The City of Normandy Park Shoreline Inventory and Characterization Report

June 2011

Prepared for the City of Normandy Park by:

King County Water and Land Resources Division
201 South Jackson Street, Suite 600
Seattle, Washington 98104

King County

Department of
Natural Resources and Parks
Water and Land Resources Division

Alternate Formats Available

206-296-6519 TTY Relay: 711

TABLE OF CONTENTS

INTRODUCTION 1
Background and Purpose 1
Overview of the Shoreline Management Act 1
Shoreline Management Jurisdiction 1
Shoreline Planning Segments 2
Report Organization 2
METHODOLOGY 3
Data Sources 3
Approach to Inventory Characterization of Processes and Shoreline Functions 4
REGULATORY CONTEXT 5
LAND USE PATTERNS 7
WATERSHED CHARACTERIZATION 10
Climate 10
Topography, Geology, Soils 10
Land Cover (Vegetation), Wetlands and Imperviousness 11
Hydrology (Surface water, Groundwater, Floodplains) 12
Water Quality 13
Coastal Processes 13
Littoral Drift Cells 13
Shoretypes and Shoreline Modifications 15
Coastal Wetlands 19
Tides 19
Wave Energy/Exposure 20
Sea Level Rise 21
Light Energy 21
REACH LEVEL CHARACTERIZATION 22
Segment 1 (Des Moines Beach) 25
Physical 26
Biological 27
Segment 2 (Marine View Park/Beaconsfield) 28
Physical 28
Biological 29
Segment 3 (Beaconsfield to Edgecliff) 31
Physical 32

Biological 33
Segment 4 (Edgecliff) 33
Physical 34
Biological 35
Segment 5 (Edgecliff to the Cove) 35
Physical 36
Biological 38
Segment 6 (North City Limits) 38
Physical 39
Biological 39
RESTORATION/PRESERVATION OPPORTUNITIES 40
Segment 1 41
Segment 2 41
Segment 3 43
Segment 4 44
Segment 5 44
Segment 6 46
DATA GAPS 46
REFERENCES 47
GLOSSARY 51
ACRONYMS 55
Appendix 1 Maps 57
Appendix 2. Data Sources Table 59

TABLES

Table 1 City of Normandy Park's Planning Segments 3
Table 2. Totals and percentages of various land cover classes within the City of Normandy Park based on 2007 Landsat imagery. 11

FIGURES

Figure 1. Direction of sediment drift towards the sign in the background of the picture. 14
Figure 2. Tidal range for spawning forage fish species (From WDFW). 24
Figure 3. Development pattern in Segment 1 also shows that residents regularly drive on the beach in order to access their houses. 26
Figure 4. Drift log accumulations in Marine View Park. 31
Figure 5. Example of the the development pattern throughout this reach 34
Figure 6. Wetland complex at the mouth of Miller and Walker Creeks.....36
Figure 7. Removal of the bulkheads at Beaconsfield is ideal candidates for restoration 42
Figure 8. The unnamed stream constrained at the mouth by two houses 43
Figure 9. Potential preservation area located in the left of the photograph. The potential restoration project is located along the right side of the photograph 44
Figure 10. Groin in the foreground could be removed to improve sediment transport processes. 45
Figure 11. Outlet of Miller and Walker Creeks. 46

Appendix 1

- Map 1 Vicinity map
- Map 2 Shoreline jurisdiction
- Map 3 Public Access Opportunities
- Map 4 Lidar/Topography
- Map 5 Land Cover
- Map 6 Impervious Surfaces
- Map 7 Streams, Basin Boundaries and Floodplains
- Map 8 Drift Cell Map
- Map 9 Shoreline Armoring.
- Map 10 Shoretype-Current (onshore) and Historic (offshore)
- Map 11 Current and Historic wetlands
- Map 12 Shoreline Segments
- Map 13 Reach 1
- Map 14 Reach 1 Physical-Geologic Features
- Map 15 Reach 1 Physical-Coastal Features
- Map 16 Reach 1 Biological Features
- Map 17 Reach 2
- Map 18 Reach 2 Physical-Geologic Features
- Map 19 Reach 2 Physical-Coastal Features
- Map 20 Reach 2 Physical-Hydrologic Features
- Map 21 Reach 2 Biological Features
- Map 22 Reach 3
- Map 23 Reach 3 Physical-Geologic Features
- Map 24 Reach 3 Physical-Coastal Features
- Map 25 Reach 3 Physical-Hydrologic Features
- Map 26 Reach 3 Biological Features
- Map 27 Reach 4
- Map 28 Reach 4 Physical-Geologic Features
- Map 29 Reach 4 Physical-Coastal Features
- Map 30 Reach 4 Biological Features
- Map 31 Reach 5
- Map 32 Reach 5 Physical-Geologic Features
- Map 33 Reach 5 Physical-Coastal Features
- Map 34 Reach 5 Physical-Hydrologic Features
- Map 35 Reach 5 Biological Features
- Map 36 Reach 6
- Map 37 Reach 6 Physical-Geologic Features
- Map 38 Reach 6 Physical-Coastal Features
- Map 39 Reach 6 Biological Features
- Map 40 Restoration and Preservation Opportunities

INTRODUCTION

Background and Purpose

The purpose of this report is to provide both an inventory and characterization of existing conditions within the shoreline jurisdiction of the City of Normandy Park (City). This information will be used to provide context for how the City will update its Shoreline Master Program (SMP), which is required to comply with the Shoreline Management Act (SMA), Revised Code of Washington (RCW) 90.58 and its implementing guidelines, Washington Administrative Code 173-26. The City's current SMP can be found online at Title 16. The City is updating its SMP with support from a grant (grant number G1000008) from Washington Department of Ecology (Ecology). The development of the inventory and characterization report is the first major step in the process of updating the City's SMP.

Overview of the Shoreline Management Act

The SMA was adopted through a public referendum in 1972. The SMA was created in response to concerns related to unplanned and uncoordinated development occurring along the shorelines of the state. It has three overarching goals (RCW 90.58.020):

1. Encourage water-dependent uses
2. Protect natural shoreline resources
3. Promote public access

The Act recognizes that "the shorelines of the state are among the most valuable and fragile of its natural resources" (RCW 90.58.020). Ecology is responsible for adopting guidelines that each jurisdiction must follow when updating their Shoreline Master Program (SMP). After adopting a set of guidelines in the 1970s, Ecology did not substantially change the guidelines until 2003. The 2003 guidelines require that SMPs do not result in a net loss of current and potential ecological functions necessary to sustain shoreline natural resources. The guidelines also reinforce the SMA goal of improving the overall condition of habitat and resources within the shoreline area (WAC 173-26-201(2)(c)).

Shoreline Management Jurisdiction

The SMA has jurisdiction over three main shoreline areas; marine shorelines, streams with mean annual flow greater than 20 cubic feet per second (cfs), and lakes with a surface area greater than 20 acres. These areas are known as "shorelines of the state." The jurisdiction extends 200 feet landward of the ordinary high water mark (OHWM), which is technically called "shorelands," as well as any associated wetlands. Associated wetlands are those wetlands that are in proximity to and either influence or are influenced by tidal waters subject to the SMA (RCW 90.58.030). Associated wetlands can extend the shorelands beyond the standard 200 foot jurisdiction. The SMA has a second category of jurisdiction, "shorelines of statewide significance." In western Washington, this category is defined as rivers with a mean annual flow of 1,000 cfs or greater, freshwater lakes with a surface area of 1,000 acres or more, and portions of Puget Sound. The Act intends that these areas be recognized and protected as a statewide resource.

None of the City's streams or lakes are classified as "shorelines of state" or "shorelines of statewide significance" since they are too small. The upland portion of the roughly 3.4 miles of marine shoreline along Puget Sound is classified as "shorelines of the state." There are two mapped associated wetlands within this shoreline. Around these two wetlands, the shoreline jurisdiction extends landward beyond the minimum 200 feet required. Based on the criteria in the SMA, the area waterward of the extreme low tide line is considered "shorelines of statewide significance."

Normandy Park has chosen not to cover associated wetland buffers under its SMP. It has also chosen not to manage coastal floodplain areas under its SMP. Both of these issues will be managed under the City's Critical Areas Ordinance. The City will decide how to address critical areas that are outside of SMP jurisdiction but overlap with critical areas that are within SMP jurisdiction in the near future.

Shoreline Planning Segments

The City of Normandy Park is located along the shores of Puget Sound between the City of Burien to the north and northeast and the City of Des Moines to the south and southeast (Map 1). The City is approximately1,600 acres in size. It is extends along the shores of Puget Sound, with a shoreline 3.5 miles long, but with an average width of only about three quarters of a mile. The approximate extent of the City's shoreline jurisdiction is shown in Map 2, and makes up the planning area for this effort. The shoreline jurisdiction of the City was broken into 6 segments using zoning, land use patterns, and geologic data. A general description, including extent, is included in Table 1.

Report Organization

The report is organized into six main sections. The first section describes the methodology used to construct the report. The second section provides a brief description of the regulatory context that the SMP is part of. The third section describes the basic land use patterns that occur within the City. The fourth section describes the larger watershed context within which the City sits. This section describes the larger characteristics of the landscape that affect ecosystem-wide processes. The fifth section is a reach by reach description of the ecologically important attributes of shoreline segments and how various anthropogenic activities have impacted these attributes/functions. The final section is a reach by reach description of the various preservation and restoration opportunities that exist within the City. Tables and figures are located within the body of the report while maps are located in Appendix 1. Appendix 2 contains the list of data sources reviewed as part of writing this report.

Table 1 City of Normandy Park's Planning Segments

Segment Name	Reach Number	Length (ft)	General description
Des Moines Beach	1	1,487	This reach extends north from the City's southern boundary with Des Moines to the last house that was built on the beach.
Marine View Park/Beaconsfield	2	5,745	This reach extends north from reach 1 to end of R15 zoning.
Beaconsfield to Edgecliff	3	2,140	This reach contains mostly low bank accretionary shoreline and begins the R20 zoning that extends north through the rest of the city.
Edgecliff	4	3,540	This reach contains high bank shoreline, vegetated slopes, with houses at the top of the bluff.
Edgecliff to the Cove	5	4,693	This reach is mostly low bank shoreline, with houses located within 100 feet of a mostly bulkheaded shore
North City Limits	6	764	This reach extends from the mouth of Miller/Walker Creek to the northern city boundary with Burien
	Total	18,369	Approximately 1.5 miles of shoreline is in R15 zoning with another 2 miles in R20 zoning

METHODOLOGY

Data Sources

A large number of reports and data sources were reviewed and compiled to create this inventory and characterization.

The reports included:

- Chrzastowski, M. J., 1982. Net shore drift of King County, Washington: Western Washington University Master of Science Thesis, 153p., 1 plate.
- Johannessen, J.W., MacLennan, A., and McBride, A, 2005. Inventory and Assessment of Current and Historic Beach Feeding Sources/Erosion and Accretion Areas for the Marine Shorelines of Water Resource Inventory Areas 8 & 9, Prepared by Coastal Geologic Services, Prepared for King County Department of Natural Resources and Parks, Seattle, WA.

- Anchor Environmental, L.L.C., 2004. Marine Shoreline Inventory Report. Prepared for Seattle Public Utilities and WRIA 9.
- Anchor Environmental, L.L.C 2006. Final Report: Prioritization of Marine Shorelines of Water Resource Inventory Area 9 for Juvenile Salmonid Habitat Protection and Restoration. Prepared for Water Resource Inventory Area 9 Technical Committee.
- King County Department of Natural Resources, 2007. Technical Appendix: Shoreline Inventory and Characterization Methodology and Results.
- BHC Consultants, 2007. Memorandum: Normandy Park Critical Areas Development Regulations Update (Best Available Science). 31 p.
- Washington Trout Water Type Survey Results South King County (2004)

Many geographic information system (GIS) data sources were reviewed for this effort. Data sets from Johannessen et al. (2005), Anchor Environmental (2004), Shorezone (2000), PSNERP (2009), and Washington Department of Fish and Wildlife (WDFW) Priority Habitat and Species (PHS) (2010) were used extensively to describe the condition of the shoreline. A complete list of the data sources reviewed for this report is available in Appendix B.

Various maps and older aerial photography were assessed as part of this report. The maps and photographs include the following:

- Topographic "T-sheet" Coastal Mapping; U.S. Coastal Survey, 1876-1877.
- Vertical aerial photography by King County, 1936.
- Vertical and oblique aerial photography by Washington Department of Ecology, 1977.
- Oblique aerial photography by Washington Department of Ecology, 2000 and 2006.
- Vertical aerial ortho-photography by King County, 2002, 2005, 2007, 2009.

Information on cultural and historic resources came from the King County Historic Preservation Program GIS data and the Washington Office of Archaeology and Historic Preservation.

Approach to Inventory Characterization of Processes and Shoreline Functions

SMA guidelines require that this report evaluate ecosystem wide processes as part of the SMP update. Ecology states, "Ecosystem-wide processes refer to dynamic physical and chemical interactions that form and maintain natural landscapes… Ecosystem or watershed processes occur over larger landscapes that include both the shoreline and watersheds draining to the shoreline" (Ecology 2010). The section on watershed characterization describes many of the physical processes that are occurring throughout the City and beyond at a larger level. It also explains how those processes are affected by human activities. The reach level characterization section provides a more in depth look at those processes and how a specific reach of shoreline functions both physically and biologically.

REGULATORY CONTEXT

Current Shoreline Management Act Compliance

The Shoreline Management Act is implemented through the development of local Shoreline Master Programs (SMP). The City of Normandy Park adopted regulations contained in Ordinance No. 539 (December 15, 1991) as its Shoreline Master Program. Goals and policies are incorporated into the City of Normandy Park 2004 Comprehensive Plan as Objective 1.13: Shoreline Protection. Development regulations contained in the SMP are adopted as part of the City of Normandy Park Municipal Code Title 16.

Local SMP's establish a system to classify shoreline areas into specific "environment designations." The purpose of shoreline environment designations is to provide a uniform basis for applying policies and use regulations within distinctly different shoreline areas. Generally, environment designations should be based on existing and planned development patterns, biological and physical capabilities and limitations of the shoreline, and a community's vision or objectives for its future development. During development of its first SMP in 1991, the City evaluated the natural and built characteristics of its shoreline jurisdiction and developed a single shoreline environment designation:

- Rural residential (running the entire length of the City's shoreline).

According to Substitute Senate Bill (SSB) 6012, passed by the 2003 Washington State Legislature, cities within King County are required to amend their local shoreline master programs consistent with the Department of Ecology's revised guidelines. The City of Normandy Park is conducting a comprehensive SMP update to comply with Ecology's revised guidelines. Support is provided by an Ecology grant (SMP Grant No. G01000008).

This baseline inventory and analysis will inform development of the goals and policies and will provide a basis for the update of shoreline environment designations during the comprehensive SMP update process, anticipated to occur through June 2012.

Comprehensive Plan, Zoning and Other City Regulations

City of Normandy Park 2004 Comprehensive Plan – The City's existing Comprehensive Plan was adopted on November 9, 2004 by Ordinance No. 742. The City will begin updating the Comprehensive Plan in 2012, as required under the Growth Management Act (GMA). The Comprehensive Plan establishes goals and policies that define the community's vision for the physical, economic, and social development of the City for the next 20 years. The Comprehensive Plan land use designations near the Puget Sound shoreline include Park and Single Family Residential. City land use designations are relevant to this shoreline characterization as they establish the general land use patterns and vision of growth the City has adopted for areas both inside and outside the shoreline jurisdiction. The City's Shoreline Master Program goals and policies are adopted by reference as one element of the Comprehensive Plan.

City of Normandy Park Municipal Code, Title 18: Zoning – Title 18 of the Normandy Park Municipal Code establishes zoning designations. Zoning designations near the Puget Sound shoreline include Low Density Single Family Residential (R-15) with a minimum lot size of 15,000 sq. ft. and Low Density Single Family Residential (R-20) with a minimum lot size of 20,000 sq. ft. Normandy Park's lone marine park is designated R-15 at this time.

City of Normandy Park Municipal Code, Title 18.36: Critical Areas Development Regulations – Chapter 18.36 of the Normandy Park Municipal Code establishes development standards, construction techniques, and permitted uses in environmentally critical areas and/or their buffers (i.e., geologic hazard areas, fish and wildlife conservation areas, wetlands, streams, flood hazard areas and aquifer recharge areas) to protect these areas from adverse impacts. Designated critical areas are found throughout the City's shoreline jurisdiction, particularly flood hazard areas, streams, geologic hazard areas, coastal bluffs, and wetlands.

City of Normandy Park: 2010 Normandy Park Stormwater Plan – The purpose of the Stormwater Management Plan is to comprehensively address how to meet the many different but related regulations, adopted plans and programs, and policies that affect urban stormwater, flooding and associated water resources. Because many of these requirements from different sources affect the same activities, an overall stormwater plan is needed to address the interrelationships of the programs and efficient approaches for meeting requirements and implementing policy, consistent with long-term goals, objectives, and policies as outlined in the City of Normandy Park Comprehensive Plan.

