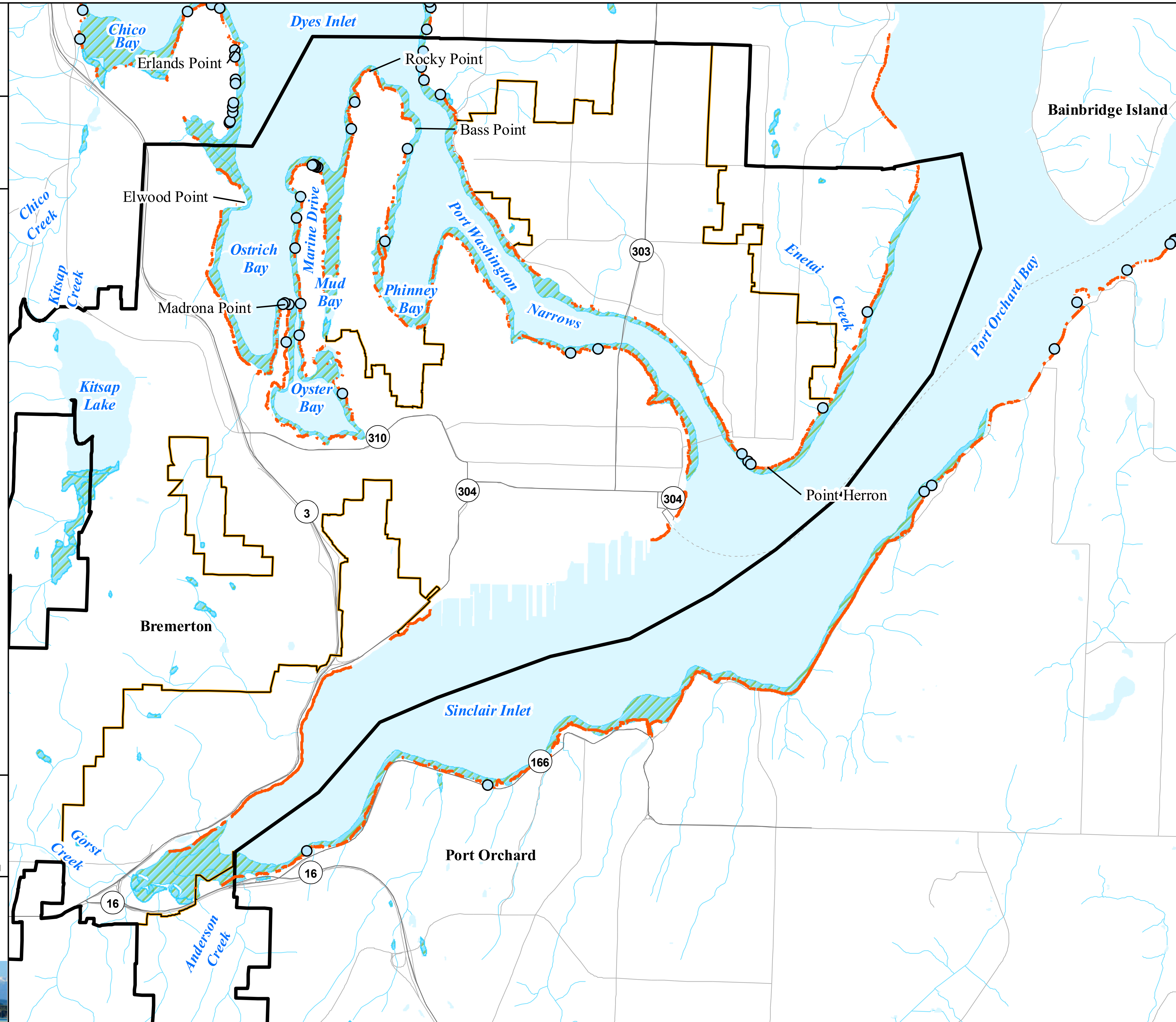


Shoreline Master Program Update
City of Bremerton

Shoreline Modifications
Armoring and Tidal Construction
Map 16A

Legend

- Tidal Construction
- Armoring
- Study Area
- Rivers and Streams
- City Boundary
- Road
- Waterbody
- Wetland (WDFW & NWI)