State and Federal Regulations

A number of state and federal agencies may have jurisdiction over land or natural elements in the City's shoreline jurisdiction. Local development proposals most commonly trigger requirements for state or federal permits when they impact wetlands or streams; potentially affect fish and wildlife listed under the federal Endangered Species Act (ESA); result in over five acres of clearing and grading; or affect the floodplain or floodway. As with local requirements, state and federal regulations may apply throughout the City, but regulated resources are common within the City's shoreline jurisdiction. The state and federal regulations affecting shoreline related resources include but are not limited to:

Endangered Species Act: The federal ESA addresses the protection and recovery of federally listed species. The ESA is jointly administered by the National Oceanic and Atmospheric Administration (NOAA) Fisheries (Formerly referred to as the National Marine Fisheries Service) and the United States Fish and Wildlife Service (USFWS).

Clean Water Act (CWA): The federal CWA requires states to set standards for the protection of water quality for various parameters, and it regulates excavation and dredging in waters of the U.S., including wetlands. Certain activities affecting wetlands in the City's shoreline jurisdiction or work in adjacent rivers may require a permit from the U.S. Army Corps of Engineers and/or Washington State Department of Ecology under Section 404 and Section 401 of the CWA, respectively.

Hydraulic Project Approval (HPA): The Washington Department of Fish and Wildlife (WDFW) regulates activities that use, divert, obstruct or change the natural flow of the beds or banks of waters of the state and may affect fish habitat. Projects in the shoreline jurisdiction requiring construction below the ordinary high water mark of Puget Sound or streams in the City could require an HPA from WDFW. Projects creating new impervious surface that could substantially increase stormwater runoff to waters of the state may also require approval.

National Pollutant Discharge Elimination System (NPDES): Ecology regulates activities that result in wastewater discharges to surface water from industrial facilities or municipal wastewater treatment plants. NPDES permits are also required for stormwater discharges from industrial facilities, construction sites of five or more acres, and municipal stormwater systems that serve populations of 100,000 or more.

LAND USE PATTERNS

The City of Normandy Park is located in southwest King County. Normandy Park is highly developed and has a well established pattern of land use. The City is bounded by approximately 3.5 miles of Puget Sound shoreline to the west and 1st Avenue South to the east. The city of Burien forms the northern boundary and the City of Des Moines forms the boundary to the south. The City's shoreline jurisdiction is composed of a variety of natural and human modified landscape features that include natural and modified beaches, concrete and rock bulkheads.

Existing Land Use

The City is predominately developed with single-family residential properties within the shoreline environment and has one public park Marine View Park and one private park known as The Cove. There are no multi-family or commercial developments within the shoreline environment. The shoreline jurisdiction also contains a few undeveloped parcels of land. Vacant parcels are described in the reach by reach description of the shoreline.

COMPREHENSIVE PLAN/ZONING DESIGNATIONS

Comprehensive Plan

According to the City of Normandy Park 2004 Comprehensive Plan, the City's shoreline jurisdiction is largely comprised of properties designated Low Density Single-Family. The only other designation located within the shoreline jurisdiction is Open Space for the private park and the public park.

General goals and policies established in the City of Normandy Park 2004 Comprehensive Plan relate to a common desire to protect the quality of Normandy Park's natural and built environment. The forested, low-density residential character of Normandy Park is in large part due to the natural landscape that flows through the community. Natural open spaces and sensitive areas are major components of the City's character and it is essential that they be preserved.

The City's existing Shoreline Master Program goals and policies are included as an element of the City's current Comprehensive Plan. These goals and policies encourage minimal adverse effects on the quality of the shoreline environment.

Zoning Designations

Zoning designations in the City generally follow land use designations as discussed above under Comprehensive Plan designation. Within the City's shoreline jurisdiction, Low Density Single-Family Residential zoning (R-15 and R-20) dominates the entire shoreline.

ROADS AND TRANSPORTATION FACILITIES

As described above, the majority of the City's shoreline is occupied by low density single family development, a private park and public park. There are generally very few roads that are found within the shoreline jurisdiction. The following road segments are located within shoreline jurisdiction:

- The westernmost 200 feet of SW Shorebrook Drive.
- Normandy Terrace SW parallels the shoreline dipping in and out of shoreline jurisdiction.
- The western end of SW 187th Street.
- Edgecliff Drive SW parallels the shoreline for most of its length, with the last 150 feet dipping into shoreline jurisdiction.
- The western end of South 216th Street.
- The western end of 218th Street.
- The western end of 219th Street.

There are also various private roads or driveways located in shoreline jurisdiction. Within this group are two sizeable private roads. There is 500 feet of private road/driveway located along the steep slopes of Segment 2. There is roughly 600 feet of road in Segment 3 that is located at the ordinary high water mark and encircles a wetland.

There are no public transit routes located within the shoreline environment of Normandy Park. The closest Metro route stops are at 1st Avenue South and 211th Street, less than a mile away from Marine View Park.

WASTEWATER AND STORMWATER UTILITIES

The Southwest Suburban Sewer District provides for the collection, treatment, and disposal of wastewater for most of the City. The Southwest Suburban Sewer District has a treatment plant located outside shoreline jurisdiction at 801 SW 168th Street. Two outfall pipes from the facility run to Puget Sound. The Midway Sewer District serves the southernmost end of the City and has one outfall that is located just south of the city limits.

The City has jurisdiction over the storm and surface water management system within the city boundaries, within and outside of roadways. Stormwater utilities consist of over 750 catch basins, 50 manholes, over 12 miles of conveyance lines, and over 8 miles of open ditches.

Other utilities in the shoreline jurisdiction include electric power, water, gas, and cable.

EXISTING AND POTENTIAL PUBLIC ACCESS SITES

Only a few existing shoreline areas in the City are available for public access (Map 3). Due to the nature of the single-family development along the shoreline, there are no pedestrian walkways open to the public, outside of the asphalt and dirt trails located in Marine View Park.

The primary access area is Marine View Park, which is located at 20945 Marine View Drive SW (Map 3). There is also limited public access to the beach at the south end of the City. The 200 feet of access is available through Des Moines Beach Park, in the City of Des Moines. The City also owns several shoreline properties in the Beaconsfield development. However, these properties do not currently have a legal upland access point. The only legal public access is by boat.

The remainder of the shoreline is residential with one private park. The private park, known as The Cove, has beach access via SW Shorebrook Drive. There is a small private gravel parking area and boat launch. Only Lot A property owners in the community have access to The Cove.

There is the potential for increased shoreline access in the future, especially around the Beaconsfield area (Map 3). Areas with potential for public access are noted in the reach by reach description in the second half of the report.

There are also several road segments that are located either in shoreline jurisdiction or along the shore that provide visual access to the shore. Although not as tangible as physical shoreline access, visual access still provides some level of enjoyment of the shoreline areas of the City (Map 3).

HISTORICAL/CULTURAL RESOURCES

The Historical/Cultural Element of the 1991 Normandy Park Shoreline Master Program provides a general goal and policy to retain and protect shoreline features having historic, cultural, scientific, or educational value locally or regionally. The Normandy Park 2004 Comprehensive Plan also addresses historic preservation. The Plan establishes the goal of protection and restoration of buildings, sites, and areas having historic, cultural, educational, or scientific value.

The King County Historic Preservation Program maintains a list of King County and local landmarks. There are three residences listed by the King County Resource Inventory within shoreline jurisdiction. The residences are known as the Hughett House at 17999 Normandy Terrace SW, the Clark House at 17915 Normandy Terrace SW, and the Gustin House at 17985 Normandy Terrace SW. Although it has been noted that Native Americans used trails in the area to access the beaches, there are no known archaeological sites within the community.

Washington State's Office of Archeological and Historic Preservation maintains the Washington State Inventory of Cultural Resources. The State did not respond to a request for information on listed historic or archeological sites in the State's database.

WATERSHED CHARACTERIZATION

Climate

Normandy Park, located along the eastern shores of Puget Sound, has a maritime climate with a fall and spring rainy season, dry summers, and cool winters. This area of Puget Sound receives between 35 and 40 inches of average annual rain fall (Woodward et al. 1995). The direction of wind is from the southwest through fall and spring and switches to coming from the northwest during the summer.

Topography, Geology, Soils

The City is located along the broad, northerly trending Des Moines Plain, which is located between Puget Sound and the Duwamish River Valley (Map 4). The upland plateau is generally between 290 feet and 340 feet above sea level in the southern half of the City. In the northern half of the City, the topography is lower due to the occurrence of a historic glacial outwash channel and the long-term erosion caused by the downcutting of Miller and Walker Creeks (Booth and Waldron 2004). The City generally slopes towards Puget Sound, with all creeks within the City flowing towards Puget Sound versus towards the Duwamish Valley. Large portions of the marine shoreline are bounded by steep bluffs along the shore, while relatively few areas have gently sloped shores.

The geology of the area was summarized by Booth and Waldron (2004). Some of the geologic features along the marine shoreline are summarized in Johannessen et al. 2005, but will be discussed under coastal processes section. The steep bluffs along the shore are the result of past glaciations, with the most recent glaciation (The Vashon Stade of the Fraser Glaciation), occurring only about 13,500 years ago. This most recent glaciation is responsible for most of the surficial deposits and generally north–south trending hills. Since the last glaciers left, upland erosion, coastal erosion, and landslides have weathered the landscape, creating the stream channels and floodplains and the steep bluffs along the shore that we see today.

The soils in the City are composed mostly of recessional outwash deposits and till. The till is present throughout most of the City, with relatively recessional outwash deposits on top of the till in many places (Booth and Waldron 2004). Till is generally a poorly sorted mixture of gravel, sand, and silts that was deposited at the base of a glacier and compacted by the overriding ice. Till is extremely dense and generally has low permeability. There are deposits of advance outwash in the steep slopes along the shores of Puget Sound (Booth and Waldron 2004). Soils maps also show the highly permeable Everett soils in the southern part of the City on the plateau. These deposits are made up of mostly well sorted sand and gravel, which provide ideal beach building materials.

Land Cover (Vegetation), Wetlands and Imperviousness

Much of the City has been developed for residential use. 2007 land cover data for Normandy Park (King County 2009a) showed that almost 60 percent of the City was classified as having low, medium, or high levels of development (See Table 2 and Map 5). Only about 35 percent of the City is covered in trees. Much of this vegetation is located along the steep bluffs along the shore and in stream corridors. The quantity and quality of the marine riparian area will be discussed in the reach level characterization. The generally low levels of forested areas in the City (and surrounding cities) have ramifications on the streams running through the City.

Table 2. Totals and percentages of various land cover classes within the City of Normandy Park based on 2007 Landsat imagery.

Land cover type	Acres	%
Bare ground/Rock/Snow	6.49	0.41%
Cultivated	8.50	0.53%
Coniferous	0.33	0.02%
Deciduous/mixed	551.70	34.66%
Immature Conifer	0.33	0.02%
Herbaceous	50.46	3.17%
Scrub/Shrub	40.67	2.55%
High Intensity Development	171.59	10.78%
Medium Intensity Development	584.12	36.69%
Low Intensity Development	172.92	10.86%
Water	4.78	0.30%
Total	1,591.89	100.00%

Mapped wetlands are limited to the marine shoreline where there are only two existing mapped wetlands present and one historically mapped wetland that has been replaced by houses. If there were wetlands in the uplands historically, they have been lost to development. There are wetlands associated with Miller and Walker Creeks, but these are outside of Normandy Park's jurisdiction.

As noted with the discussion of land cover, much of the City has been developed. Much of the development has brought impervious surfaces (Map 6), areas where water cannot be absorbed and is instead shed quickly into stream systems. Impervious surfaces include buildings, pavement, and other compacted surfaces (i.e., lawns). This has the effect of causing much higher stream flows during the rainy season, along with reduced flows in summer. The Miller and Walker Creeks Basin Plan (2006) indicates that this basin is about 22 percent impervious with a predicted increase to 30 percent in the future without changes in zoning. This basin is fairly indicative of the development and impervious patterns throughout the City.

Hydrology (Surface water, Groundwater, Floodplains)

In Washington State, the major river watersheds were delineated into Watershed Resource Inventory Areas (WRIA) and numbered (Williams et al. 1975). Areas that had direct drainage into Puget Sound were lumped into the closest major WRIA. The City is located within WRIA 9, or the Green/Duwamish Watershed. None of the water draining out of the City flows into the Green River itself, but flows directly into Puget Sound through three small streams and various undefined overland flows. Most previous efforts at mapping stream basins lump areas without defined channels into areas with defined drainage, generally creating an agglomeration of drainages. A recent effort by the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) created much finer scale subbasin boundaries that broke out actual direct drainages to Puget Sound from larger defined stream drainages. PSNERP data shows that there are two larger subbasins with defined streams that flow into Puget Sound (Miller, Walker, and Normandy Creeks) and three smaller subbasins that have no primary flow path to Puget Sound (PSNERP 2009) (see Map 7). The three small unnamed basins are only 167, 103, and 82 acres in size and located in the southern half of the City. Normandy Creek has a basin size of 865 acres. Miller and Walker Creeks are combined into one basin of 6,000 acres.

The combined low numbers of wetlands and high amounts of development and imperviousness has tremendous impacts on the hydrology of the City's streams. The Miller and Walker Creeks Basin Plan (2006) states, "Under forested conditions, it is expected that six cubic feet of water per second would flow past the mouth during a one-year return period (storm flow from a rain event likely to occur on average once a year). Currently storm flows at the mouth for the same type of rain event are at about 95 cubic feet per second, or about sixteen times higher than under forested conditions." The plan also noted that most of the runoff is conveyed to the creek by a series of pipes and ditches which are intended to speed up delivery of water to the creek. This type of change to the hydrology clearly has impacted flooding, erosion, and deposition patterns throughout the basin. This stormwater pattern also has the added problem of limiting the natural rates of recharge which would keep the streams flowing in summer. Thus aquatic habitat first experiences damaging high flows during the winter, and then reduced flow levels in summer which greatly limit the amount of physical habitat available.

As noted above, some recharge of groundwater can happen in areas that have appropriate soils and have not been impacted by impervious surfaces. The highly permeable Everett soils occur mostly in the southern part of the City on the plateau, providing recharge potential to Normandy Creek. Critical Aquifer Recharge Areas are defined as "areas designated by WAC 365-190-080 (2) that are determined to have a critical recharging effect on aquifers used for potable water as defined by WAC 365-190-030 (2)." These areas include wellhead protection areas, areas within a 10-year time of travel and other areas that affect groundwater. There are no public wells or wellhead protection areas located within the City. The City has no Critical Aquifer Recharge Areas (BHC 2007).

Most of the major streams within the City have had their floodplains mapped (Map 7). Miller and Walker Creeks have had their floodplains mapped for much of their length, and they are generally limited to the immediate stream corridor. The only substantial stream floodplain area is limited to the lower 1,500 feet of Miller/Walker Creeks, with a floodplain area about 800 feet wide. Normandy Creek's floodplain is mostly limited to the immediate stream channel, but it

has a broad forested floodplain at its headwaters. This area is mostly owned by the City. The marine shoreline has also had a floodplain/coastal inundation area mapped along the entire length of shoreline. Given the topography of the City's shoreline, it does not go inland more than 70 feet from OWHM in most places. A detailed description of the floodplain areas is found in the reach description.

Water Quality

There has been limited water quality sampling of the marine environment in Puget Sound and the streams that are in the City of Normandy Park. Past work indicated that there were elevated levels of zinc, copper, fecal coliform bacteria and pesticides in Miller Creek (Miller and Walker Creeks Basin Plan 2006). The currently available data does indicate that there are still problems, especially in the Miller/Walker Creek Basin. Section 303 of the Federal Clean Water Act requires that Washington State prepare a list of all surface waters that are impaired by pollutants. Washington Department of Ecology maintains the 303(d) list, which was last updated in 2008. Miller Creek is listed as not meeting the water quality standards for fecal coliform bacteria and dissolved oxygen. It is also listed as a "Water of Concern" under 305(b) for pH. The marine area just off the mouth of Miller/Walker Creeks is also listed as "Water of Concern" under 305 (b) for fecal coliform bacteria.

Although Des Moines Creek is technically outside the City of Normandy Park's jurisdiction, the water flowing from it could still impact the marine waters along the City's shoreline. Des Moines Creek is listed under 303(d) as not meeting the water quality standards for fecal coliform bacteria and dissolved oxygen. It is also listed under 305(b) as a "Water of Concern" for temperature and copper. The Midway Sewer District also has direct marine outfall just south of the Normandy Park City limits.

Ambient marine water quality sampling by King County in 2005 through 2007 just off the mouth of Miller/Walker Creeks found various pesticides and other man-made chemicals at low levels (King County 2009b). Hexacholorobenzene was found at concentrations above the Lowest Apparent Effects Thresholds standard. There is no known source of hexachlorobenzene in the City, but this compound is still used in some pesticides and has previously been used in some wood preservatives and may have originated upstream of the city limits (King County 2009b). Although the data from 2005-2007 showed the sample site meeting fecal coliform standards, data collected since have shown that the site is not meeting the fecal coliform water quality standards (S. Mickleson, personal communication, 2010). It should also be noted that the Southwest Suburban Sewer District has a marine outfall in close proximity to the ambient water quality sampling location.

Coastal Processes

Littoral Drift Cells

Unlike the freshwater systems which are primarily defined by their surrounding watershed or basin, marine shoreline areas are generally defined by the drift cell in which that shoreline is located. Drift cells, drift sectors, or littoral cells are all different ways to describe the process of

how sediment moves along a particular segment of shoreline. Drift cells are independent segments of shoreline along which littoral movements of sediments occur at noticeable rates depending on wave energy and currents (Figure 1). Each drift cell typically includes one or more sources of sediment (e.g., a "feeder bluff" or stream outlet), one or more transport zones (within which the sediment moves along the shore), and one or more accretion areas (e.g., a sand spit) where the sediment is deposited. This process creates and maintains the habitat diversity along the shoreline. Since many intertidal organisms are tied to substrate type, any changes to this process can have profound changes throughout the ecosystem (Dethier 2009).

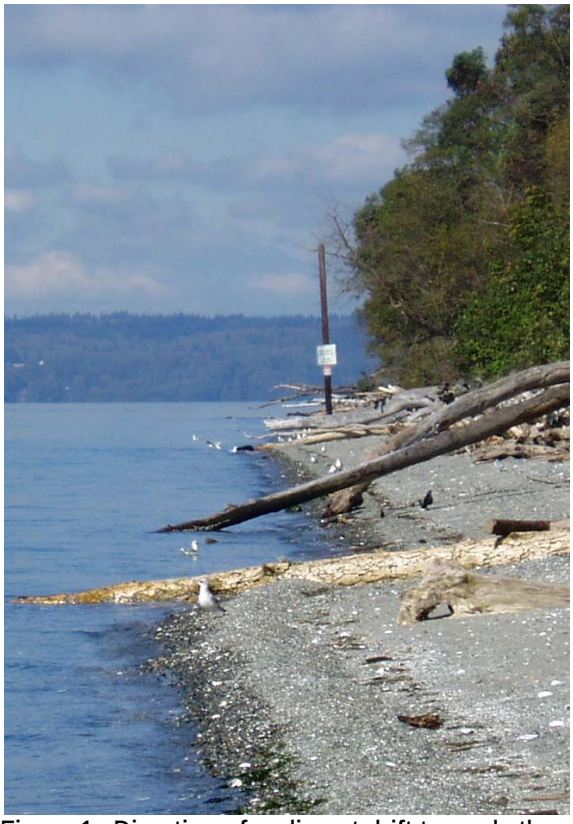

Figure 1. Direction of sediment drift towards the sign in the background of the picture. Sediment has built up, via littoral drift, on the log in the foreground (Photograph from Coastal Geologic Services).

Prior to the development of the Des Moines Marina, drift cell Ki-8-3 (all the drift cells in Puget Sound are numbered) moved sediment from just south of Saltwater State Park northward all the way to the tip of Three Tree Point (Map 8). The construction of the marina in the 1960s caused the drift cell to be split into 4 different pieces (Chrzastowski 1982). Ki-8-3 was shortened and now ends at the southern extent of the marina at the mouth of Massey Creek. It is slightly over 2 miles long. The marina itself (Ki-8-2/Ki8-3-NAD) represents an area where, due to the breakwaters, no drift occurs, and accounts for roughly 2,500 feet of the historic shoreline. Both of these drift cells are entirely located in the City of Des Moines. Just to the north of the marina, Ki-8-2, a very short drift cell, transports sediment towards the marina. This drift cell is reversed from its historic drift direction due to being in the wave shadow of the marina. The northern 120 feet of this drift cell is located in Normandy Park, with the remaining 864 feet of the cell located in the City of Des Moines. The remaining piece of the original drift cell is now named Ki-7-3,

and it exhibits northward drift all the way to Three Tree Point. Almost all of Normandy Park's 3.5 miles of shoreline are located within this drift cell.

The areas within drift cells Ki-8-3, Ki-8-2/Ki-8-3NAD, and Ki-8-2 are no longer connected to or provide sediment to Ki-7-3. This 3.8 mile area that was cut off had significant amounts of feeder bluffs. Approximately 1 mile is currently classified as feeder bluff or exceptional feeder bluff, while almost a mile of what is armored was classified as having been feeder bluffs historically (Johannessen et al. 2005). Furthermore, a comparison of historic aerial photographs shows that large amounts of sediment can clearly be seen building up on the south side of the marina. Between 1977 and 2009, there has been at least 50 feet of horizontal build up of the beach for the 1,000 feet of shoreline south of the marina.

As noted above, drift cell Ki-7-3 was relatively recently (geologically) modified by the construction of the marina roughly 50 years ago. Changes to geomorphic processes do not necessarily display themselves on the landscape right away. Some of the effects in drift cell Ki-7-3 caused by the marina intercepting sediment will may not be experienced for some time to come.

Drift cell Ki-7-3 is 24,000 feet long (including the portion in the City of Burien). Slightly over 66 percent (15,850 feet) of its shoreline has been armored, mostly by residential development (Map 9). It is also composed of 3,300 feet (14 percent) of unmodified accretion shoreforms, 4,000 feet (16 percent) of feeder bluffs, and 850 feet (4 percent) of transport zones (Map 10). Based on historical reconstruction mapping (Johannessen et al. 2005), the areas that are currently bulkheaded were comprised mostly of feeder bluffs (47 percent), and accretion shoreforms (32 percent). A total of 65.4 percent of the all the sediment sources for the drift cell, as it now exists, have been lost due to bulkheading.

Shoretypes and Shoreline Modifications

In 2004 the marine shorelines in King County were classified according by the type of role they play in sediment delivery and transport processes (Johannessen et al. 2005). This classification system relied on both field collected data and readily available GIS data sets. A more recent classification system was created in order to classify all shorelines in Puget Sound (Shipman 2008). However, the application of the newer classification system is based on only GIS data available Puget Sound wide and was done at a coarser level than the work done in 2005. The newer system also does not discreetly tie its classification to the different components of the sediment delivery/transport processes. For these reasons, the 2005 shoretype (Johannessen et al. 2005) data will be used throughout the rest of this report.

These shoretypes were broken into exceptional feeder bluffs, feeder bluffs, transport zones, accretion shoreforms, and modified (or armored). The exceptional feeder bluff classification was applied to areas with high erosion rates and had the highest volume of sediment input per linear foot. The feeder bluff classification was used for areas with the potential for substantial sediment delivery, but may be more episodic and have a longer recurrence interval than exceptional feeder bluffs. Transport zones are shoreline areas that did not appear to contribute much sediment to the nearshore, nor did they appear to be building beaches in front of them. In essence, they are in a fairly stable equilibrium with sediment merely being transported

alongshore. The modified classification was used to note areas that had been bulkheaded or altered so much that the natural geomorphic state was concealed and sediment delivery to the nearshore was halted. Accretion shoreforms denote areas that were or are depositional in nature. Given that even in depositional environments humans bulkheaded the shoreline, the classification was further broken into subcategories representing the level of development of the backshore, if a bulkhead existed, and if the depositional area was associated with a stream mouth.

Although shoreline modifications are not a process, as a group, they can greatly impact the way processes interact on the landscape. Given their prevalence and level of impacts, especially to the sediment delivery and transport processes, they are described here. Shoreline modifications can be broken into four main categories, armoring (sea walls, revetments, bulkheads, etc.), groins, boat ramps, and overwater structures (i.e., docks).

Groins are structures that are placed perpendicular to shore. The purpose of a groin is to catch all the sediment that is moving along the shore and build up a beach on the updrift side of the groin. Although this can create a wider beach of finer substrate on one side, it also starves the beach down drift of the groin, creating a coarser beach that may downcut as the existing sediment is moved downdrift but not replaced due to groin stopping sediment transport. Generally, once one is built the downdrift landowners attempt to build others in order to protect their beach, creating a cascading affect through the system. Although groins are not prevalent in the City, 12 groins were mapped as being in the City in 2004 or found in aerial photos from 2010. They occur mostly in the northern portion of the City, in segment 5.

Boat ramps are generally structures that allow for a boat to be put into Puget Sound directly from a private landowner's property. There are no public boat ramps within the City. They are frequently made of cement and sometimes are protected on the updrift side by a groin intended to keep the ramp clear of sediment and drift logs. The bed of the ramp generally creates an area where epibenthic organisms are not able to colonize and creates an area where forage fish cannot spawn. The longer or wider the ramp is the greater the impact of the area where native naturally occurring organisms cannot find suitable habitat. Also, ramps are usually maintained so that beach berms and organic debris are not allowed to build up, changing the upper beach's ecological community. There are private boat ramps throughout the shoreline of the City, but no public boat ramps.

Overwater structures generally refer to docks, but includes any other structure that floats or sits on top of or over the water the water. Docks can have an impact on various aspects of shoreline ecology. First, juvenile salmon are known to avoid swimming beneath substantial docks. They swim around the perimeter of the dock which makes them more susceptible to predation by larger fish that occupy deeper waters (Nightingale and Simenstad 2001). Depending on the spacing of the pilings supporting the dock, docks can also affect wave energy, which in turn impacts the ability to transport sediment by acting like a groin. The shade from docks can limit the growth of eelgrass underneath it and adjacent to it. Furthermore, invertebrates with shells generally build up on the pilings supporting the dock. These animals eventually die and create a mound of shell hash around the pilings, creating a sediment type in which eelgrass cannot grow. Most older docks in Puget Sound were constructed with creosote pilings, which are known to be toxic to various marine larvae (Stratus 2006).

Shoreline armoring is probably the most prevalent shoreline modification and the one with the greatest long-term impact. Shoreline armoring refers to any form of structure placed on the shoreline that's main purpose is to halt erosion of the adjacent land. These can include older creosote piling walls, concrete seawalls or, more typical of current construction, riprap bulkheads. Shoreline armoring is currently present on slightly over 53 percent of the City of Normandy Park's shorelines.

As noted above, the armoring of the shoreline is normally undertaken in order to stop actual or perceived erosion of the shoreline. Since most beaches in Puget Sound are derived from bluff sediments and not fluvial sediments (Shipman 2004), armoring, especially on feeder bluffs, can have long lasting impacts. As more and more of a drift cell's sediment sources are bulkheaded, the ability for the beach and the nearshore habitats to maintain themselves is greatly diminished. Over time, this likely causes a loss of some beaches and downcutting (or lowering) of other beaches (MacDonald et al. 1994). Downcutting of the beach can exacerbate the original problem shoreline armoring was intended to fix, and cause the bulkheading to fail as it gets undermined by the downcutting.

Separate from the issue of locking up beach sediment sources, if the bulkhead was constructed below the OHWM, the bulkhead likely has several other impacts. First, the deeper into the intertidal zone the bulkhead goes, the more it is likely to act like a groin. In this case, it can act to both stop sediment delivery and transport. Bulkheads also reflect wave energy differently than natural shorelines. This can lead to winnowing of the sediments on a beach, causing a general coarsening of the beach. Increasing the sediment sizes of materials on the beach can affect both the plant and invertebrate community found on the beach (Thom et al 1994).

Bulkheads also generally stop the eventual inland horizontal migration of the shoreline. Over time, this can cause beaches to become steeper and narrower as wave energy acts on the shore and is unable to push the shoreline inland (MacDonald et al. 1994). The steepening and narrowing can both reduce the amount of physical habitat available to some species as well as physically change what species can exist on the beach.

The physical location of the bulkhead can also greatly affect the amount of physical habitat that is available to certain organisms. Sand lance and surf smelt spawn in the upper intertidal of beaches, from roughly +5 to +12 tidal elevation. Many bulkheads are located well below +12 elevation, possibly eliminating all of the potential spawning habitat. Several species of juvenile salmonids also use shallow water habitat as a place to feed, as refuge from predators, and as a migration corridor. The deeper the shoreline armoring goes, the more the juvenile fish are pushed in deeper habitats where the food resources are likely different and the potential for predation is thought to be higher (Brennan et al. 2004). Several studies in other parts of the United States have shown that bulkheading impacts the number and type of shore birds found along the shore (Dugan et al. 2003, Urban-Malinga et al. 2008).

The tidal elevation also greatly impacts the amount of organic material that is recruited onto the beach. On an unmodified beach, there is typically a beach berm that forms just above the mean higher high tide line. Organic material (i.e., leaves, logs, algae) are deposited on this berm by

the tides. On most bulkheaded shorelines, the bulkhead is located on top of the location where this accumulation would occur, meaning that there is no place for organic material to accumulate. Higgins et al. 2005 showed that for WRIA 9 shorelines, drift log accumulations occurred on slightly over 38 percent of the unarmored shorelines, while only about 10 percent of the armored shorelines had drift log accumulations. Tonnes (2008) also showed that bulkheading reduced driftwood accumulations, but he also found significantly reduced the numbers of taltrid amphipods on armored beaches without drift logs. Work in 2003 (Sobosinski) to compare armored versus unarmored shorelines (irrespective of driftwood) showed similar results with taltrid amphipods being significantly reduced on armored beaches. Although taltrid amphipods have not been heavily studied to understand how they fit into Puget Sound's food web, it is known that they are at least an important component of the diet of some shorebirds (Neuman et al. 2008).

Bulkheads can also stop saltwater from reaching low-lying backshore habitats. The makeup and structure of coastal wetlands is greatly dependent on how often saltwater is able to overtop the natural beach berm system. In many cases within King County, the low-lying habitats have been already converted into another use. Thus, the bulkhead is not the primary cause for the loss or degradation of that habitat. However, there are some cases, with at least one within the City, where the bulkhead is the primary cause for degradation of an existing coastal wetland.

Shoreline armoring is also believed to affect how groundwater interacts with the beach (MacDonald et al 1994). Bulkheads either block water seepage onto the beach or they can focus it through discreet drainage points. Focusing flow into discreet discharge points would affect the microclimate of habitats on the beach (i.e., reducing moisture levels of the broader beach area at low tide), though this has not been studied. It is also believed that bulkheads can create an increase in elevation of the level of groundwater since they can act as a dam along a bluff toe where water would have naturally come out. This increase in groundwater level can increase the pore pressure on the beach itself, causing erosion of the beach (MacDonald et al. 1994).

When the shoreline is armored, there appears to be a general tendency to remove the native shoreline vegetation (i.e., trees). This may simply be in order to have a view of the sound or as part of clearing for construction of a house and or a bulkhead. In WRIA 9, it was shown that marine riparian vegetation was greatly reduced or heavily modified (turned into landscaped lawns) on armored shorelines in comparison to unarmored shorelines (Higgins et al. 2005). Not only were the amount of trees reduced, but the condition of the trees (density and location) was also heavily degraded in areas with armoring. For example, 80 percent of the trees in unarmored areas overhung the intertidal area, while less than 13 percent of the armored areas had trees overhanging the intertidal zone. In 2007, Toft found differences in the diets of juvenile Chinook salmon between shorelines that were armored and without vegetation compared to shorelines that were armored with vegetation. Given the changes in riparian condition noted above, Toft's results indicate that there may be significant impacts to the availability of prey to juvenile salmonids.

Perhaps the biggest but least understood impact is the cumulative effects of having so much shoreline that is heavily altered. The cumulative effects of shoreline armoring are likely occurring at least at two spatial scales. First, since each drift cell's sediment delivery and

transport processes are somewhat independent from one another, the physical cumulative effects of armoring are likely limited to each drift cell. However, the biological effects of shoreline armoring likely span much of Puget Sound. For example, juvenile Chinook salmon are known to migrate throughout Puget Sound, going from one drift cell to the next (Brennan et al 2004). More research would help quantify the cumulative effects of shoreline armoring, as it has the potential to be a significant driver in the declines of various aquatic and avian species.

Coastal Wetlands

Historical data on the marine shoreline area indicates that most of the area was composed of forested bluffs, with two larger wetland areas in Segment 5 (Map 11). The southern end of the segment contained a wooded marsh that was at least 7 acres in size and located at the mouth of Normandy Creek (1890s USGS and Collins and Sheik 2005). Based on the first maps available, development had all ready occurred along the edges of this wetland, indicating that it was likely originally a larger wetland complex that had already been partially filled for development purposes. Currently, the area is built out with residential homes and the wetland no longer exists. The second wetland complex at the mouth of Miller and Walker Creeks was indicated in early maps as a 9-acre wooded marsh. This marsh also had development occurring along its edges by the time the first maps had been created. This wetland has been modified by development, and is currently partly managed as an emergent wetland. As noted above, there is third wetland that was likely present historically, but missed in the historic mapping (Map 11). This 3-acre wetland is located in Segment 3 and is a freshwater wetland because of the road and berm that limits saltwater access.