November 15, 2010

Scale in Feet: 0 – 3,500

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f16a_ShorelineModArmoring.mxd

Data Sources: Kitsap County, City of Bremerton, Parametrix, Washington Department of Natural Resources, East Kitsap Nearshore Inventory (EKNI), Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

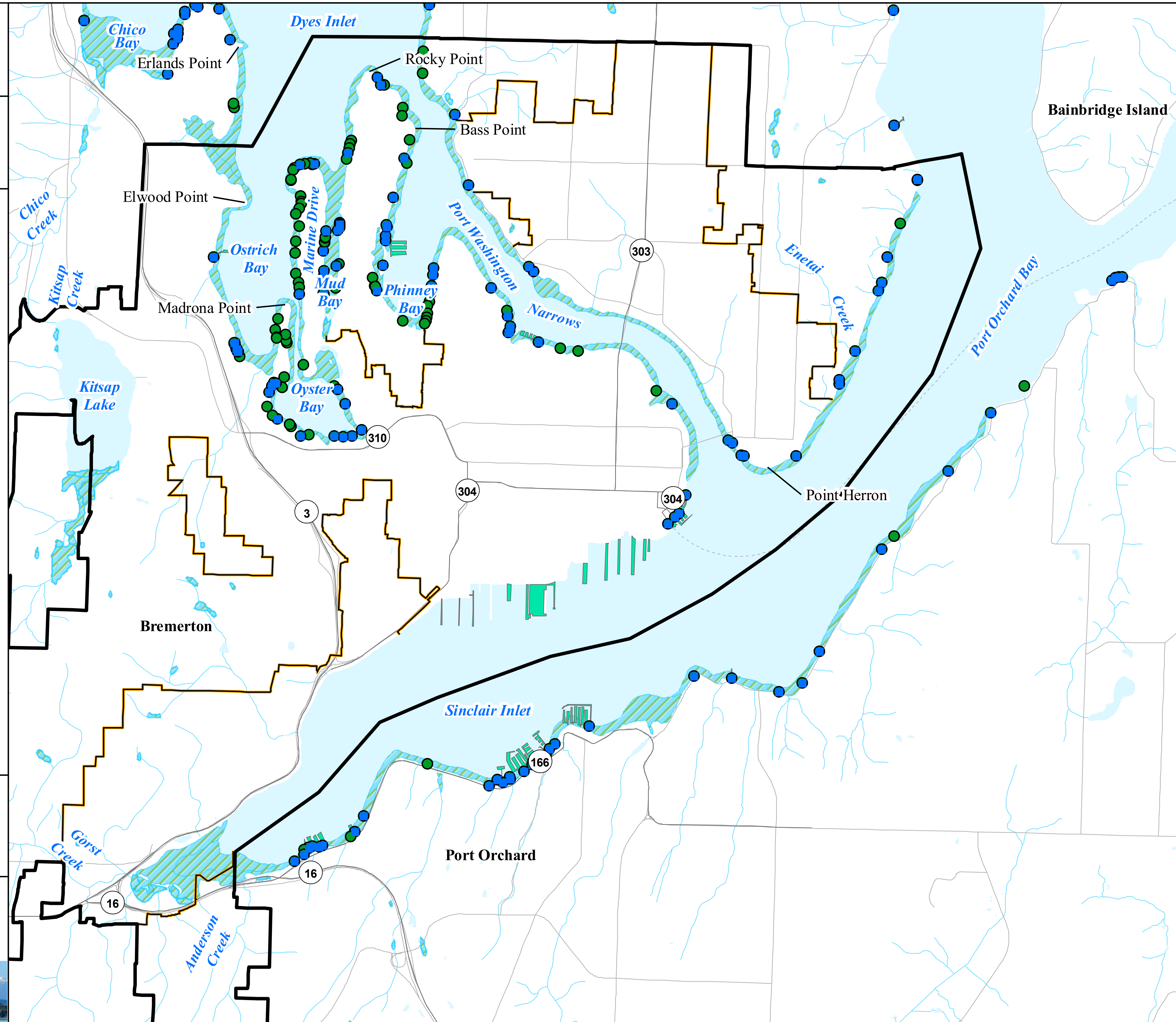
CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Shoreline Modifications
Piers, Docks, Floats, Overhanging Structures, and Large Docks/Marinas
Map 16B