Tides

Both wave energy and tidal regimes are important processes in shaping shorelines. Humans modify how wave energy interacts with shorelines by building breakwaters or armoring and by creating waves through boat wakes (Williams et al. 2003). Tidal regimes on shorelines are modified by altering timing frequency, and magnitude of the freshwater flow of rivers and streams (Williams et al. 2003), through water diversions, dams, and increasing impervious surfaces. They can also be modified by filling intertidal areas, causing the ordinary high water mark of the marine shoreline to move seaward.

Tides along King County's marine and estuarine shorelines are mixed semi-diurnal, resulting in two high tides and two low tides of unequal height every day. Generally, the tidal regime is affected at a regional scale and not controllable at the local level. Tidal influence can also be affected by changes in sea level over the long term by tectonic subsidence and global warming, and over the short term by storm surges and El Niño events (Williams et al. 2003).

The extent of tidal influence can be altered (truncated or lost) through alterations in beach profiles and elevations by shoreline armoring, and by artificial tidal restrictions at stream outlets caused by culverts, tide gates, and weirs. Shoreline armoring at or below ordinary high water levels shifts tidal influence to offshore areas which in turn can preclude the growth of important marine vegetation, such as eelgrass, and the existence of spawning habitat for certain fish species (Williams et al. 2004). Tide gates and weirs on streams and wetlands can limit or prevent salinity gradients and backwatering effects that can create highly productive fresh-to-saltwater transition areas for vegetation, as well as fish and wildlife. For example, in Segment 3, what is

likely originally a salt marsh appears to now be a freshwater emergent wetland (this wetland is not currently mapped/delineated) because a private road cuts off the ability of Puget Sound to inundate the area.

Wave Energy/Exposure

A good description of wave energy can be found in Williams et al. (2003): "Waves are characterized by length, period, and height, and are the physical representation of energy moving through water. The short-period waves generated by local winds and vessel wakes are superimposed on the water elevation that varies with tide, season, and longer-term influences. In addition to winds and vessels, waves may be generated by geologic sources (i.e., large-scale bluff collapse, seismic forces). The wave energy is translated across the water and is ultimately expended on the shoreline, working to erode, transport, and deposit beach sediment (U.S. Army Corps of Engineers 2002; Terich 1987). Compared with other locations in the U.S., Puget Sound is considered to be a moderate wave-energy environment, even in the most exposed locations (McDonald and Witek 1994)." All of the City's shorelines are considered semi-protected by the Shorezone database (Berry et al. 2000).

Under natural conditions, wave energy is primarily generated by localized wind patterns and can be increased greatly during high wind events. It also can be increased through boat traffic (Anchor Environmental 2000). This impact is focused on areas of high boat traffic, where wave energy is increased on a regular basis, not everywhere boats might cause a wake to occur infrequently. The amount of wave energy reaching the shoreline can also be decreased by submerged aquatic vegetation, which can moderate wave energy (Williams et al. 2003). Given that there is a major commercial shipping lane in this portion of Puget Sound, running north to south between Vashon and Maury Islands and the City of Normandy Park, it is expected that the impact of increased wave energy has occurred fairly uniformly throughout the City's jurisdiction.

Wave energy translates its energy from the water to the shoreline, dissipating the energy on the shoreline. The natural transfer of energy onto the shoreline is altered by shoreline armoring, which tends to dissipate and deflect energy differently than natural banks. The type of natural shoreline (rocky or sandy) and artificial armoring (hard rock vs. vegetative, bio-engineered banks) and location of the armoring relative to the tidal elevation (well above the high tide line versus below tide line) play a strong role in the effect of the alteration. Williams et al. (2004) state,

> "Wave reflection forces generally increase as armoring methods intensify, with higher impacts to beach processes in areas with solid vertical or recurved seawalls, and lower impacts in areas using graded or porous structures (e.g., revetments and riprap) or dynamic "soft" solutions (MacDonald et al. 1994; Williams and Thom 2001).
>
> Hardened armoring approaches, such as bulkheads and revetments, represent the types of shoreline modifications most likely to affect wave-energy regimes. Encroachment of the structure into the intertidal zone, measured as the vertical distance of the mean high-water line from the toe of the structure, also may increase the reflective energy of waves."

Existing data on marine shoreline armoring is limited to presence/absence and encroachment. It does not include data on type of armoring (i.e., recurved seawall, riprap, wood piling).

Other structures such as jetties, docks, piers, and breakwaters decrease wave energy through intervention of wave motion before it reaches the shorelines. Thus, when the wave energy reaches the shoreline, the actual amount of energy expended has been greatly reduced and changed. This can be seen in how the marina just south of the City has impacted drift patterns within the City (described below).

Sea Level Rise

The relative change in sea level is a response to a series of complicated processes that are in turn affected by factors affecting other parameters on a global as well as local scale, such as temperature, wind patterns, oceanic currents, and precipitation. A recent report from Mote et al. (2008) provides a range of potential sea level rise based on three different projections and incorporating seasonal cyclic events (El Niño/La Niña), vertical land movement and thermal expansion. Their predictions for this area in the year 2100 range from a low level of 6 inches to a high of 4 feet. The medium projection was for about 1 foot over the next 100 years.

Looking at sea level rise at the a Puget Sound scale, increased sea elevations will make development and infrastructure in low-lying areas more susceptible to flooding due to high tides and storms. Waves will encroach further onto low-lying beaches and cause greater beach erosion, threatening or damaging low-lying structures. At the same time, steep slopes may receive increased moisture, due to predicted changes in precipitation patterns, potentially resulting in an increase in landslides that deliver more material to the marine shoreline, which may cause property destruction and threaten human safety (Shipman 2009).

A little over half of Normandy Park's shores are currently armored, so that a slightly higher sea level may have minimal impacts on natural processes, but a significant rise might begin to allow overtopping of armoring with storms and very high tides. Areas like Segment 1, where houses are built out on the beach, will be the most at risk to increased inundation and storm damage. Shoretypes, known as transport zones, are composed of mostly stable bluffs and gentle sloping shorelines. A rise in sea level will likely cause these areas to become active feeder bluffs, perhaps endangering residences currently considered safe. A rise in sea level also will likely cause current feeder bluffs to become more active and increase erosion rates.

Light Energy

Light energy plays an important role in biological processes such as reproduction, growth, and predator-prey relationships. Light energy also plays an important role in controlling water temperatures, but that aspect of light energy is not analyzed here due to a lack of stream shoreline jurisdiction within the City. Alterations to both natural light patterns and artificial light at night time are two differing components of how light energy interacts with the shoreline. Alterations to light energy can happen by removing vegetation, increasing artificial light or shading out natural light through overwater structures.

Under natural conditions, the delivery of light to the shoreline is controlled by topography, cloudiness, degree vegetative canopy closure, and seasonal day length. The primary alteration to

the delivery of light during the daytime is the removal of shoreline vegetation. One example of an impact due to marine shoreline vegetation removal is the decrease in survival of surf smelt eggs, due to loss of shade and subsequent desiccation along marine shorelines (Rice 2006). In addition, it can affect the predator/prey relationships in aquatic ecosystems, by giving an adaptive advantage to visual predators over longer periods of time (i.e., no refuge at night for animals that must rise to the surface to feed).

During night time, the delivery of light can be increased by artificial lighting (sometimes called "light pollution"), which can have unintended consequences on the migration, predation and feeding of various animals. For a detailed discussion of some of the documented impacts, see the review by Longcore and Rich (2005). The primary indicators of increased night time lighting are the lack of trees and the presence of streets or houses along the shoreline, and the presence of docks and piers.

The primary alteration that decreases light's ability to penetrate the water along the shoreline is the presence of overwater structures like docks, piers, and marinas. This type of alteration has been associated with changes to the migration of fish and the ability of eelgrass to grow.

REACH LEVEL CHARACTERIZATION

As noted earlier, Normandy Park's 3.5 miles of shoreline was split into six segments or reaches based on a combination of zoning, geology, and land use patterns (Map 12). Segment 1 is the only reach that contains a portion of drift cell Ki-8-2. Segment 1 was defined primarily by a dense cluster of houses that are located mostly on the beach, backed by a bluff with houses at the top of the bluff. Given the unique development pattern, this segment was broken out into its own reach. Segment 2 is predominately composed of steeper vegetated bluffs and the northern boundary ends at the break in zoning from RA15 to RA20. Marine View Park is located within this segment. Segment 3's southern boundary is based on the change in zoning and its northern boundary is based on a change in topography and land use. Segment 3 has mostly low bank shores with houses relatively close to the shoreline along with broad accretionary beaches. Segment 4 boundaries are based on the shoreline changing from low bank and accretionary in nature (Segments 3 and 5) to being vegetated bluffs and a source of sediment. The segment is composed of vegetated bluffs with houses along the top of the bluff and miscellaneous armoring along the toe of the slope. Segment 5's shoreline is composed of low-lying accretionary beaches with houses fairly close to the shore. Segment 5 contains the estuary area of Miller and Walker Creek mouths. Segment 6 contains the last part of the northern portion of the City. It is a high bank, vegetated bluff area with shoreline armoring along the entire toe of slope.

The next section provides a summary of each segment's specific physical and biological characteristics. Each segment's physical characteristics are broken into subsections covering geologic information (seismic hazards, landslide hazards, steep slopes, and erosion), coastal processes (shoretypes, changes to wave and light energy, and tidal barriers) and hydrology (stream inputs, or other water freshwater features). Each segment's biological characteristics are broken into Fish and Wildlife Habitat Conservation Areas (FWHCA), marine riparian areas and large wood and drift log accumulations.

Fish and Wildlife Habitat Conservation Areas (FWHCA) are areas that are called out in the Growth Management Act and are incorporated into the City's Critical Areas Ordinance (NPMC 18.36.610). Broadly, they are habitat areas that the City attempts to provide greater protection than habitats that do not fall into FWHCA. They include habitats used by threatened and endangered species, forage fish spawning areas, shellfish, eelgrass, kelp, and ponds less than 20 acres.

Some biological information is fairly course and applies to all the segments or certain aspects of the information is the same no matter what reach is being described. Since the information is the same for each segment, the data is summarized here and not by each reach.

Salmonids

Three salmonid species (Chinook salmon, bull trout, and steelhead trout) are listed as 'threatened under' the Endangered Species Act. Based on sampling in Marine View Park in 2001, and other areas throughout King County in 2001 and 2002, juvenile Chinook salmon are found in the shallow nearshore waters throughout much of the year (Brennan et al. 2004). Juvenile steelhead trout were also found in the shallow nearshore waters, but in much smaller numbers than Chinook salmon. Bull trout were rarely found in this sampling (Brennan et al. 2004), though they are known to use marine waters in northern part of King County as well as northern Puget Sound (Goetz 2005). Thus, it is expected that Chinook salmon and steelhead trout use all of the shoreline within the City of Normandy Park, while it is much less likely that bull trout are present within the city limits.

Forage Fish

Three species of forage fish (herring, sand lance, and surf smelt) are known to spawn in nearshore areas in Central Puget Sound. Within King County, herring only spawn in the intertidal areas in Quartermaster Harbor, though they can be present in the waters around Normandy Park. Sand lance and surf smelt both spawn on the upper intertidal (+5 to +12 tidal elevations) of beaches throughout Puget Sound (see Figure 2). The specific surveys by WDFW of spawning beaches will be discussed in each segment.

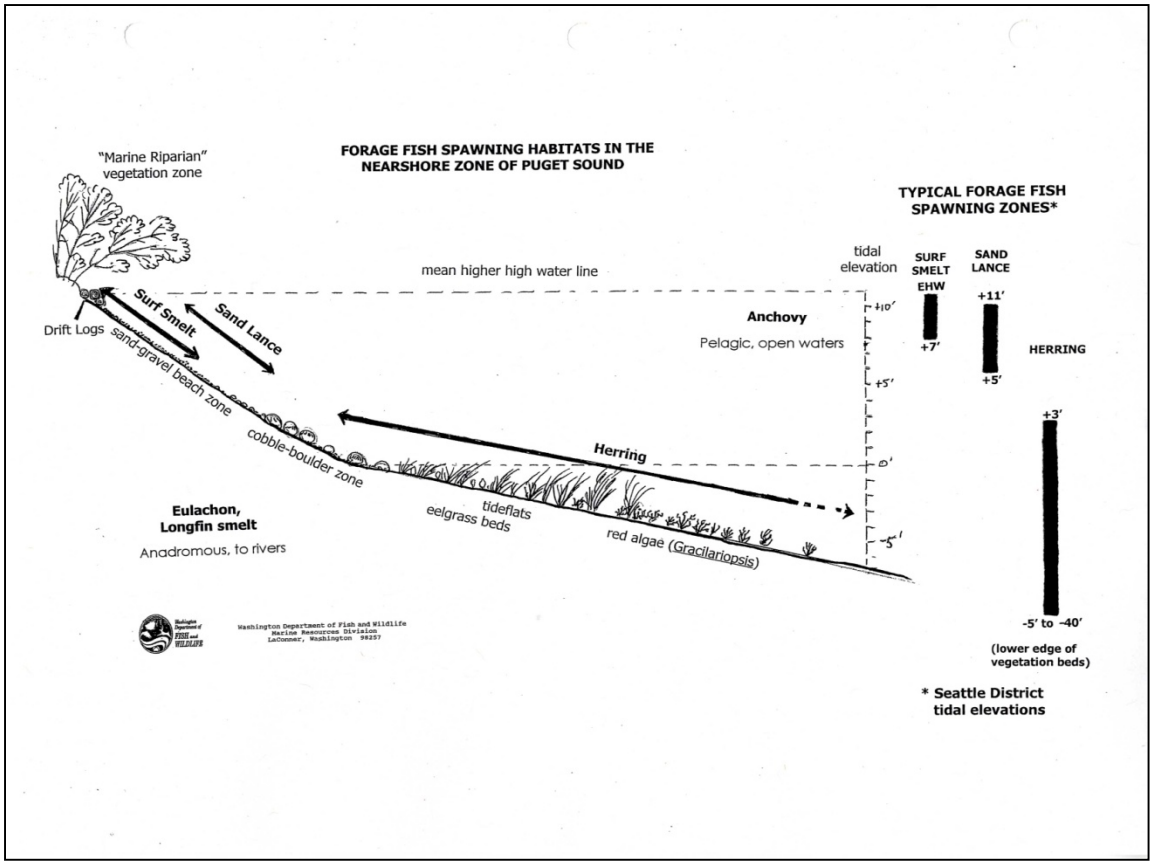

Figure 2. Tidal range for spawning forage fish species (From WDFW).

Marine Riparian

The concepts related to the functions that riparian vegetation provides in the marine environment are primarily drawn from literature on freshwater riparian areas. The literature indicates that marine riparian areas provide the following: source of wood/organic material to the beach, prey source to fish, fish and wildlife habitat, shade, microclimate habitat conditions, water quality protection, and slope stability/erosion control (Brennan 2007).

Although it is not clear how much of the logs on Puget Sound beaches come from freshwater sources (i.e., rivers) or from marine bluffs, it is clear that marine shorelines were historically a source of trees/drift logs to the beaches of Puget Sound (Tonnes 2008). This source has been greatly reduced in the City by residential development that has cleared much of the trees along the shore. It has been shown that there are significant differences with the intertidal invertebrate community in beaches with and without drift logs (Tonnes 2008, and Sobocinski 2003).

The vegetation along the shores is also likely a significant source of food for various marine organisms. Romanuk and Levings (2003) found dramatic differences in the numbers of invertebrates associated with vegetated and nonvegetated shores in Howe Sound of British Columbia. They found that aquatic arthropods were eight times more abundant at vegetated versus unvegetated shores. For terrestrial arthropods, they found them at 65 times the level at vegetated versus nonvegetated shores. Juvenile salmonid diet data collected in 2001 and 2002

along the shores of central Puget Sound indicated that juvenile Chinook salmon were eating high numbers of terrestrial insects (Brennan et al. 2004).

Brennan and Culverwell (2004) found that 80 percent of all wildlife species in King County can be found in the marine riparian areas. This amounts to roughly 57 mammal species, at least 192 bird species, 5 species of reptiles, and 9 amphibians.

Shade and microclimate can also be an important function of the riparian areas for various animals. Rice (2007) showed that armored beaches had a statistically significant higher daily mean light intensity, higher air temperature, higher substrate temperature, and lower daily mean relative humidity. Both Pentilla (2001) and Rice (2006) showed that beaches without shade had a higher mortality of surf smelt eggs.

In 2004, the riparian conditions of the marine shorelines of King County were characterized (Anchor 2004) as part of a larger survey/classification effort. This characterization focused on roughly a 200-foot zone landward from the OHWM. The vegetation was classified by type (trees, shrubs, etc.), density (continuous or patchy), adjacency (adjacent to the OHWM or separated), and if the vegetation was overhanging the intertidal. A related data set from the survey describes whether the shoreline has drift log accumulations parallel to shore and whether trees or large wood debris (LWD) are still attached by the roots perpendicular to the shore. These data are used in reach descriptions to characterize the riparian conditions of each reach.