Legend

- Overhanging Structure
- Piers, Docks and Floats
- Study Area
- Rivers and Streams
- City Boundary
- Road
- Large Docks and Marinas
- Waterbody
- Wetland (WDFW & NWI)



November 15, 2010

0 3,500

Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f16b_ShorelineModPiers.mxd

Data Sources: Kitsap County, City of Bremerton, Parametrix, Washington Department of Natural Resources, East Kitsap Nearshore Inventory (EKNI), Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI)

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

Shoreline Master Program Update
City of Bremerton

Shoreline Modifications
Pilings and Boat Launches
Map 16C

Legend

- Pilings
- Boat Launches
- Study Area
- Rivers and Streams
- City Boundary
- Road
- Waterbody
- Wetland (WDFW & NWI)

November 15, 2010

0 3,500

Scale in Feet

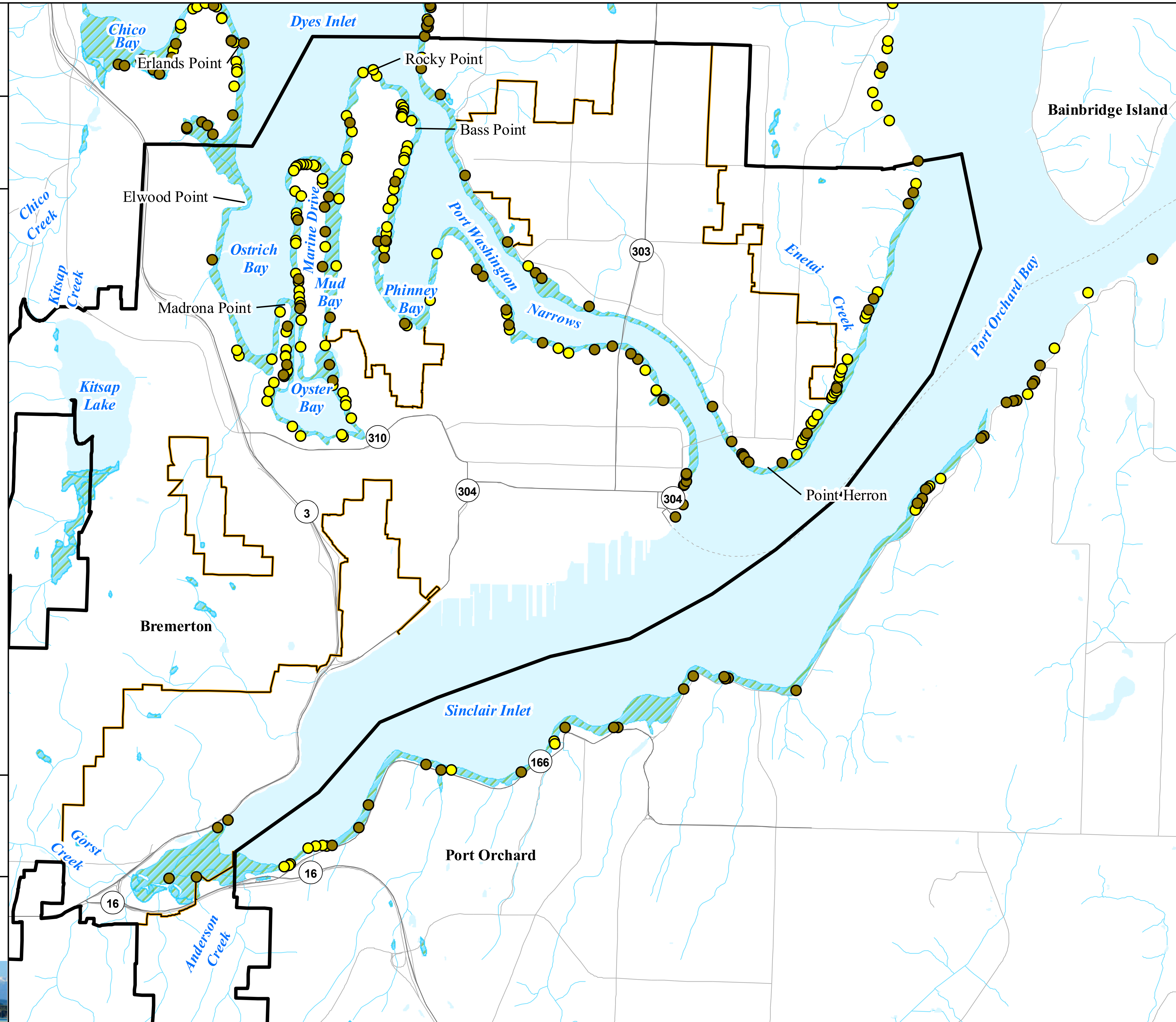
N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f16c_ShorelineModPilings.mxd