Segment 1 (Des Moines Beach)

This reach has 17 houses at the toe of a bluff that is 100 to 160 feet tall (Map 13). The 200 foot SMA jurisdiction extends up the bluff and includes the edges of many of the houses that are located on the top of the bluff. This reach also has seven vacant parcels along the shore. The houses at the toe of slope appear to have been built on the intertidal area of the beach (Figure 3). The 1936 aerial photos show many houses were already present along the beach. These houses appear to be served by the Midway Sewer District. There is public access to the beach along the first 200 feet of the segment. The access originates from the City of Des Moines. The physical access to most of the houses appears to be either from driving on the beach from Des Moines Beach Park (in the City of Des Moines) or walking trails that lead from the public rights of way off of South 218th Street and South 219th Street. The specific issues around property access should be further researched by the City in order to establish appropriate policies and regulations within this reach.

Figure 3. Development pattern in Segment 1 also shows that residents regularly drive on the beach in order to access their houses.

Physical

Geologic (Map 14)

All of Segment 1 is listed by Washington Department of Natural Resources (WDNR) as having very low liquefaction susceptibility (Palmer et al. 2007). There were no existing landslides mapped in 2005 (Johannessen et al.). WDNR's shallow-rapid landslide potential model indicates that this segment of shoreline has a mix of high and low probability of landslide susceptibility (Shaw and Vaugeois 1999). The City's Critical Areas Ordinance states, "any area with a slope of 25 percent or steeper and with a vertical relief of more than 20 or more feet shall be designated a landslide hazard area" (Normandy Park Municipal Code 18.36.510, 2010). Slope data for Normandy Park shows that the bluff face and most of the SMA jurisdiction throughout this segment has a slope greater than 25 percent and (King County 2010a). The bluff area has also been characterized as an erosion hazard area (King County, 2010b).

Coastal Processes (Map 15)

This segment has been completely bulkheaded. The bulkhead types are a mix of riprap and cement walls. Since the entire segment is armored, there are no other current shoretypes present other than 'modified' (Johannessen et al. 2005). Recent mapping classifying the historic nature of the shoreline showed that the majority of the segment was an exceptional feeder bluff, with a small area mapped as feeder bluff. This indicates that the area used to provide sediment to the drift cell. Note that the southern 100 feet of this segment currently would supply sediment to the south. This is due to the current conditions of the marina creating the wave shadow described above. Much of the armoring in this segment was classified as being located below the OHWM

(Anchor 2006). As noted above, the deeper into the intertidal the armoring goes, the bigger impact and more spread out through the ecosystem the armoring impacts occur. This segment did not have any groins built to catch sediment, however given that many of the bulkheads extend deep into the intertidal, many of the bulkheads act as groins, intercepting sediment moving along the shore. Although there are no mapped boat ramps in this segment, a review of 2009 aerial photographs shows at least one boat ramp. There are no known overwater structures or tidal barriers in this segment. Given the very close proximity of the houses in this reach to the water, there is greater potential for artificial light pollution at night in this segment than most of the others in the City.

Hydrology (no map)

There are no known streams, wetlands or other water sources in this segment, though it is possible that there are seeps along the toe of the slope throughout this segment. Historically, there was a large wetland complex just south of the segment at the mouth of Des Moines Creek. The 100 year floodplain is mapped with a base flood elevation of 16 ft. The topography along this segment is fairly uniform, creating a regular 20 to 50 foot wide strip of floodplain that runs along the shore just above the OHWM. Most of the houses located along the toe of the bluff are at least partially within the 100 year floodplain.

Biological

Previous forage fish surveys in this reach did not find any sand lance or surf smelt spawning on the beaches, however only one survey has been done in this reach (WDFW 2010) (Map 16). Surveys of submerged aquatic vegetation in the 1990s showed that there are no known kelp beds in Segment 1 (Berry et al. 2000). However, Department of Agriculture maps from 1911–1912 indicate that kelp was more prevalent along the shore in King County than it is now (Thom and Hallum 1990). Surveys in the 1990s showed that eelgrass is found in patchy beds throughout the segment (Berry et al. 2000). Washington Department of Fish and Wildlife shellfish data indicate that hardshell clams can be found close to shore throughout this reach and that geoducks can be found in a parallel band between 700 and 2,000 feet offshore (WDFW 2010).

The marine riparian area has been heavily modified by the development that has occurred over the last 100 years. The trees that are present are limited to the area between the houses at the toe of the bluff and the houses at the top of the bluff, thus providing only a few of the potential benefits of vegetated buffers. The primary benefit the vegetation is providing is slope stabilization. However, it should be noted that the trees along the top of the bluff slope have been thinned or removed throughout much of the segment. Also, most of the trees at the top of the bluff are gone and replaced with lawns. This was most likely done in order to provide unobstructed views of Puget Sound, and it is likely this has increased slope instability for the tall bluffs just above the houses on the shore. Given that the whole reach has been bulkheaded and that most of the bulkheads are well below the ordinary high water line, there are no accumulations of drift logs on the beach and no ability for LWD to accumulate and overhang the intertidal. There are also no known dune grass areas from surveys in 2004 (Anchor 2004).

As noted above, one of the primary means of accessing the houses is driving along the beach. Driving along the beach has the potential to create a variety of damage to the beach. Any benthic or epibenthic organisms on the upper beach are likely to get crushed by vehicles. This

includes any forage fish that might be spawning on the beaches. It is not known if residents drive along the lower intertidal areas during low tides. If they do, there is the potential to heavily damage any eelgrass patches present. Car use on the beach also creates a likely source of consistent pollution through leaks of various car fluids (i.e., oil, antifreeze). The cumulative impacts of all the stressors on the ecology of this segment of shoreline are potentially high.

Segment 2 (Marine View Park/Beaconsfield)

This mile long reach includes mostly steep bluffs throughout the segment, with about 600 feet of low bank shoreline in the northern portion (Map 17). The development pattern in this segment is different from Segment 1 because the bluff has been interrupted by multiple reentrants created by localized surface and groundwater discharge. Since the bluff face undulates greatly in this segment, most of the development at the top of the bluff was set back farther from shoreline than in Segment 1. In Segment 2, the top of the bluff is generally much greater than 300 horizontal feet away from the OHWM, in comparison to Segment 1, where it is generally less than 200 feet. There are 52 shoreline parcels in this reach. Only 7 of these parcels have houses within 200 feet of the shoreline and there are 34 vacant parcels. Two of the houses are located on the shore, at the toe of the bluff, and are located close to Segment 1. Unlike the houses in Segment 1, these two houses have upland access via a road cutting across a steep slope. This segment also includes Marine View Park, which is the only physical public access point to shore for residents of the City. Many of the vacant parcels are found in the Beaconsfield area and are very skinny parcels, some only 20 feet wide, that contain only steep slopes. The City currently owns some of the properties in the Beaconsfield area and is currently attempting to acquire more. These skinny private properties provide some of the best potential public access (Maps 3 and 17) within the City.

Physical

Geologic (Map 18)

Most of Segment 2 is listed by WDNR as having very low liquefaction susceptibility (Palmer et al. 2007). There are 2 small areas in the northern end of the segment (~3 acres total) that are classified as having a moderate to high susceptibility to liquefaction. These two low bank areas contain 3 of the 7 houses along the shore in this segment. There were nine different landslides mapped in 2005 (Johannessen et al.) comprising about 1,400 feet of the shoreline. WDNR's shallow-rapid landslide potential model indicates that this segment of shoreline has a mix of high and low probability of landslides susceptibility (Shaw and Vaugeois 1999). The City's Critical Area's Ordinance states, "any area with a slope of 25 percent or steeper and with a vertical relief of more than 20 or more feet shall be designated a landslide hazard area" (Normandy Park Municipal Code 18.36.510, 2010). Slope data for Normandy Park shows that the bluff face and most of the SMA jurisdiction throughout this segment has a slope greater than 25 percent (King County 2010a) and is characterized as an erosion hazard area (County 2010b). The only two shoreline areas that do not have steep slopes are the two areas that have a high susceptibility of liquefaction.

Coastal Processes (Map19)

This segment has been bulkheaded along 50 percent of the shore. Other shoretypes present include a modified accretion shoreform, a few hundred feet of transport zone, and roughly half a mile of active feeder bluff (Johannessen et al. 2005). Recent mapping classifying the historic nature of the shoreline showed that the majority (47 percent) of the armored area was mapped as being an exceptional feeder bluff, with a smaller area (30 percent) mapped as feeder bluff. This indicates that this area used to provide a significant amount of sediment to the drift cell. The accretion areas located in this segment have a heavily modified backshore caused by houses and clearing. The bulkhead types are a mix of riprap, old creosote pilings and cement walls. Much of the armoring in this segment was classified as being located below the OHWM (Anchor 2006). All of this information indicates that the physical impacts of the bulkheading in this reach are high.

This segment did not have any groins built to catch sediment, however given that many of the bulkheads extend deep into the intertidal, many of the bulkheads act as groins, intercepting sediment moving along the shore. There are three mapped boat ramps in this segment. Two of the ramps are quite extensive, with one extending 110 waterward of the OHWM and the other extending 65 feet out. There are no known overwater structures or tidal barriers in this segment. Given the general lack of proximity of houses in this reach to the water and the highly vegetated slopes, there is a very low potential for artificial light pollution at night in this segment.

Hydrology (Map 20)

Although no streams or other water features in this reach show up in the County's GIS stream layer, there are at least two small streams that are highly visible in most aerial and oblique photographs. The southerly stream mouth is highly constrained due to being located between the two houses that are located on the beach. The two houses and their bulkheads create an approximately 60-foot-long by 10-foot-wide flume. Given the steepness of the hillside it is unlikely that this stream could provide salmonid spawning habitat, but the stream mouth would provide rearing habitat. The other stream is located between Marine View Park and the Beaconsfield development and appears to have a natural outlet. A survey done in 2003 of an upstream segment classified the water type as perennial with no fish (Washington Trout 2004).

Throughout the southern two thirds of the segment, the 100 year floodplain is mapped with a base flood elevation of 16 ft. The topography along this portion of the segment is fairly uniform, creating a regular 20 foot wide strip of floodplain that runs along the shore just above the OHWM. The two houses that are located on the shore in the southern end of the segment appear to be partially within the 100 year floodplain. In the northern part of the segment, the base flood elevation alternates between 16 and 10 feet. The floodplain bulges inland twice, in one case by as much as 200 feet. Two of the other five houses in the northern part of the segment appear to be partially located within the 100 year floodplain.

Biological

Previous surveys in this reach have not found any sand lance or surf smelt spawning on the beaches (WDFW 2010) (Map 21). Unlike Segment 2, surveys have occurred throughout the reach in four different time periods (in three different years). Given that some of the beaches in this segment could support surf smelt and sand lance (i.e., have appropriate physical space and

appropriate substrate), it is unclear why they are currently not spawning in this segment. Surveys of submerged aquatic vegetation in 1990s showed that there are no known kelp beds in Segment 2 (Berry et al. 2000). The same surveys showed that eelgrass is found in patchy beds throughout the segment.

Washington Department of Fish and Wildlife shellfish data indicate that hardshell clams can be found close to shore in the southern portion of this segment and that geoducks can be found in a band parallel to shore more than 700 feet offshore (WDFW 2010). It should also be noted that the two large boat ramps in this segment extend fairly deep and appear to be cement structures that would preclude most naturally occurring subtidal organisms (i.e., various clams).

The marine riparian area in this segment is probably the most intact within the City. Trees make up slightly over 90 percent of the shoreline vegetation. Although the trees are a mix of dense and patchy stands, most of the trees do not overhang the intertidal. The lack of overhanging vegetation is created by a combination of natural steep bluffs along the shore and shoreline armoring interrupting the ability of the trees to overhang the intertidal. Given the broad area covered by steep slopes, this area is one of the more heavily treed areas in the City. Similar to Segment 1, many of the trees at the top of the bluff have been replaced with lawns. This was most likely done in order to provide unobstructed views of Puget Sound, and may have created some slope instability.

There were no areas of smaller dune grass areas from surveys in 2004 (Anchor 2004). However, there is a small patch of dune grass visible in 2006 oblique photographs at the very southern end of the segment. The dune grass is located behind the bulkhead, indicating that there is freshwater seepage coming out of the toe of slope.

There are no mapped areas of LWD, likely for the same reasons noted above for the generally low amount overhanging trees. However, there are significant areas (~60 percent of the segment) of drift log accumulations (see Figure 4). The areas of the segment that do not have drift logs are generally bulkheaded below the OHWM, providing no ability for the logs to accumulate.

Figure 4. Drift log accumulations in Marine View Park.

Segment 3 (Beaconsfield to Edgecliff)

This 2,000 foot long segment's geomorphology is fairly similar to Segment 2 (Map 22). This segment includes mostly low bank shoreline that is at the base of one of the areas that the bluff has substantially eroded inland due to localized surface and groundwater discharge. There is one short area (~400 feet) of bluff in the middle of the segment which is fairly stable due to the beach in front of it being accretionary. Although the bluff face undulates in this segment, there were more substantial flat areas near the toe of slope where development of sizable houses has occurred. There are 10 shoreline parcels in this reach. Five of these parcels have houses within 200 feet of the shoreline. The houses are between 25 feet to 50 feet from the OHWM. There is only one vacant parcel which is covered in trees and other vegetation. This parcel is recommended for protection in the restoration and protection plan later in this report. This is the only segment within the City that has a private road along the beach. The road is about 500 feet long and the waterward edge is located at about the OHWM. This segment is also one of the only segments with a coastal wetland.

Physical

Geologic (Map 23)

Most of the shoreline edge of Segment 3 is listed by WDNR as having moderate to high liquefaction susceptibility (Palmer et al. 2007). There is one area where the moderate to high rating goes inland 800 feet, but there are no houses located here. Most of the upland area is listed as having low susceptibility. The houses are located along the edge of the two classifications, but within the low classification. There were no landslides mapped in 2005 (Johannessen et al.). WDNR's shallow-rapid landslide potential model indicates that most of this segment's shoreline has a low probability of landslides susceptibility (Shaw and Vaugeois 1999), though the data is absent for portion of the segment with a bluff in the backshore. Steep slope data for Normandy Park (calculated according to the City's CAO) shows that most of the SMA jurisdiction throughout this segment has a slope less than 25 percent (King County 2010a) though the bluff area in the center of the segment does have steep slopes approximately 50 feet back from the OHWM. The segment is characterized as having a mix of areas with and without erosion hazards (King County 2010b). The area of erosion hazard starts in the middle of the segment and extends north through the segment. The hazard is not mapped to the shoreline edge, but 40 to 90 feet inland from OHWM.

Coastal Processes (Map 24)

The entire segment is mapped as an accretion shoreform, but almost 45 percent of it has been heavily modified by clearing, bulkheads, and a road (Johannessen et al. 2005). The bulkhead types are a mix of riprap and cement walls. The armoring in this segment was classified as being located at or above OHWM (Anchor 2006). This generally indicates the impacts of these bulkheads are less on the actual beach environment, but the upland portion of the segment has been heavily modified by development. This segment did not have any groins, boat ramps, or overwater structures mapped in 2005 (Anchor 2006). Given the close proximity of houses in this reach to the water in the northern half and most southern portion, there is a moderate potential for artificial light pollution at night in this segment.

Hydrology (Map 25)

Although no streams in this reach show up in the County's GIS stream layer, there are at least two small streams that are highly visible in most aerial and oblique photographs and were mapped in 2004 by Washington Trout (now known as Wild Fish Conservancy). The southerly stream flows into the mapped wetland in this reach. The stream was not classified by Washington Trout as they did not have physical access to creek in order to classify it. The wetland is approximately three acres in size and appears to be isolated from the marine environment by a private road that runs along the shore. Given the low-lying beach face, it appears that under natural circumstances there would be a connection to the Sound, creating a salt marsh versus a freshwater dominated marsh. The northerly stream is highly constrained due its location in a cement flume. The flume is approximately 130 feet long by 2 feet wide and outlets onto the beach. This stream was classified by Washington Trout (2004) as being perennial without fish. It is unclear how much habitat would be opened up if the flume barrier was made passable, but given the steepness of the hillside it is unlikely that this stream could provide salmonid spawning habitat. Washington Trout (2004) noted that the landowner said that there was a salt marsh at the mouth 50 years ago, before the houses were built on top of the

marsh. If the mouth was restored, or at least the flume made more passable, it is likely that the area would be used by rearing salmonids from nonnatal areas (i.e. from other stream systems).

The base flood elevation of the 100-year floodplain is highly variable in this segment. From south to north, it begins with a 10-foot elevation, changing to a 9-foot elevation and then extending through the next segment with a 16 foot elevation. In the southern part of the segment, the floodplain bulges inland twice. The northern bulge matches the location of the mapped wetland and extends inland by approximately 120 feet. Given the lower base flood elevation mapped in this area, the houses appear to be out of the floodplain. In the northern half of the segment, the floodplain extends inland above the OHWM irregularly between 20 feet and 70 feet. Three of the four houses at the northern end of the segment appear to be within the edge of the floodplain.

Biological

Previous surveys in this reach found surf smelt spawning on the beaches, but no sand lance (WDFW 2010) (Map 26). Surveys in 1994 found surf smelt in the center and at the northern end of the segment, amounting to a total of 1,300 feet of this segment being mapped as spawning beach. Spawner surveys have occurred mostly in the center of the reach in 1994 and 2006. Surveys of submerged aquatic vegetation in 1990s showed that there are no kelp beds in Segment 3 (Berry et al. 2000). The same surveys showed that eelgrass is found in patchy beds throughout the segment, with a continuous band of eelgrass in the northern 300 feet of the segment.

Washington Department of Fish and Wildlife shellfish data indicate geoducks can be found in a band parallel to shore more than 700 feet offshore (WDFW 2010).

The marine riparian area in this segment is some of the least intact within the City. Trees make up slightly over 22 percent of the shoreline vegetation. This single dense patch of trees does not overhang the intertidal, though it does extend up the slope and onto the plateau above. The rest of the vegetation in this segment is made up of lawns and landscaping. Given the accretionary nature of this shoreline and that bulkheads were mostly built above the OHWM, there are drift log accumulations throughout the segment. However, given the lack of trees along the shore, there are no mapped areas of LWD.

Along with the one mapped wetland, there are also two smaller areas of dune grass noted in 2004 surveys (Anchor 2004). One of those is located at the mouth of the northerly stream. The other is located in some dunes just to the south in front of one of the beach front houses.

Segment 4 (Edgecliff)

This 3,500-foot-long segment's geomorphology is much more similar to Segment 1 than segments 2 and 3 (Map 27). The shoreline is typified by a vegetated, steep, uniform bluff with no houses at the toe of slope. The bluff height starts at around 250 feet in the southern end and slowly transitions to a 50-foot-tall bluff at the northernmost end. There are 33 shoreline parcels in this reach, with only 1 vacant parcel. Only four of these parcels have houses within 200 feet of the shoreline. Edgecliff road is approximately 350 feet from shore and parallels the shore for most of the segment (Figure 5). There is generally a row of houses between the road and the

slope of the bluff. The houses are set back from the edge of bluff on average 30 feet. This segment does have one historic house (the "Tracy House") that is located just outside of shoreline jurisdiction, while much of the property is located on the bluff face.

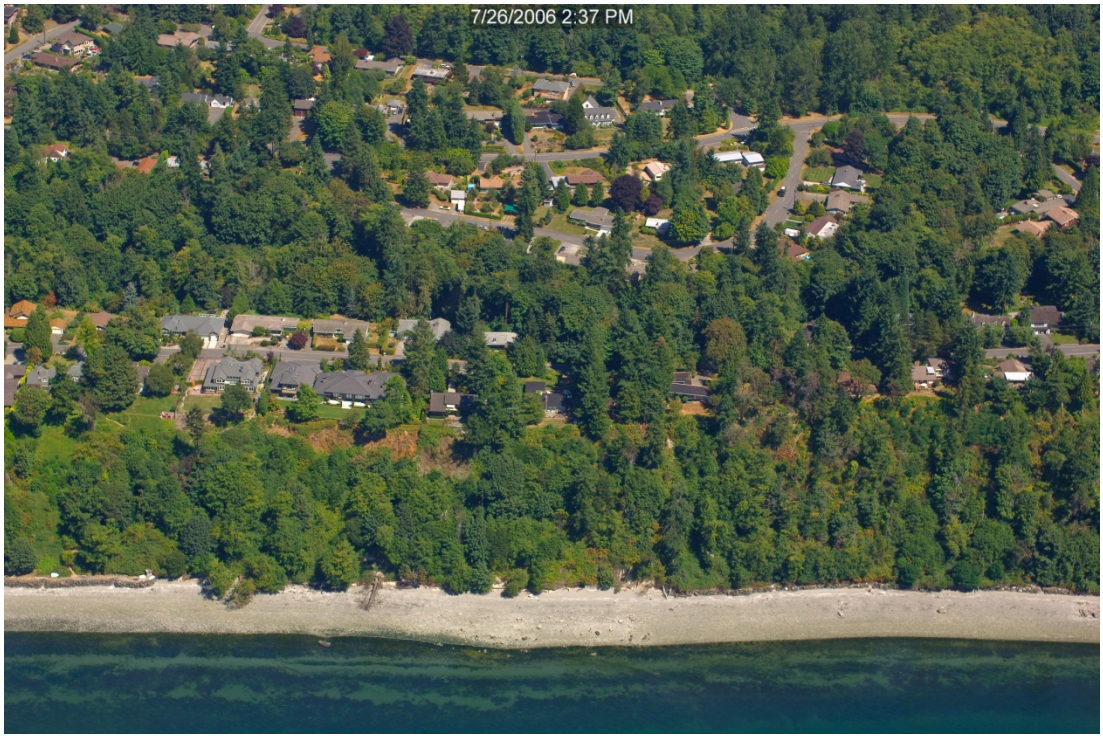

Figure 5. Example of the the development pattern throughout this reach (Photograph from WDOE).

Physical

Geologic (Map 28)

All of the shoreline edge of Segment 4 is listed by WDNR as having low liquefaction susceptibility (Palmer et al. 2007). There was only one landslide mapped in 2005 (Johannessen et al.), at the very southern end of the segment. WDNR's shallow-rapid landslide potential model indicates that the southern two thirds of this segment's shoreline has a mostly high or moderate probability of landslides susceptibility (Shaw and Vaugeois 1999). The northern third is mostly a mix of low and high probability of landslide susceptibility. Steep slope data for Normandy Park (calculated according to the City's CAO) shows that most of the SMA jurisdiction throughout this segment has a slope greater than 25 percent (King County 2010a) with the northern 500 feet having less steep slopes. The segment is characterized as having erosion hazards in only the southern half of the segment along the bluff face (King County 2010b). There is no erosion hazard data available for the northern half of the segment (King County 2010b).

Coastal Processes (Map 29)

Most of the segment is mapped as either a feeder bluff or modified (Johannessen et al. 2005). Bulkheads are found along 54 percent of this segment. The bulkhead types are mostly low rock revetments and with some cement walls. The armoring in this segment was classified as mostly

being below OHWM (Anchor 2006). The bulkheads in this reach appear to have been constructed to limit erosion of the toe of slope. One larger (~350 feet) bulkhead was built far into the intertidal and filled in behind the bulkhead in order to provide a level platform at the toe of slope. Historical reconstruction of the armored sections indicates that they were previously acting as feeder bluffs (Johannessen et al. 2005). Given that the bulkheads are below OHWM, and are blocking sediment from reaching the beach, they have a fairly significant impact on the nearshore environment. This segment had one groin mapped in the center of segment, but the groin appears to be falling apart and not effective. There were no boat ramps or overwater structures mapped in 2005 (Anchor 2006). Given the lack houses near the water, there is a low potential for artificial light pollution at night in this segment.

Hydrology

No streams or seeps are known to occur in this reach. There are no known wetlands. Throughout the segment, the 100 year floodplain is mapped with a base flood elevation of 16 ft. The topography along this portion of the segment is fairly uniform with steep bluffs along the shore, creating a regular 10-foot-wide strip of floodplain that runs along the shore just above the OHWM. Since all of the houses are located at the top of the bluff in this segment, there are no houses located within the floodplain.

Biological

Previous surveys in this reach found surf smelt spawning on the beach in the southern end of the segment, but no sand lance (WDFW 2010) (Map 30). Surveys in 1994 found surf smelt spawning along a total of 700 feet of this segment. Spawner surveys have occurred throughout the reach in 1994 and 2006. Surveys of submerged aquatic vegetation in 1990's showed that there are no known kelp beds in Segment 4 (Berry et al. 2000). The same surveys showed that eelgrass is found as a continuous band throughout the whole segment. Washington Department of Fish and Wildlife shellfish data indicate geoducks can be found in a band parallel to shore more than 1,000 feet offshore (WDFW 2010).

The marine riparian area in this segment is some of the most intact within the City. Trees are found along the entire length of shoreline, though approximately 65 percent of the trees are not dense, but patchy. Overhanging trees make up slightly over 73 percent of the shoreline, with much of overhanging vegetation being patchy in nature. It should be noted that much of the treed area thins out as it gets to the top of the bluff, especially in the northern section of the segment. This is likely for views of Puget Sound, but the lack of trees and predominance of shrubs will likely affect the slope stability over the long term. There is one small area (~200ft) of LWD mapped in the southern portion of the segment. There are drift log accumulations in the southern and northern sections of the segment.

Segment 5 (Edgecliff to the Cove)

This almost mile long segment's geomorphology is fairly different than the other segments to the south (Map 31). This segment includes mostly low bank shoreline that gently slopes towards Puget Sound and is likely part of a remnant glacial outwash channel (Booth and Waldron 2004). Given the gentle slope, the area is also highly built out by residential land use. There are 32

shoreline parcels in this reach. None of these are vacant. Twenty-eight of the parcels have houses within 200 feet of the shoreline. Most of the houses are set back 60 to 100 feet from the OHWM. There are several houses that are located less than 30 feet from the OHWM. This segment also contains three historic houses in the northern half. They are the "Hughett House," "Gustin House," and another unnamed house (King County 2010c). Normandy Terrace SW parallels the shore in this segment, with a small portion of the road being in shoreline jurisdiction. This segment is also one of the only segments with a coastal wetland. The northern end of this segment also has a large stream delta that protrudes out into Puget Sound 1,000 feet or more. The Southwest Suburban Sewer District has a direct outfall offshore of the delta. This outfall may be responsible for some of the unusual water quality data noted above.

Figure 6. Wetland complex at the mouth of Miller and Walker Creeks Photograph from WDOE).

Physical

Geologic (Map 32)

Most of the shoreline area of Segment 5 is listed by WDNR as having very low liquefaction susceptibility (Palmer et al. 2007). There are two areas where the moderate to high rating occurs. The first is located in the southern portion of the segment, where a freshwater wooded marsh was mapped in the 1870s (Collins and Sheikh 2005). It is approximately 900 feet long and goes inland 150 feet. Only one house was located within the high rating, though this house was recently demolished. It is unclear if a new house will be rebuilt in this location. The second area of high susceptibility is located at the mouth of Miller and Walker Creeks. This area was also mapped as a wooded marsh in the 1870s (Collins and Sheikh 2005). The Cove community center buildings, as well as the Normandy Park Swimming Club are located within this area. There were no landslides mapped in 2005 (Johannessen et al.). WDNR's shallow-rapid landslide potential model indicates that most of this segment's shoreline has a low probability of landslide susceptibility (Shaw and Vaugeois 1999). A small portion of shoreline just south of Miller and Walker Creek mouths has high probability of landslide susceptibility mapped due to a slight increase in height of the shoreline in this area. Steep slope data for Normandy Park (calculated

according to the City's CAO) shows that most of the SMA jurisdiction throughout this segment has a slope less than 25 percent (King County 2010a) though the area just south of Miller and Walker Creeks does have steep slopes for about 1,000 feet along the shore. There were no erosion hazards mapped in this area (King County 2010b).

Coastal Processes (Map 33)

The segment is mapped as a combination of accretion shoreforms and modified shorelines (Johannessen et al. 2005). Close to 50 percent of the shoreline has been bulkheaded (Anchor 2004). Historically reconstruction of the bulkheaded areas indicated that they were likely composed of accretion shoreforms (Johannessen 2005). The bulkheading is concentrated in the residential area in the central and southern portions of the segment. The bulkhead types are a mix of rock/riprap revetments and cement walls. Sixty percent of the armoring in this segment was classified as being below the OHWM (Anchor 2006). Combined, this data indicates that the impact of these bulkheads is focused on the actual beach environment and backshore environments, and not on the sediment delivery functions. This segment has 11 groins throughout the segment. Half of them appear to be old and failing, but one appears to be relatively new and larger (20 feet wide by 80 feet long) and is visibly trapping a fair amount of drift logs and sediment on the updrift side. This groin certainly affects sediment transport to other properties downdrift. Immediately downdrift of this groin is the remnant of a boulder field that could also be removed. There are at least 7 boat ramps in this reach, most of which are fairly short and extend far into the intertidal. There two overwater structures in this reach. The first one is at the southern end of the segment and is roughly 5 feet wide by 50 feet long. The northern one connects a private residence on the right bank of Miller Creek at its mouth to the very end of the beach berm spit where a helipad was constructed. Given the general close proximity of houses in this reach to the water in the southern and central portions, there is a moderate potential for artificial light pollution at night in this segment.

Hydrology (Map 34)

The three mapped streams in Normandy Park all outlet to Puget Sound in this segment. The southerly stream, Normandy Creek, is a short stream that drains Nature Trails Park. Although no fish were found during stream surveys in 2004, fish were believed to be present historically (Washington Trout 2004). The surveys were unable to determine if the piped outlet was a barrier to fish passage, but the habitat in the stream above the mouth was classified as having adequate spawning habitat. The outlet appears to be piped 80 feet waterward of the OHWM. This stream was most likely responsible for the historically mapped wooded marsh that was located at the mouth of this creek. There are no obvious signs of the historic seven acre wetland today. The wetland area is visible in 1936 aerial photographs. It appears that the wetland area was filled at some point prior to 1974, the next time period with an available aerial photograph. The other two streams in this segment are Miller and Walker Creeks, which join together to a single stream channel just before the creek enters saltwater. Historically, both creeks fed into a nine acre wetland complex (Collins and Sheikh 2005). Portions of that wetland still remain. Approximately 2.3 acres appears to be scrub-shrub wetland. This wetland area is focused around the two stream channels near where they combine to one channel. Most of this area is part of the private park, 'The Cove.' An enhancement project in the recent past created a large pond along the channel of Walker Creek. The pond has a dam on its outlet in order to control water levels. It is not believed that salt water reaches the pond (Peter Landry, personal communication, 2010).

At least two acres of the former wetland area is currently managed as a lawn. The larger wetland area is likely to change as sea level rise occurs. It is likely that much of the lower area managed as lawn will eventually revert back to some form of salt marsh. In 2004, Washington Trout's surveys showed high numbers of both coho salmon and cutthroat trout in both streams.

The base flood elevation of the 100 year floodplain is highly variable in this segment. From south to north, it begins with a 16 foot elevation, changing to a 10 foot elevation around the mouth of Normandy Creek, continues north at 16 foot until it gets to the Cove where the base flood elevations is approximately 9 foot. There is one section of shore in the southern end of the segment where the floodplain goes inland approximately 200 feet and incorporates approximately 3 houses. The next portion of the segment has a uniform 30 foot wide strip of floodplain that runs along the shore just above the OHWM. Although no houses appear to be located within the floodplain other associated structures are (i.e. boat houses). The area around the cove has a substantial amount of floodplain, with well over 85% of the private park parcel located within the floodplain.

Biological

Previous surveys in this reach did not find any surf smelt or sand lance spawning on the beaches (WDFW 2010) (Map 35). There have only been five documented surveys in this segment, which occurred in 1993, 1994 and 2006. Given that some of the beaches in this segment could support surf smelt and sand lance (i.e., have appropriate physical space and appropriate substrate), it is unclear why they are currently not spawning in this segment. Surveys of submerged aquatic vegetation in 1990s showed that there are no known kelp beds in Segment 5 (Berry et al. 2000). The same surveys showed that eelgrass is found in patchy beds throughout the segment. Washington Department of Fish and Wildlife shellfish data indicate geoducks can be found in a band parallel to shore more than 1,000 feet offshore (WDFW 2010).

The marine riparian area in this segment is some of the least intact within the City. Landscaping and grass make up over 80 percent of the riparian vegetation of this segment. There are two patches of trees in the center of the segment totaling 564 feet of shoreline and one small patch at the northern edge of the segment. A large portion of the trees comes from a single parcel that contains one of the historic houses. Given that much of the bulkheading was built below the OHWM it is somewhat surprising that there are so many drift log accumulations along the shore. Drift log accumulations were mapped in almost 70 percent of the segment, mostly in the central and northern portions. However, given the lack of trees along the shore, there are no mapped areas of LWD.

There are two areas of smaller areas of dune grass habitat noted in 2004 surveys (Anchor 2004). These are both located along the spit at the mouth of Miller and Walker Creeks and are probably contained within existing mapped wetland.

Segment 6 (North City Limits)

This 750 foot long segment's geomorphology is fairly similar to segments one and four (Map 36). The shoreline is typified by a vegetated, steep, uniform bluff with one house at the toe of slope. The bluff height is about 100 feet high throughout the segment. There are only six

shoreline parcels in this reach; two are vacant. Portions of three houses are within the shoreline jurisdiction. One of these houses is built at the toe of the bluff and on the intertidal area.