Data Sources: Kitsap County, City of Bremerton, Parametrix, Washington Department of Natural Resources, East Kitsap Nearshore Inventory (EKNI), Washington Department of Fish and Wildlife (WDFW), National Wetland Inventory (NWI)

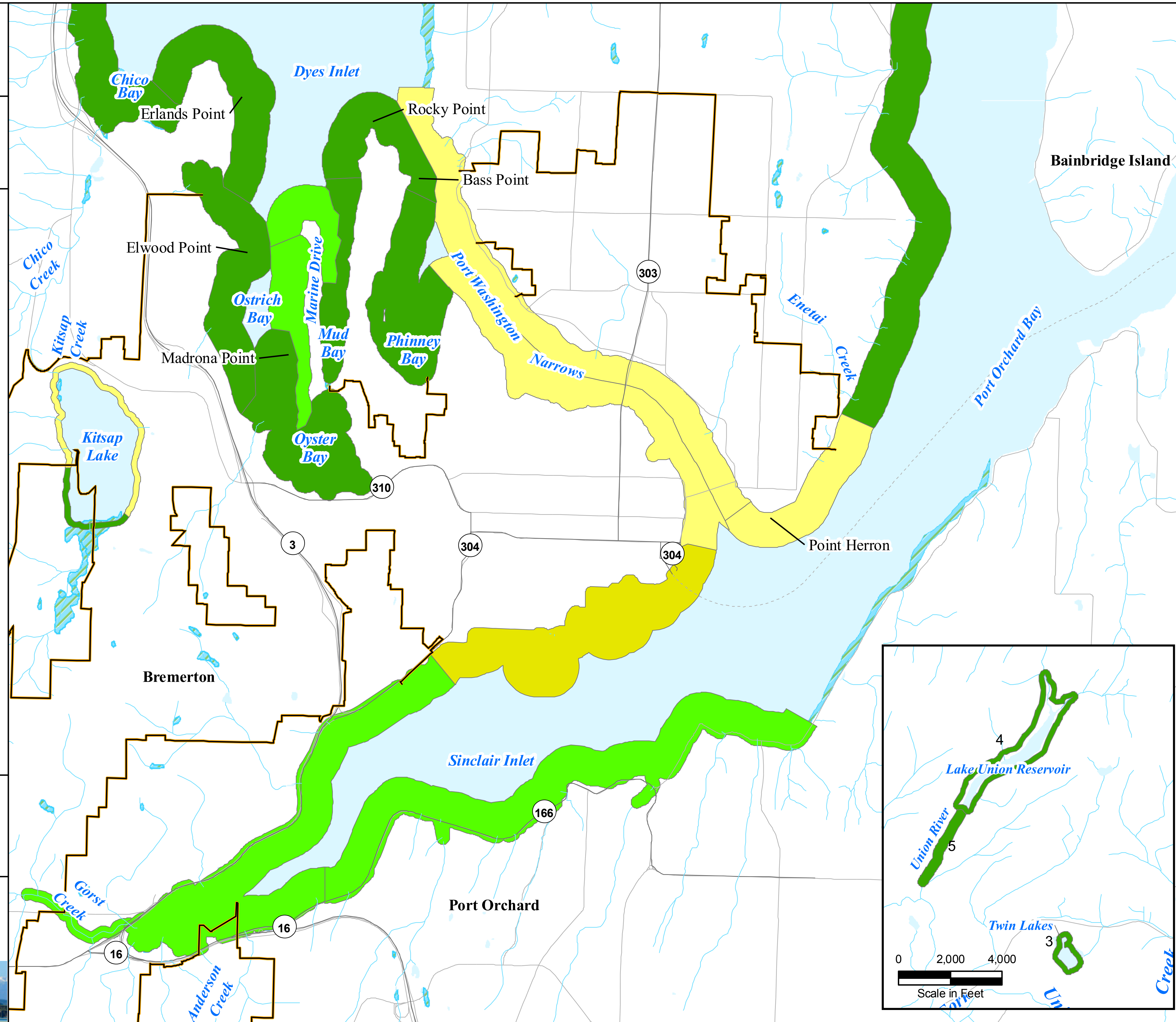
Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON



Shoreline Master Program Update
City of Bremerton

Ecological Function Ranking
Map 17



Legend

- Rivers and Streams
- Road
- City Boundary
- Waterbody
- Wetland (WDFW/NWI)

Ecological Function Ranking

- High
- Medium
- Medium to Low
- Low

November 10, 2010

0 3,500
Scale in Feet

N

K:\gis\1896_bremertonSMP\mapdocs\InventoryMaps\Revisions102810\f17_EcologicalFuncRanking.mxd

Data Sources: Kitsap County, City of Bremerton, East Kitsap Nearshore Inventory (EKNI), Parametrix

Note: Shoreline jurisdiction boundaries depicted on this map are approximate and are intended for planning purposes only. Additional site-specific evaluation may be needed to confirm/verify information shown on this map.

CITY OF BREMERTON

APPENDIX A

Shoreline Photos

Rocky shoreform and small inlet at Bass Point (Ecology, Washington Coastal Atlas).

Barrier estuary in Phinney Bay. Spit has been developed and a channel cut across the spit (Ecology, Washington Coastal Atlas).

Barrier lagoon/pocket estuary in Chico Bay. Sand spits partially enclose the inlet; tidal flows maintain salt marsh, flats, and distributary channels (Ecology, Washington Coastal Atlas).

Bluff-backed beaches with high bluffs, Port Washington Narrows. Unstable or eroding bluff faces (little or no vegetation where slides occur) provide sediment source for beach (Ecology, Washington Coastal Atlas).

Artificial shoreforms associated with the Puget Sound Naval Shipyard. Fill, armoring, and overwater structures on the shoreline and within nearshore intertidal and subtidal areas (Ecology, Washington Coastal Atlas).

Embayment – coastal inlet with fringing marsh and mudflats – Ostrich Bay (Ecology, Washington Coastal Atlas).

Lakes (Google Earth, 2009).

Depressional wetlands (Google Earth, 2009).

Recent slide areas – bluffs along Port Washington Narrows (Ecology, Washington Coastal Atlas).

Shoreline armoring; bulkheads and fill in the upper intertidal (Ecology, Washington Coastal Atlas).

Fill, overwater structures, and armoring (bulkheads, riprap) in the intertidal beach south of Manette Bridge (Ecology, Washington Coastal Atlas).