Physical

Geologic (Map 37)

All the shoreline edge of Segment 6 is listed by WDNR as having either low or low to moderate liquefaction susceptibility (Palmer et al. 2007). There were no landslides mapped in 2005 (Johannessen et al.). WDNR's shallow-rapid landslide potential model indicates that southern half of the segment's shoreline has a low probability of landslide susceptibility, though small portions throughout are listed as having a high probability. (Shaw and Vaugeois 1999). There is no data for the northern half. Steep slope data for Normandy Park (calculated according to the City's CAO) shows that almost the entire SMA jurisdiction throughout this segment has a slope greater than 25 percent (King County 2010a). There is no data on erosion hazards in this segment (King County 2010b).

Coastal Processes (Map 38)

All of the segment is mapped as modified (Johannessen et al. 2005) and is bulkheaded. The bulkhead types are mostly low rock revetments and with some cement walls. The armoring in this segment was classified as mostly being located above the OHWM (Anchor 2006), though based on 2006 oblique photos most of the armoring appears to actually be below the OHWM. Historical reconstruction of the armored sections indicates that they were probably acting as feeder bluffs (Johannessen et al. 2005). Given that the bulkheads are below the OHWM, and are blocking sediment from reaching the beach, they have a fairly significant impact on the nearshore environment. This segment had no groins, boat ramps, or overwater structures mapped within it (Anchor 2004). Given the lack of proximity of houses to the water in this reach and the highly vegetated bluffs, there is a low potential for artificial light pollution at night in this segment.

Hydrology

No streams or seeps are known to occur in this reach. There are no known wetlands. Throughout the segment, the 100 year floodplain is mapped with a base flood elevation of 16 ft. The topography along this portion of the segment is uniform with steep bluffs along the shore, creating a fairly regular 10 to 20 foot wide strip of floodplain that runs along the shore just above the OHWM. The one house located at the toe of the bluff appears to be partially within the floodplain, while all of the other houses are located at the top of the bluff and not within the floodplain.

Biological

Previous surveys in this reach found no surf smelt or sand lance spawning on the beach (WDFW 2010) (Map 39). There were only two recorded surveys done in this segment; one in 1994 and one in 2006. Surveys of submerged aquatic vegetation in 1990s showed that there are no known kelp beds in Segment 6 (Berry et al. 2000). The same surveys showed that patchy eelgrass was found throughout the whole segment. Washington Department of Fish and Wildlife shellfish

data indicate geoducks can be found in a band parallel to shore more than 1,000 feet offshore (WDFW 2010).

The marine riparian area in this segment is composed mostly of trees. Patchy trees are found along the entire length of shoreline, though approximately 15% of the trees are separated from the shoreline by a house. There are no overhanging trees within this segment. Unlike many of the other segments, there is a fair amount of vegetation along the top of the bluff. Given the shoreline armoring of the whole segment, no LWD was mapped in the segment. There is a very small area of drift log accumulations in the southern most edge of the segment (Anchor 2004).

RESTORATION/PRESERVATION OPPORTUNITIES

As part of the characterization, opportunities for either restoring shoreline processes or preserving unique pieces of shoreline were described both for within segments and looking at the City as a whole.

There are a variety of general or programmatic actions that the City could undertake throughout the City as new or redevelopment proposals come in. These include:

- Protect existing native vegetation along the shore and bluff face.
- Undertake noxious and invasive weed control throughout the shoreline area.
- Protect and preserve functioning feeder bluffs.
- Protect existing LWD and drift log accumulations on the beach.
- Severely limit the circumstance where new bulkheads could be created in areas that currently don't have any.
- Promote the use of shoreline setbacks for all new construction.
- Remove shoreline armoring where ever possible as part of redevelopment proposals, especially in areas that were historically feeder bluffs. If shoreline armoring needs to be replaced, consider requiring that soft-shore armoring options be exhausted before allowing a standard rock revetment. If replacement rock revetment is allowed, move the revetment back so that it is located above the OHWM.
- Revegetate as much of the shoreline as possible. This is especially important in the bluff areas. There are many areas throughout the City where the vegetation at the top of the bluffs has been removed for views. There are many ways to plant and prune trees that still allow for views of Puget Sound. This could help to better stabilize bluffs, especially in areas where houses are located very close to the bluff edge or at the bottom of the bluff.
- Restore tributary stream mouths, which tend to provide wetland habitats that are extremely rare in central Puget Sound.
- Restore coastal wetland areas and fish access to them whenever opportunities arise.

- Remove abandoned human made structures (i.e., failing docks, creosote pilings, and creosote debris on the beach).
- Create an education program for shoreline landowners on the importance of the nearshore environment and on safety related to the various hazards that come with living on the shore.
- Take actions to clean up all stormwater discharges that enter Puget Sound.
- Minimize the number of docks, trams or trails/stairs. Require new ones to be shared by more than one shoreline landowner.
- Reduce or eliminate driving on the beach.

The reach specific restoration/protection measures are described below by segment and can be found on map 40.

Segment 1

There are no obvious parcels of land in this segment which are of high habitat quality that would be an ideal target for conservation efforts. The restoration potential in this segment is also highly constrained by the existing development pattern of houses on the beach and at the top of bluff. The entire segment of shoreline was called out in Joahnnessen et al. (2005) as the third highest restoration priority in the entire drift cell for bluff restoration. Restoration efforts in this segment need a programmatic approach to address: driving on the beach; houses located in unsafe locations below bluffs; houses that will likely be heavily impacted by changes in sea level; and houses that are mostly sitting on and displacing intertidal habitat.

Segment 2

Beaconsfield is an active salmon recovery project being undertaken by the City and the Cascade Land Conservancy in the middle of this segment. The project involves purchasing approximately 1,000 feet of shoreline (27 vacant parcels) in order to undertake bulkhead removal. Most of the parcels are very skinny and have no upland access, but are bulkheaded (Figure 7). This stretch of shoreline ranked as the highest bluff restoration priority for the entire drift cell (Johannessen et al. 2005). There is a single house at the top of the bluff, which is located on a small promontory of land with steep slopes on three sides. The property owner also owns one of the shoreline properties. A feasibility study was done in 2006 (Johannessen et al. 2006) to look at how much of the bulkhead could be removed without endangering the house at the top of the bluff. This report showed that 535 feet of the bulkhead could be removed. Since then the Cascade Land Conservancy and the City have been acquiring properties in order to remove the portion of the bulkhead that was called out in the feasibility report. A follow up feasibility study will begin in 2010 to look at bulkhead removal alternatives.

This project could be expanded slightly by acquiring a combination of conservations easements and public access easements on the 2 nonvacant parcels that are between the Beaconsfield project and the City's Marine View Park. The two parcels are generally well vegetated along the shore and they could provide the public with legal access to the recently acquired lands. This area was called out in Johannessen et al. (2005) as one of the highest priorities for protection throughout King County.

Figure 7. Removal of the bulkheads at Beaconsfield is ideal candidates for restoration (Photograph from Coastal Geologic Services).

At the southern most end of Segment 2, is an area that is bulkheaded and where the bulkhead does not appear to serve much of a purpose (i.e., parcels are vacant). Between 200 to 500 feet of bulkhead could potentially be removed. This location also has a small area of dune grass (~60 ft of shore) behind the bulkhead, indicating that there is freshwater seepage coming out of the toe of slope. Creating connectivity between this small habitat and the shoreline could provide a variety of fish and wildlife benefits. The City could explore landowner willingness to remove the bulkhead or look at acquiring the properties in a fashion similar to Beaconsfield's.

Just north of this location is a highly constrained stream mouth, which is pinched between two houses (Figure 8). If this stream mouth were restored, the location has the potential to provide excellent salmonid rearing habitat (Johannessen et al. 2005). However, this restoration would likely require removing at least one of the houses, if not both. This potential restoration action is called out in the WRIA 9 habitat conservation plan.

Figure 8. The unnamed stream constrained at the mouth by two houses (Photograph from Coastal Geologic Services).

Segment 3

In this segment there is one main restoration option and one area that could be protected. There is a parcel that is close to 9 acres in size that has about 300 feet of densely forested shoreline. This type of habitat is rare within the City and should be preserved to the greatest degree possible. The restoration action would be to restore the existing freshwater wetland to a salt marsh (Figure 9). At a minimum, this would entail creating some form of bridge or culvert under the private road. A more comprehensive restoration approach would be to remove much of the private road that is currently circling the wetland as it appears to be mostly superfluous since there is a second loop road around the upland portions of the wetland that connects the developed portions of the property. This could restore tidal inundation to what appears to be an isolated three acre wetland.

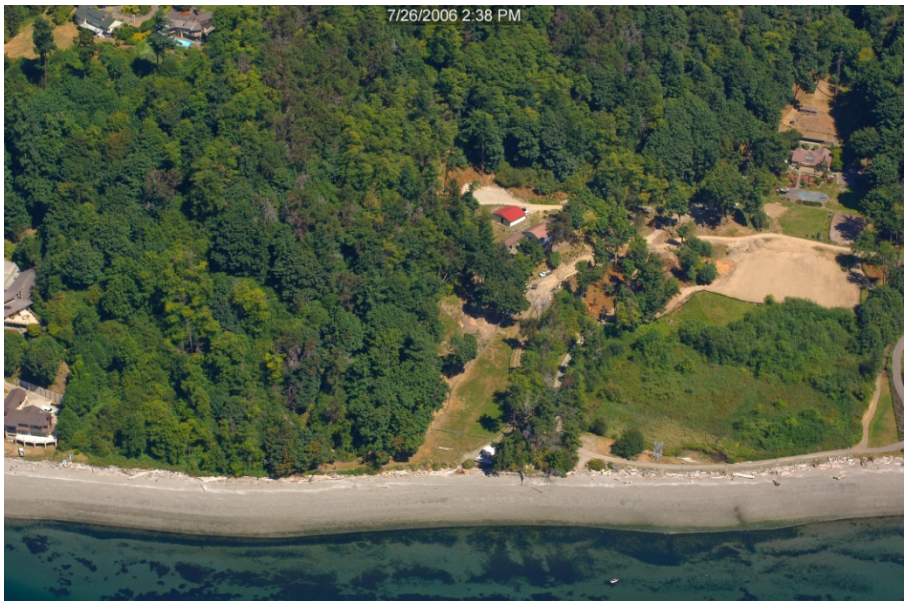

Figure 9. Potential preservation area located in the left of the photograph. The potential restoration project is located along the right side of the photograph. (Photograph from WDOE).

Segment 4

As noted above there is one bulkhead in this reach that is located much farther out in the intertidal than the others. When this bulkhead needs to be repaired (parcel numbers 6117500615, 6117500620, 6117500625), the bulkhead could either be removed entirely or moved back above the OHWM, allowing for more access to the upper beach to forage fish and other aquatic species.

Although the bluff vegetation along the water is mostly trees, there is definitely a need for more trees along the bluff, especially along the top of the bluff. A vegetation enhancement project along this entire segment would be ecologically beneficial and would likely benefit slope stability.

Segment 5

The only obvious conservation action in this reach would be to preserve the existing vegetation on the four parcels that still have trees.

The mouth of Normandy Creek could be enhanced or partially restored because a significant amount of habitat was lost due to residential development. The creek could be daylighted between existing houses or routed through some of the lawns. It is not obvious how best to enhance this creek mouth given the constraints of existing houses. It is likely that any significant amount of restoration would require the acquisition and demolition of one of the existing houses adjacent to the marsh. More effort should be undertaken to better understand how this system is currently piped into Puget Sound and if there are opportunities to improve it.

Potentially related to restoring the mouth of Normandy Creek, the large groin noted above could be removed as part of shoreline redevelopment (Figure 10). This would allow sediment transport to be restored.

Figure 10. Groin in the foreground could be removed to improve sediment transport processes.

There are various aspects to the area around the mouth of Miller and Walker Creeks that could be restored or enhanced.

- The helipad, bridge, and the shoreline armoring surrounding the spit could be removed (see Figure 11)
- Work with the private residence on the right bank of Miller/Walker Creek to remove the overwater platform.
- The two acre area of historic wetland that is currently managed as lawn could have the historic fill and existing grass removed and be revegetated with native wetland plants.
- The created pond near the outlet of Walker Creek could have the outlet dam removed so that water levels in the pond feature fluctuate naturally.
- Remove the road and boat ramp at the base of the spit.
- Look at ways to increase salt water inundation to the area behind the beach berm.

Figure 11. Outlet of Miller and Walker Creeks. Note the bridge over the creek, riprap along both sides of spit, and helicopter platform on spit.

Segment 6

There are few discreet restoration opportunities in this segment. The only obvious restoration opportunity would be to acquire the one house that is located on the beach and remove the structure, restoring the upper intertidal habitat.

DATA GAPS

The following data gaps were identified in the process of compiling the information in the report:

1. Water quality data for the marine shorelines is limited to one area in the northern part of the City.
2. Data on the both the historic and current extent of wetlands within the city limits is not very extensive.
3. Information on potential public access points is lacking.
4. Flow patterns for surface water routes and general drainage patterns is lacking in the southern half of the City.
5. Data on the historic and current distribution of eelgrass and kelp is lacking.
6. Forage fish spawning beach data was collected infrequently in the past and is insufficient. More comprehensive surveys need to occur.

REFERENCES

Anchor Environmental. 2000. Phase 1 final biological and habitat survey data report. Prepared for Washington State Ferries by Rich Passage Wave Action Study Team.

Anchor Environmental, L.L.C. 2004. Marine Shoreline Inventory Report - WRIA 9. Prepared for Seattle Public Utilities and WRIA 9. Seattle, WA.

Anchor Environmental, L.L.C 2006. Final report: Prioritization of Marine Shorelines of Water Resource Inventory Area 9 for Juvenile Salmonid Habitat Protection and Restoration. Prepared for Water Resource Inventory Area 9 Technical Committee.

Berry, H.D., J.R. Harper, T.F. Mumford Jr., B.E. Bookheim, A. T. Sewell, and L. J. Tamayo. 2000. The Washington State ShoreZone Inventory User's Manual.

BHC Consultants, 2007. Memorandum: Normandy Park Critical Areas Development Regulations Update (Best Available Science). 31 pp.

Booth, D.B., Waldron, H.H. 2004. Geologic map of the Des Moines 7.5-minute quadrangle, Washington, U.S. Geological Survey, Open-File Report, scale 1:24,000.

Brennan, J.S., and H. Culverwell. 2004. Marine Riparian: An assessment of riparian functions in marine ecosystems. Washington Sea Grant. Seattle, Washington. 34 pp.

Brennan, J.S., K.F. Higgins, J.R. Cordell, and V.A. Stamatiou. 2004. Juvenile Salmon Composition, Timing, Distribution, and Diet in Marine Nearshore Waters of Central Puget Sound in 2001-2002. King County Department of Natural Resources and Parks, Seattle, WA 164pp. http://www.kingcounty.gov/environment/watersheds/central-puget-sound/nearshore-environments/juvenile-salmonid-report.aspx

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.

Casola, J.H., J.E. Kay, A.K. Snover, R.A. Norheim, L.C. Whitely Binder, and Climate Impacts Group. 2005. Climate Impacts on Washington's Hydropower, Water Supply, Forests, Fish, and Agriculture. A report prepared for King County (Washington) by the Climate Impacts Group (Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle).

Chrzastowski, M.J., 1982, Net shore-drift of King County, Washington: Western Washington University Master of Science thesis, 153 p., 1 plate. Johanessen, J.

Collins, B. D. and A.J. Sheikh. 2005. Historical Reconstruction, Classification, and Change Analysis of Puget Sound Tidal Marshes. Puget Sound River History Project, Department of Earth and Space Sciences, University of Washington, Seattle. Report to the Washington Department of Natural Resources Aquatic Resources Division, Olympia, Washington.

Department of Ecology, 2010. Shoreline Master Program Handbook, Chapter 7, shoreline inventory and characterization. Accessed May 2010. http://www.ecy.wa.gov/programs/sea/shorelines/smp/handbook/Chapter7.pdf

Dethier, M. N. 2009. Impacts of armoring on Puget Sound beaches: Diverse Effects on Diverse Scales.

Dugan, J.E., D.M. Hubbard, M.D. McCrary, and M.O. Pierson. 2003. The response of macrofauna communities and shorebirds to macrophyte wrack subsidies on exposed sandy beaches of southern California. Estuarine, Coastal and Shelf Science 58S:25-40

Geotz, F. A., E. Jeanes, E. Beamer, G. Hart, C. Morello, M. Camby, C. Ebel, E. Conner, and H. Berge, 2004. Bull Trout in the nearshore, preliminary draft. June 2004, 111pages.

Higgins, K.F., P. Schlenger, J. Small, D. Hennessy, J. Hall, 2005. Spatial Relationships between Beneficial and Detrimental Nearshore Habitat Parameters in WRIA 9 and the City of Seattle. 2005 Puget Sound Georgia Basin Research Conference Proceedings.