Bluffs with recent slide areas, near Phinney Bay (Ecology, Washington Coastal Atlas).

APPENDIX B

Matrix of Processes and Stressors

	Landscape Processes																										
Stressor	Water Delivery	Water Movement	Water Storage	Water Loss	Tidal Flows	Freshwater Input	Sediment Supply/Delivery	Sediment Transport	Sediment Accretion, Deposition, Storage	Distributary Channel Migration	Tidal Channel Formation & Maintenance	Channel Migration	Floodplain Connectivity	Nearshore Connectivity	Habitat Connectivity	Nitrogen Delivery	Nitrogen Cycling/Retention	Phosphorous Delivery	Phosphorous Cycling /Retention	Pathogen/Toxin Retention or Processing	Carbon Cycling	LWD Delivery and Movement	Organic Matter Import and Export	Exchange/Movement of Organisms	Disturbance Regime	Solar Incidence/Light Energy	Invasive Species Establishment
Land Cover/Loss of Forests	✓	✓		✓		✓	✓								✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓
Impervious Surfaces	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓					✓	
Dams		✓	✓	✓	✓			✓		✓	✓	✓	✓		✓							✓		✓	✓		
Stream Crossings/Culverts		✓			✓			✓	✓	✓	✓	✓	✓	✓	✓							✓		△			
Channel Confinement/ Disconnection of Floodplains		✓	✓				✓	✓			✓	✓		✓		✓			✓	✓		✓	✓	✓	✓		

	Landscape Processes																										
Stressor	Water Delivery	Water Movement	Water Storage	Water Loss	Tidal Flows	Freshwater Input	Sediment Supply/Delivery	Sediment Transport	Sediment Accretion, Deposition, Storage	Distributary Channel Migration	Tidal Channel Formation & Maintenance	Channel Migration	Floodplain Connectivity	Nearshore Connectivity	Habitat Connectivity	Nitrogen Delivery	Nitrogen Cycling/Retention	Phosphorous Delivery	Phosphorous Cycling /Retention	Pathogen/Toxin Retention or Processing	Carbon Cycling	LWD Delivery and Movement	Organic Matter Import and Export	Exchange/Movement of Organisms	Disturbance Regime	Solar Incidence/Light Energy	Invasive Species Establishment
Fill – filling of wetlands/floodplains/ estuaries/marshes/ beaches/ nearshore	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		
Water Quality – nutrients, pollutants, pathogens																✓	✓	✓	✓	✓						✓	✓
Roads (esp. nearshore and adjacent to rivers/streams) **Railroad**	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓		✓	✓	✓			✓
Tidal barriers					✓	✓		✓	✓	✓	✓		✓	✓								✓	✓	✓	✓	✓	
Shoreline Armoring		✓	✓				✓			✓	✓	✓	✓	✓	✓							✓	✓	✓	✓	✓	
Overwater structures **Marinas**		✓			✓			✓	✓						✓	✓								✓		✓	

	Landscape Processes																										
Stressor	Water Delivery	Water Movement	Water Storage	Water Loss	Tidal Flows	Freshwater Input	Sediment Supply/Delivery	Sediment Transport	Sediment Accretion, Deposition, Storage	Distributary Channel Migration	Tidal Channel Formation & Maintenance	Channel Migration	Floodplain Connectivity	Nearshore Connectivity	Habitat Connectivity	Nitrogen Delivery	Nitrogen Cycling/Retention	Phosphorous Delivery	Phosphorous Cycling /Retention	Pathogen/Toxin Retention or Processing	Carbon Cycling	LWD Delivery and Movement	Organic Matter Import and Export	Exchange/Movement of Organisms	Disturbance Regime	Solar Incidence/Light Energy	Invasive Species Establishment
Jetties/ Breakwaters/ Groins								✓	✓					✓	✓							✓	✓	✓			
Water Diversions/Withdrawals		✓	✓	✓	✓	✓	✓	✓	✓															✓			✓
Invasive Species		✓	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓			✓