Johannessen, J.W., MacLennan, A., and McBride, A, 2005. Inventory and Assessment of Current and Historic Beach Feeding Sources/Erosion and Accretion Areas for the Marine Shorelines of Water Resource Inventory Areas 8 & 9, Prepared by Coastal Geologic Services, Prepared for King County Department of Natural Resources and Parks, Seattle, WA.

Johannessen, J.W. A. MacLennan and J. Waggoner, 2006. Beaconsfield on the Sound Bulkhead Removal Feasibility Study, Prepared for Cascade Land Conservancy, 34 p.

King County Department of Natural Resources, 2007. Technical Appendix: Shoreline Inventory and Characterization Methodology and Results.

King County Department of Natural Resources and Parks, 2009a. Land cover GIS data for King County in 2007. Accessed May of 2010.

King County Department of Natural Resources and Parks, 2009b. Water Quality Status Report for Marine Waters, 2005-2007. Prepared by Kimberle Stark, Scott Mickleson and Stefanie Keefer. Seattle, WA.

King County Department of Natural Resources and Parks, 2010a. Erosion Hazard GIS data for King County. Accessed May of 2010.

King County Department of Natural Resources and Parks, 2010b. Unpublished slope data. Accessed May of 2010.

King County Department of Natural Resources and Parks, 2010c. King County Historical Sites GIS data. Accessed May of 2010.

Landry, Peter. Personal Communication, June 8 2010.

Longcore, T., and C. Rich. Eds. 2005. Ecological Consequences of Artificial Night Lighting. Island Press, Washington, D.C.

MacDonald, K.B. and B. Witek. 1994. Management options for unstable bluffs in Puget Sound, Washington. Coastal Erosion Management Studies, Volume 8. Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia, Washington.

MacDonald, K.B., D. Simpson, B. Paulsen, J. Cox, and J. Gendron. 1994. Shoreline armoring effects on the physical coastal processes in Puget Sound, Washington. Coastal Erosion Management Studies, Volume 5. Shorelands and Coastal Zone Management Program, Washington State Department of Ecology, Olympia, Washington.

Mickleson, Scott. Personal Communication, May 15, 2010

Mote, Phillip, A. Peterson, S. Reeder, H. Shipman, and L. Binder. 2008. Sea Level Rise in the Coastal Waters of Washington State. University of Washington Climate Impacts Group and Washington Department of Ecology. Seattle and Olympia.

Neuman, K.K., L. Henkel, and G. Page. 2008 Shorebird Use of Sandy Beaches in Central California. Waterbirds 31 (1): 115-121.

Nightingale, B., and C. Simenstad. 2001. Overwater structures: Marine issues. Aquatic Habitat Guidelines: An integrated approach to marine, freshwater, and riparian habitat protection and restoration. Prepared for Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington State Department of Transportation by University of Washington, Seattle, Washington

Normandy Park Municipal Code, accessed Jan 2010. http://www.codepublishing.com/wa/normandypark/

Palmer, Stephen P.; Magsino, Sammantha L.; Bilderback, Eric L.; Poelstra, James L.; Folger, Derek S.; Niggemann, Rebecca A., 2007, Liquefaction susceptibility and site class maps of Washington State, by county: Washington Division of Geology and Earth Resources Open File Report 2004-20,

Penttila, D.E. 2001. Effects of shading upland vegetation on egg survival for summer-spawning surf smelt, Hypomesus, on upper intertidal beaches in Northern Puget Sound. In Proceedings of Puget Sound Research, 2001 Conference. Puget Sound Action Team. Olympia, Washington.

Puget Sound Nearshore Ecosystem Restoration Project. 2009. PSNERP change analysis database, downloaded June 2009

Rahmstorf, S., 2007: A semi-empirical approach to projecting future sea-level rise. Science, 315, 368-370.

Rice, Casimir, A. 2006. Effects of Shoreline Modification on a Northern Puget Sound Beach: Microclimate and Embryo Mortality in Surf Smelt (*Hypomesus pretiosus*). Estuaries and Coasts, Vol. 29, No. 1, p 63-71. http://www.psat.wa.gov/Programs/orca/forage_fish/smelt-and-armoring_Rice_2006.pdf

Rice, Casimir, . 2007. Evaluating the Biological Condition of Puget Sound. PhD dissertation, University of Washington

Romanuk, T. N., and C. D. Levings. 2003. Associations between arthropods and the supralittoral ecotone: dependence of aquatic and terrestrial taxa on riparian vegetation. Environmental Entomology 32:1343-1353.

Shaw, S.C. and Vaugeois, L.M., 1999. Comparison of GIS-based Models of Shallow Landsliding for Application to Watershed Management.

Shipman, H. 2004. Coastal bluffs and sea cliffs on Puget Sound, Wasington, in Formation, evolution and stability of coastal cliffs-status and trends, US Geological Survey Professional paper 1693, Denver Co, 123p.

Shipman, H. 2008. A Geomorphic Classification of Puget Sound Nearshore Landforms. Puget Sound Nearshore Partnership Report No. 2008-01. Published by Seattle District, U.S. Army Corps of Engineers, Seattle, Washington.

Shipman, H. 2009. The Response of the Salish Sea to Rising Sea Level: A Geomorphic Perspective. In Proceedings of Puget Sound Georgia Basin Ecosystem Conference, 2009 Puget Sound Partnership, Olympia, Washington.

Stratus 2006. Creosote-Treated Wood in Aquatic Environments: Technical Review and Use Recommendations. Prepared for National Marine Fisheries Service, Southwest Region, Habitat Conservation Division by Stratus Consulting, Inc., Boulder CO.

Sobocinski, K.L. 2003. The impact of shoreline armoring on supratidal beach fauna of central Puget Sound. MS Thesis, University of Washington

Soil Conservation Service. 1973. Soil Survey of King County Area, Washington. U.S. Department of Agriculture, Soil Conservation Service.

Terich T.A. 1987. Living with the shore of Puget Sound and the Georgia Strait. Duke University Press, Durham, South Carolina.

Thom, R. M. and L. Hallum. 1990. Long-term changes in the areal extent on tidal marshes, eelgrass meadows, and kelp forests of Puget Sound. FRI-UW-9008. Fisheries Research Institute, School of Fisheries, University of Washington, Seattle, Washington

Thom, R. M., D. K. Shreffler, and K. B. MacDonald. 1994. Shoreline armoring effects on coastal ecology and biological resources in Puget Sound. Coastal Erosion Management

Studies, Volume 7. Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia, Washington.

Toft, J.D., J.R. Cordell, C.A. Simenstad, and L.A. Stamatiou. 2007. Fish distribution, abundance, and behavior along city shoreline types in Puget Sound. North American Journal of Fisheries Management 27:465-480

Tonnes, D.M. 2008. Ecological functions of marine riparian areas and driftwood along North Puget Sound shorelines. MS Thesis, University of Washington.

U.S. Army Corps of Engineers. 2002. Coastal Engineering Manual, Part II, Chapter 3. Estimation of nearshore waves. EC 1110-2-1100.

Urban-Malinga, B., T. Gheskiere, S. Degraer, S. Derycke, K. W. Opalinski, and T. Moens. 2008. Gradients in biodiversity and macroalgal wrack decomposition rate across a macrotidal, ultradissipative sandy beach. Marine Biology 155:79–90

Washington Trout, Water Type Survey Results South King County (2004)

Williams, R.W., R. M. Laramie, and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization, WRIA-09. Washington State Dept. of Fisheries. 34 pp.

Williams G.D. and RM Thom. 2001. Marine and estuarine shoreline modification issues. PNWD-3087. Prepared for Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington State Department of Transportation by Battelle Marine Sciences Laboratory, Sequim, Washington.

Williams, G.D., R.M. Thom, M.C. Miller, D.L. Woodruff, N.R. Evans, and P.N. Best. 2003. Bainbridge Island Nearshore Assessment: Summary of Best Available Science. PNWD-3233. Prepared for the City of Bainbridge Island: Bainbridge Island, WA; by Battelle Marine Sciences Laboratory: Sequim, WA.

Williams, G.D, R.M. Thom, and N.R. Evans. 2004. Bainbridge Island Nearshore Habitat Characterization and Assessment, Management Strategy Prioritization, and Monitoring Recommendations. PNWD-3391. Prepared for the City of Bainbridge Island: Bainbridge Island, WA; by Battelle Marine Sciences Laboratory: Sequim, WA.

Woodward, D.G., Packard, F.A., Dion, N.P., and Sumioka, S.S. 1995. Occurrence and quality of ground water in Southwestern King County, Washington: Water-Resources Investigations Report 92-4098, prepared in cooperation with State of Washington Department of Ecology, Regional Water Association of South King Co., and Seattle-King County Department of Public Health, Tacoma.

GLOSSARY

Accretion shoreforms

Areas of the marine shoreline where sediment is deposited either currently or has done so in the past. These areas generally have broad backshores, large accumulations of drift logs, and marsh or dune grass vegetation communities. They are frequently part of a lagoon/spit complex, and are also frequently found at stream mouths along the marine shorelines.

Armoring

Refers to any structure that is placed along the shoreline that is intended to halt erosion or lateral movement of the shoreline. Seawalls, bulkheads, and revetments are typical forms of shoreline armoring.

Critical Areas Ordinance or CAO

Critical areas include aquatic areas, wetlands, wildlife habitat, geologic hazard areas, flood hazard areas, and critical aquifer recharge areas. The City of Normandy Park's Critical Areas Ordinance (NPMC Chapter 18.36) is authorized under the WA Growth Management Act and is intended to protect public safety and the existing functions and values of critical areas.

Drift cell (also known as Littoral Cell)

An independent reach of shoreline, along which littoral movements of sediment occurs depending on wave energy and currents. Each drift cell typically includes one or more sources of sediment, such as a feeder bluff, that introduces sediment onto a beach, and one or more accretion areas; an example of an accretion area is a sand spit where the drifted sediment material is deposited.

Ecosystem-wide processes

The suite of naturally occurring physical, biological, chemical and geologic processes that shape landforms within a specific shoreline ecosystem and determine both the types of habitat present and the associated ecological functions.

Feeder bluff (also known as sea cliffs and coastal bluffs)

Is a bluff along the marine shoreline that is actively contributing, or feeding, sediment to marine beaches. Bluff sediment is the primary source of beach sediment in Puget Sound.

Impervious surface

A hard surface which either prevents or retards the entry of water into the soil which causes water to run off the surface in greater quantities or at an increased rate of flow

Groin

A wall that is typically built perpendicular to shore with the intended purpose of intercepting littoral drift. The updrift side of the groin builds up sediment while the downdrift side can be starved of sediment.

Ordinary High Water Mark or OHWM

RCW 90.58.030(2)(b): "Ordinary high water mark" on all lakes, streams, and tidal water is that mark that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation as that condition exists on June 1, 1971, as it may naturally change thereafter, or as it may change thereafter in accordance with permits issued by a local government or the department: PROVIDED, That in any area where the ordinary high water mark cannot be found, the ordinary high water mark adjoining salt water shall be the line of mean higher high tide and the ordinary high water mark adjoining fresh water shall be the line of mean high water.

Restoration

The reestablishment or upgrading of impaired ecological shoreline processes or functions. This may be accomplished through measures including but not limited to revegetation, removal of intrusive shoreline structures and removal or treatment of toxic materials. Restoration does not imply a requirement for returning the shoreline area to aboriginal or pre-European settlement conditions.

Shorelands or shoreland areas

For tidal waters and lakes, shorelands are "those lands which extend landward two hundred feet as measured on a horizontal plane from the ordinary high water mark." Wetlands "which are in proximity to and either influence or are influenced by the tidal water" and "which are in proximity to and either influence or are influenced by the lake" are also shorelands. (See WAC 173-22-040.)

Shorelines of Statewide Significance

The following shorelines of the state:

1. Those areas of Puget Sound and adjacent salt waters and the Strait of Juan de Fuca between the ordinary high water mark and the line of extreme low tide as follows: (A) Nisqually Delta – from DeWolf Bight to Tatsolo Point, (B) Birch Bay – from Point Whitehorn to Birch Point, (C) Hood Canal – from Tala Point to Foulweather Bluff, (D) Skagit Bay and adjacent area – from Brown Point to Yokeko Point, and (E) Padilla Bay – from March Point to William Point;
2. Those areas of Puget Sound and the Strait of Juan de Fuca and adjacent salt waters north to the Canadian line and lying seaward from the line of extreme low tide;
3. Those lakes, whether natural, artificial, or a combination thereof, with a surface acreage of one thousand acres or more measured at the ordinary high water mark;
4. Those natural rivers or segments thereof as follows: (A) Any west of the crest of the Cascade range downstream of a point where the mean annual flow is measured at one thousand cubic feet per second or more, (B) Any east of the crest of the Cascade range downstream of a point where the annual flow is measured at two hundred cubic feet per second or more, or those portions of rivers east of the crest of the Cascade range downstream from the first three hundred square miles of drainage area, whichever is longer; and
5. Those shorelands associated with the water bodies above.

Shorelines, Shoreline jurisdiction, or Shorelines of the State

Shorelines of the state are shorelines along:

- All marine waters;
- Rivers and streams with more than 20 cubic feet per second mean annual flow;
- Lakes and reservoirs greater than 20 acres in area;
- Associated wetlands; and
- Shorelands adjacent to these water bodies.

Shoreline Master Program

Means the cumulative total of all shoreline master program and amendments thereto approved or adopted by rule by the Washington Department of Ecology.

Shoreline Master Program Guidelines

The Shoreline Management Act gives the Washington Department of Ecology authority to adopt Shoreline Master Program Guidelines (WAC 173-26; Guidelines) that local governments must follow when adopting and updating their Shoreline Master Programs. Ecology substantially updated the Guidelines in 2003.

Shoreline Uses

The Shoreline Master Program Guidelines define shoreline uses as follows:

Water dependent

A use or portion of a use which cannot exist in a location that is not adjacent to the water but is dependent on the water by reason of the intrinsic nature of its operations. Examples of

water dependent uses include ship cargo terminal loading areas, fishing, ferry and passenger terminals, barge loading facilities, ship building and dry docking, marinas, aquaculture, float plane facilities, surface water intake, and sewer outfalls.

Water related
A use or portion of a use which is not intrinsically dependent on a waterfront location but whose economic viability is dependent upon or substantially benefited by a shoreline location because: (a) the use has a functional requirement for a shoreline location such as the arrival or shipment of materials by water or the need for large quantities of water; or (b) the use provides a necessary service supportive of the water-dependent uses and the proximity of the use to its customers makes its services less expensive and/or more convenient. Water-related uses include manufacturing of ship parts large enough that transportation becomes a significant factor in the product's cost, professional services serving primarily water dependent uses, and storage of water-transported foods. Other examples of water-related uses include the warehousing of goods transported by water, seafood processing plants, hydroelectric generating plants, gravel storage when transported by barge, oil refineries where transport is by tanker, and upland log storage for water-borne transportation.

Water enjoyment
A recreational use or other use that facilitates public access to the shoreline as a primary characteristic of the use; or a use that provides for recreational use or aesthetic enjoyment of the shoreline for a substantial number of people as a general characteristic of the use and which through location, design, and operation ensures the public's ability to enjoy the physical and aesthetic qualities of the shoreline. In order to qualify as a water-enjoyment use, the use must be available to the general public and the shoreline-oriented space within the project must be devoted to the specific aspects of the use that fosters shoreline enjoyment. Primary water enjoyment uses may include, but are not limited to: Parks with activities enhanced by proximity to the water; Piers and other over water improvements that include substantial public access to shorelines of the state; Restaurants that directly incorporate visual access to and enjoyment of the water; Museums with an orientation to shoreline topics; Aquariums; and Resorts that directly incorporate access to and enjoyment of the water.

Water-oriented
A use that is water-dependent, water-related, or water-enjoyment, or a combination of such uses.

Non-water-oriented
Those uses that are not water-dependent, water-related, or water-enjoyment.

Wetlands

Areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Water Resource Inventory Area or WRIA

Water Resource Inventory Areas were formalized under Washington Administrative Code (WAC) 173-500-040 and authorized under the Water Resources Act of 1971, Revised Code of Washington (RCW) 90.54. The WRIA boundaries were used in Washington to develop recovery plans for salmonids listed as threatened under the federal Endangered Species Act.

ACRONYMS

CAO	Critical Area Ordinance
cfs	Cubic feet per second
City	The City of Normandy Park
CLC	Cascade Land Conservancy
Ecology	Washington Department of Ecology
FWHCA	Fish and Wildlife Habitat conservation Areas
GIS	Geographic Information System
LWD	Large Woody Debris
OHWM	Ordinary High Water Mark
PHS	Priority Habitat and Species
PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
RCW	Revised Code of Washington
SMA	Shoreline Management Act
SMP	Shoreline Master Program
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WDFW	Washington Department of Fish and Wildlife
WRIA	Watershed Resource Inventory Area

APPENDIX 1 MAPS

Maps 1 through 40 are a separate attachment.

APPENDIX 2. DATA SOURCES TABLE

Data sources table is a separate attachment.